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Does adoption of on-farm tree planting depend on Forest co-management? Evidence from selected Forest sites in Kenya

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1. Introduction

A key element of decentralization is the transfer of power over forest decision making from State to lower units such as provinces, districts, wards, villages, or even user groups (Brown and Bosworth, 2007; Jens, 2018). The concept of co-management is one such form of decentralization that confers responsibilities and skills to local communities to undertake joint management of a given resource (Ballet et al., 2009; Berkes, 2009). While there is no agreed definition of co-management, the term broadly refers to an approach where two or more social actors negotiate, define and guarantee among themselves a fair means of sharing the management functions, entitlements and responsibilities for a given territory, area or set of natural resources (Feyerabend et al., 2000). The term has been around for decades and it has changed in theory, practice and terminology. For instance, the term now falls under many labels, including community-based forest management and conservation (Cronkleton, 2011), community-based ecosystem and natural resource management (Cronkleton et al., 2012; Khatun, 2015), sustainable forest management (Skutsch, 2015), joint forest management (Pattanayak et al., 2013; Newton, 2016), and participatory forest management (Loaiza, 2016).

Despite its widespread application in environmental policy, the practice of forest co-management has been criticised on account of its lack of effectiveness in delivering sustainable resource management outcomes and increased benefits to communities (Blaikie, 2006; Mogoi et al., 2012). This is attributed to inadequate legal provisions to guarantee the rights and responsibilities of communities, and weak benefit-sharing arrangements (Lowe and Ombai, 2013). Other studies conclude that co-management has not materialized on the ground that substantive changes in rights and access to resources has not taken place in areas where it has been implemented (Chomba et al., 2015). These contrasting experiences point to the gaps in the literature on the factors responsible for participation in forest co-management.

Previous studies about forest co-management have focused on traditional agroforestry practices and biodiversity conservation (McNeely and Schroth, 2006; Bhagwat et al., 2008; Jose, 2012), and analyzing potential effects of decentralization reforms and local community involvement in forest management (Getz et al., 1999). Others have concentrated on economic benefits of participating in forest co-management (Mogaka et al., 2001; Ogada, 2012; Matiku et al., 2013; Mutune and Friss, 2016) and impact of Participatory Forest Management (PFM) on the wealth of households (Matiku et al., 2013; Guthiga et al., 2014). Very few studies have focused on the role of forest co-management in influencing farmers' behaviour in adopting on-farm tree planting. Those that have focused on on-farm tree planting (Bluffstone and Mekonnen, 2017; Meijer et al., 2015) lack empirical evidence on household participation in co-management and changes on on-farm tree planting.

This study seeks to address this gap by first examining the drivers of households' participation in Community Forest Associations (CFAs) which is the framework through which communities take part in forest management, before analyzing how this participation impacts on household adoption of on-farm tree planting. Economic theory does not provide clear predictions about the effects of decentralization policies on forest users' behaviour. Instead, we must empirically derive how such policies interact with existing socio-demographic variables such as age, gender and educational variables and other factors to change incentives at the local level. We therefore test the effects of farmers' participation in community forest associations and how this affects on-farm tree planting.

Linking forest co-management and adoption of on-farm tree planting is an area of immense policy interest. The knowledge of the effect of co-management on farmer's adoption of on-farm trees is important in three respects. First, it enables policy makers and programme managers to evaluate the reform process in the forest sector. Second, it provides evidence-based understanding upon which programmes can be designed and evaluated on sustainable forest management, and third, adoption of on-farm tree planting is important towards attainment of the 10% Government of Kenya policy on tree cover target and achievement of the Sustainable Development Goals (SDGs) 12, 13 and 15.

More specifically, the objectives of this study are two-fold; first, to evaluate the factors that determine participation in forest co-

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management and second, to analyze the effects of participating in forest co-management on the adoption of on-farm tree planting. We aim to achieve these objectives by answering the following research questions, namely: (1) what factors determine participation in forest management through CFAs? (2) Does participation in CFAs affect farmers' willingness to participate in forest conservation? (3) If yes, through which channels? To answer these questions, the study assesses forest co-management practices across selected forest sites in Kenya.

The rest of the paper is organised as follows: Section 2 discusses forest reforms in Kenya and reviews theories of on-farm tree planting by households. Section 3 describes the methodology, conceptual framework, study sites, data collection, and analytical framework. In section 4, we present the results while section 5 discusses these results. Finally, section 6 gives conclusion and implication of the study.

2. Background to Forest reforms and farm forestry decisions by households

2.1. Overview of Forest reforms in Kenya

Kenya's forest sector operated without a formal forest policy until 1957 when White Paper No. 85 of 1957 was published, and which outlined ten principles on forest management: Reservation; protection; management; industry; finance; employment; African areas; private forests and other forests not under the State ownership; public amenity, and; wildlife research and education. The first principle was restated as a policy in 1968 through Sessional Paper No. 1 of 1968 and adopted as the Forest Act (*Cap*. 385). This Act provided for development of the Kenya Forestry Master Plan and establishment control and regulation of central forests and forest areas in Nairobi and on unalienated government land under the Forests Department. Under this governance regime, access to State forests was tightly controlled by forest guards who ensured continued forest health through exclusion, and only activities approved by the Forest Department were carried out. Forest neighbouring communities and other stakeholders remained mere spectators in forest management. Nonetheless, in the 1970s and 1980s, Kenya was rated highly in plantation development alongside countries such as Chile (Ogweno et al., 2009).

Most problems in the forest sector can be traced way back to the 1990s following extreme plundering and mismanagement of the forests. The problems facing the forestry sector in Kenya are therefore partly due to historical uncontrolled extraction of timber and other forest products and general poor forest governance, which are not only forest sector problems, but also related to regime and political administration of the day. In response, radical reforms were introduced in the sector vide the Forest Act, 2005 which became effective in 2007. This legal framework provided for the Kenya Forest Service (KFS) to devolve powers to other stakeholders, including CFAs, to support protection and conservation efforts through a legislative agreement. Reforms in the Forest Act, 2005 were emphasized in the Constitution of Kenya 2010 through devolution of natural resource management. Until 2007, the country's forest management objectives mostly excluded local resource users from forest decision-making. There were minimal and stringent provisions for subsistence extraction and use of forest products.

The Forest Act, 2005 is progressive and provides for Participatory Forest Management (PFM) as a framework upon which forest neighbouring communities participate in forest management through formation of CFAs. CFAs are established to protect concession areas from destruction and encroachment; to ensure forest area is maintained for conservation of biodiversity, cultural or recreational use; to maintain physical boundaries of the concession; and to take precautions to prevent occurrence and spread of forest fires (Republic of Kenya, 2005). In return, communities would benefit through improved access to forest resources and training on farm agro-forestry. Thus, co-management would be a channel for adoption of on-farm tree planting for participant members (Ajayi et al., 2009), ease pressure on the forest (Reyes et al., 2005), and increase household income through sale of fruits, poles and firewood (Bluffstone et al., 2008). Proponents of co-management argue that forest benefits to communities are contingent upon their participation level, although these benefits vary across countries and are location specific (Mwangi et al., 2011). At times, the net benefits flow to a section of the community, leaving out others (Jumbe and Angelsen, 2007) and therefore studies should incorporate the effect of location in the design.

The engagement of communities in forest management through CFAs is provided for in the Forest Act, 2005 section 46 (1). Accordingly, members of the forest community may come together with other residents in the same area and register a CFA under the Societies Act (*Cap.* 108). The association so registered then applies to the Director Kenya Forest Service for permission to participate in forest conservation and management in their local forest in accordance with the provisions of the Forest Act, 2005. The membership into CFAs may be through existing community structures such as community-based organizations that may be formal or informal. Association members pay user fees to access benefits from the forest. Paid up members are issued with a receipt as proof of user rights. The associations have by-laws and guidelines that cover meeting attendance, election of officials and other rules that are followed by the members.

2.2. Review of theories of on-farm tree planting by households

This section reviews the link between participation in community forest management groups and households' farm forestry investment decisions. It also explores other factors that may motivate households to undertake on-farm tree growing. It is generally recognized in the literature that several factors explain the differences in farm tree-growing decisions by smallholder farmers. However, the specific socio-economic and institutional variables affecting the decisions differ across countries, regions, villages, and farms. Moreover, the direction of influence of a given variable is not often consistent across studies.

Participation in forest management groups has been shown to influence decisions to plant more trees on-farm (Emtage and Suh, 2004). Perhaps this is because it enhances people's attached value to forest ecosystems and the need to protect them, which in turn results in their desire to increase forest cover on their farms. Moreover, participation in community-based conservation groups enhances farmers' access to diversity, quality, and quantity of tree species (Boffa et al., 2005). Besides, participation in community forest management, and households' decisions to plant trees may be directly influenced by household-specific, plot-specific and institutional factors. For example, farm forests have enormous environmental advantages beyond direct benefits to the farm households. To comprehend these indirect benefits, the decision-maker at household level requires some education, either formal or informal, obtained through schooling or extension services. Thus, better educated household heads or households with access to government or farmer-farmer extension services are expected to be better adopters of farm forestry (Muneer, 2008), either because they view tree planting as a means of improving the land (Dewees, 1995) or because they are able to appreciate other non-quantifiable benefits as ambiance, micro-climate modification or carbon sequestration. This also explains why households with good social networks tend to have a higher possibility of planting trees in their farms because they can get extension services through such networks (Gebreegziabher et al., 2010; Muneer, 2008).

Institutional factors have also been shown to influence the decisions by households to plant trees. Secure land tenure arrangements, for example, have been found to influence tree planting decisions among farmer groups. Trees take a longer gestation period and only farmers who are confident of continued use of a given plot would be encouraged to plant them (Bannister and Nair, 2003; Deininger and Feder, 2001; Gebreegziabher et al., 2010; Warner, 1995). However, some studies do not agree with the idea that secure tenure may encourage tree planting and cite cases where communal ownership of land has been more

conducive for development of farm forestry (German et al., 2009). Perhaps tree planting in areas with ambiguous land tenure system is a means used by households to place a claim of legitimacy of ownership and/or access.

3. Theory and methodology

3.1. Introduction

In order to accomplish our two objectives of evaluating the factors that determine participation in forest co-management and analyze the effects of participating in forest co-management on the adoption of on-farm tree planting, this study focused on four (4) forest sites in Kenya (Aberdares, Cherangany, Kakamega and Arabuko Sokoke) and data collected in the month of November and December 2015. The forest sites were selected to ensure representation of different agro-ecological zones of the country. The forest sites were also chosen because they were at different stages of implementing forest reforms. For example, Arabuko Sokoke is a coastal forest and was the first to start implementing participatory forest management prior to the Forest Act, 2005 and has a long history of community participation in forest management. Cherangany started implementation of forest reforms only in 2012 after coming into force of the Forest Act, 2005. Kakamega forest is the only remaining rain forest in Kenya and is the furthest east remnant of the Guinea-Congolean rain forest. Cherangany and Aberdares are the two largest water towers in Kenya and are therefore of interest to the government in relation to conservation.

3.2. Theoretical and conceptual framework

We used the theory of Common Pool Resources (CPR) as the theoretical undernimming to understand the role of CFAs in contributing to sustainable management of forests and securing livelihood of local communities as per Ostrom's principles for sustainable governance of common-pool resources (Ostrom, 1990). The theory provides an insight into the analysis of relationships, local people's participation, user rights and benefits from forest resource use as a common resource. Conceptually, forest reforms are viewed as strengthening community participation in forest management through devolution of some decision-making powers to communities through CFAs comprising of community representatives. This enables control of communities' access to forest benefits and therefore avoid the problem of the tragedy of the commons as argued by Hardin, 1968.

Thus, CFAs are designed as avenues for promoting sustainable forestry, and as instruments for innovative development. Individuals or forest user groups participating in CFAs are guided by a set of rules meant to promote sustainable forest management. The ability of CFAs to create knowledge, set rules, sanctions and rewards would influence individual farmers adoption and implementation of innovation on on-farm tree planting. Decisions to adopt or not to adopt are reflected on changes in on-farm trees. Evaluating the effects of CFAs on farmer adoption of on-farm tree planting technologies compares changes in initial and final conditions as shown in the conceptual framework (Fig. 1).

According to Fig. 1, a key outcome of forest co-management is to ease forest pressure by promoting on-farm tree planting as an alternative to forest tree. Individuals increase the number of trees on their farms depending on several factors key among them; knowledge on tree planting, group influence and persuasion and perceived benefits and enforcement of rules all of which are championed by locals. Effectiveness of co-management depends on the extent to which the forest act is operationalized at the local level through creation of CFAs whose primary function is to promote tree planting within their locale. CFAs focus on gazetted forests, yet, the knowledge and experience acquired by a member's participation in the CFA is expected to be manifested on the private farms. Thus, observing changes in on-farm trees of CFA member provide important insights on the success of the forest reforms initiated through the forest Act.

3.3. Study population and sampling

Prior to this survey, boundaries of the CFAs were obtained from the KFS station managers for each site and generally covered areas not extending five (5) kilometers away from the forest boundaries. A list of all households within each CFA was obtained from village elders to constitute a sample frame. The information was verified by Community-Based Organizations (CBOs) operating in the area. A sample of 475 households was drawn and interviewed. The distribution of the sample in the four study sites was as follows: Aberdares 122, Cherangany 94, Kakamega 131 and Arabuko Sokoke 128. The household was our focal unit of analysis. The preferred respondent was the household head. However, where the household head was not available, any household member who is 18 years and above and had knowledge about forest reforms and farming activities was chosen as a respondent.

The specific households to be interviewed in each study site as per the sample were determined using systematic random sampling technique by picking the first household unit in each CFA along a transect walk, followed by the next 6th household and so on. To ensure household homogeneity and to avoid error of bias due to geographical differences, we used a radius of up to two (2) kilometers from the household to the forest site. Those households who were members of CFAs but dropped their membership were treated as non-CFA households. On average, the interview per household lasted one hour.

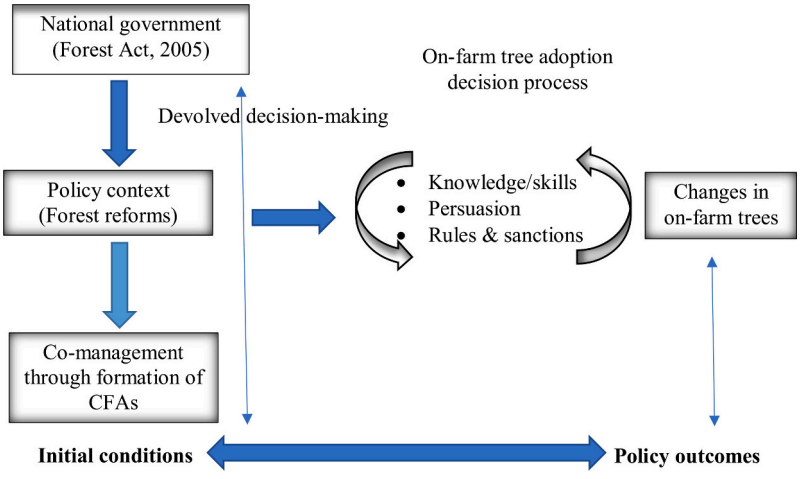

Fig. 1. Conceptual Framework for understanding Forest Co-management in Kenya. (Source: Author's conceptualization.)

3.4. Data collection and instruments

Primary data to evaluate the effects of forest co-management on on-farm tree planting behaviour was collected by use of a semi-structured household questionnaire with questions on respondent's observation of the changes in on-farm tree planting in and around their own farms in the preceding five (5) years prior to the study in 2015. The questionnaire comprised of three broad sections. Section one contained questions on personal and household characteristics, including age, gender, level of education, and assets. Section two contained information on farm size, crop enterprises, production, revenues and farm labour, while section three covered issues of membership to CFA, distance to the nearest edge of the forest, benefits and costs of participating in CFA and changes observed in on-farm tree planting.

Secondary data was obtained through review of relevant literature such as policies and laws, journals, annual reports, and survey reports. Further, at least one Focus Group Discussion (FGD) per study site was conducted to clarify issues emanating from the household survey. Each FGD was attended by an average of 10 participants carefully selected to represent various stakeholders in the forest sector, such as farmers, forest product beneficiaries (e.g. timber loggers and traders), government officials from Kenya Wildlife Service (KWS) and KFS, provincial administration, among others, from each CFA. Discussions were based on a pre-designed FGD guide that covered a range of issues on the effects of forest reforms, CFAs activities, relationship between CFA and KFS and KWS, and lessons and challenges in forest co-management. On average, each FGD lasted up to 2 h.

3.5. Empirical estimation

The factors determining on-farm tree planting were identified through literature review. The dependent variable (*On-farm trees*) is the reported changes in on-farm tree planting by the respondents for the period prior to and after the establishment of the CFA. The variable was categorized into three responses and assigned arbitrary codes, where 0 = Less trees: 1 = No change and 2 = More trees (Table 1). We specify the model in a functional relationship as follows:

$$Y = f(X) \tag{1}$$

Using variables in Table 1, eq. (1) can be re-written in an expanded form as:

$$\begin{aligned} Y = {} & \beta 0 + \beta 1(\mathrm{FARMSIZE}) + \beta 2(\mathrm{GENDER}) + \beta 3(\mathrm{CFA\_MEMBER}) \\ & + \beta 4(\mathrm{EDUCATIONL}) + \beta 5(TENURE) + \beta 6(AGE\_HHD) \\ & + \beta 7(AGE2\_HHD) + \beta 8(TRAIN) + \beta 9(EXTENSION) \\ & + \beta 10(REPLANT) + \varepsilon \end{aligned} \tag{2}$$

where:

Y is changes in on-farm trees (the dependent variable) and.

Independent variables are:

FARMSIZE = farm size; *GENDER* = gender of the respondent; *CFA_MEMBER* = membership to CFA; *EDUCATIONL* = education level of respondent in years; *TENURE* = land tenure type; *AGE_HHD* = age of the household head; *AGE2_HHD* = square of the age of household head; *TRAIN* = training in tree planting; *EXTENSION* = extension services received; and *REPLANT* = replanting trees after cutting. The error term (ε) captures any unobserved variables and measurement errors in variables.

The hypothesized relationship of independent variables in the model are:

a) ***Forest co-management*** practice, which is proxied by ***Membership to CFA*** in which case membership to CFA can have mixed results. First, because the members can access resources from the forest, they may not have incentives to plant trees in their own farms. Being a member of a CFA and having access to training and extension services can, however, motivate them to plant trees in their own farms.

b) Individual characteristics:

- ***Age*** of the household head: It is hypothesized that older household members have longer farming and conservation experience and are therefore more likely to engage in tree planting in their own farms.
- ***Gender*** of the household head: It is assumed that male-headed households are more likely to grow trees than their female-headed counterparts based on their gender roles.
- ***Education*** of the household head: From the literature, the results on this variable produce mixed results. However, in this study, it is assumed that the more educated household heads are likely to embrace on-farm tree planting than those with little or no education.

c) Skills in tree planting is expected to raise the probability of a household's participation in tree planting in their own farms proxied by:

- ***Training*****:** Access to information through short-term training such as in tree planting is assumed to positively influence households to plant trees in their own farms.
- ***Extension:*** Access to advice from extension officers is assumed to motivate and influence households in planting trees in their farms.

d) Availability of space to plant trees including:

- ***Farm size,*** where households with large landholding are more likely to grow trees to conserve their land and the surrounding environment at large. Households with larger farm sizes are also likely to

Table 1
Description of the variables.

Variable	Type of variable	Description and measurement	Expected sign
On-farm trees	Ordinal categorical	Changes observed in on-farm tree planting prior to and after CFA (less trees = 0; no change = 1; more trees = 2)	Dependent
Farm size	Continuous	Size of household agricultural farm (acre)	+
Gender	Binary categorical	Gender of household head (M = 1; F = 0)	+
Age	Continuous	Age of household head in years	+
Age squared	Continuous	Square of age variable	+/−
Education	Continuous	Number of years in formal education by household head	−
Membership to CFA	Binary categorical	Whether household member belongs to a CFA (Yes =1; No = 0)	+
Tenure	Binary categorical	Has land tenure, proxied by ownership of a title deed (Yes = 1; No = 0)	+
Training	Binary categorical	Member of household has received training on tree planting (Yes = 1; No = 0)	+
Extension	Binary categorical	Household has received extension services on tree management and planting practices (Yes = 1; No = 0)	+
Replant	Binary categorical	Household replants/replaces cut trees (Yes = 1; No = 0)	+

grow trees due to less competition from alternative land uses such as crop production.
- ***Tenure,*** where the State-owned land tenure system may lead to a decrease in the confidence of planting trees as opposed to individual land tenure.

The variables used in the empirical model, their descriptions and expected signs are summarized in Table 1.

An Ordered Logistic Regression analysis was performed to fit a regression model. This model allows for prediction of probabilities of changes in tree planting decisions (the outcome variable). Before model estimation, preliminary analyses were done to test presence of multicollinearity among explanatory variables. The obtained tolerance value of collinearity diagnostics greater than 0.1 indicates no perfect multicollinearity between the considered explanatory variables in the model.

4. Results

4.1. Characteristics of the sample communities

The average age of the household head is 44 years, which falls within the band of most of the respondents interviewed who were aged 36–60 years. The education level is average at primary school. Nonetheless, there were great disparities in levels of education across the study sites. The average size of the households in the sample is 5 members, with about 68% being male headed.

The average farm size in the four forest sites is 3.27 acres, with a minimum of 0 (for those referred to as squatters living in forest land) and a maximum of 26 acres. The mean size, however, varied from 2.30 acres in Kakamega, 3.38 acres in Aberdares, 2.23 acres in Cherangany and 4.99 acres in Arabuko Sokoke.

4.2. Participation in CFA and Forest conservation

Participation of forest-dependent communities in forest management group and activities has been recognized as one of the pathways to improving forest conservation and management, promoting sustainable use while securing forest benefits and opportunities for the people. The main aim of participatory approach is to empower and benefit the local people.

Farmers were asked to state if they belonged to any forest association. A majority, 64.5% indicated that they belonged to a CFA and were therefore participants in forest co-management, 4.5% stated they belonged to CBOs, 5.0% were members of a farmer group or cooperative while 26.0% did not belong to any group. In terms of CFA membership, Arabuko Sokoke had the highest proportion at 77%, followed by Aberdares at 71%, Cherangany at 59% and Kakamega had the least at 51% of the sampled respondents per forest site (Table 2).

Farmers who are participants in co-management received training through their respective CFAs to enable them discharge functions under the agreement signed with KFS. The trainings focused on fire management, tree nursery establishment, tree planting, and soil and water conservation. Civil society groups operating at local level were the main providers of these trainings followed by KFS, and other government agencies such as the National Environment Management Authority, and the Ministry of Agriculture.

Members of CFA who did not receive the training cited reasons such as inadequate training providers, lack of awareness of the trainings and "don't think the training is necessary" as the main impediments to not receiving any training. The training challenges therefore result from a combination of supply and demand factors. Application of tree planting training was observed to be highest in Kakamega with 93.5% followed by Aberdares at 90.7%, Arabuko Sokoke at 90.3% and Cherangany with the lowest at 73.9%. Lack of seedlings and/or cost of seedling and the time requirement for planting trees were the main reasons cited for non-application of tree planting.

Information on benefits received from the forest was obtained from the respondents and the results show that about 80% of the respondents on average indicated firewood as the main benefit they received or accessed from the forests, followed by grazing and farmland at 7.9% and 6.7%, respectively. The types of forest benefits enjoyed by the communities are tabulated by forest sites and summarized in Table 3.

To receive forest benefits, farmers were required to pay some fee, and the survey data show that 87.5% had paid some form of fee in the last 12 months preceding the survey. The mean fee was Ksh 2061 (US$ 20.2) per year but ranged from Ksh 1081 (US$ 10.6) in Arabuko Sokoke, Ksh 1226 (US$ 12.0) in Kakamega, Ksh 2008 (US$ 19.7) in Cherangany and Ksh 3388 (US$ 33.2) in Aberdares. The maximum fee of Ksh 120,000 (US$ 1176.5) was recorded in Aberdares. Fee payment was cited as a constraint in accessing forest benefits, along with distance, forest degradation and bad relationship with KFS staff. In some cases, introduction of co-management has limited community benefits and access rights. This is because one cannot enter the forest to get resources at will as before. However, no fee is paid for grazing and watering cows in the forest, but a permit or license is required for watering cows. Forest fires are very rare because of conservation efforts and monitoring of the forest by the CFA and the community.

4.3. Changes in on-farm tree planting and Forest condition

Farmers were asked to state observed changes in on-farm tree planted on their farms and the condition of the forest since they started participating in CFA activities. On average, about 78% of the respondents indicated that they observed increase in on-farm tree planting around their area. Comparison of the perception on the observed

Table 3
Type of forest benefits accessed by forest area (%).

	Forest Area			
Benefit type	Arabuko Sokoke	Aberdares	Cherangany	Kakamega
Firewood	92.1	80	69.1	78.2
Charcoal	0.0	0.0	1.2	1.3
Farmland	1.4	7.9	14.8	2.5
Timber	0.0	0.7	1.2	0.0
Medicinal herbs and aromatic plants	0.0	0.7	1.4	5.1
Fodder (cut and carry)	0.0	0.0	0.0	1.3
Grazing	3.9	6.4	12.3	9
Poles	2.6	0.0	0.0	1.3
Soil conservation	0.0	4.3	0.0	1.3
Total	**100.0**	**100.0**	**100.0**	**100.0**

Source: Author's computation from the 2015 Survey data.

Table 2
Membership to CFA and other groups.

Membership	Arabuko Sokoke	Aberdares	Cherangany	Kakamega	Average
CFA	77	71	59	51	64.5
CBO	3	2	6	7	4.5
Farmers group or Cooperatives	10	5	1	4	5.0
Others	10	22	34	38	26.0
Total	100	100	100	100	100

changes in on-farm tree planting varied across the forest sites with 88% in Arabuko Sokoke, 68% in Kakamega, 74% in Cherangany, and 83% in Aberdares. However, the perception on observed changes in forest condition shows that, on average, majority (81%) observed increased trees around the forest. The results are presented on Table 4.

However, four challenges were common to all the forests' sites. First, both CFA and non-CFA farmers complained of inequitable distribution of benefits from the forests between the community members and the State. Information from Focus Group Discussions (FGDs) shows that the State received the greatest benefits particularly arising from timber products. This has created tension between the government agency, KFS and the CFAs in the forest sites. It was reported that the government conservation agency personnel were no longer interested in CFA co-management of forests. Political interference was reported as the other major challenge affecting the operation of CFAs. Where the CFA is perceived to be successful, some local politicians influence the selection of CFA leadership to gain political support during subsequent elections. Weak enforcement of the forest regulations was cited as another challenge. Although CFAs had provided community forest scouts to support KFS guards in monitoring and enforcing the forest regulations, weak collaboration affected the smooth operations between the two groups.

4.4. Determinants of participation in on-farm tree planting

To identify the factors that influence households in adoption of on-farm tree planting, we run an Ordered Logistic Regression to estimate odds ratios. Table 5 shows the results of the estimates of odds ratios for the Ordered Logistic Regression. The reported changes in on-farm trees were regressed on ten explanatory variables: farm size (*FARMSIZE*), gender (*GENDER*), CFA membership (*CFA_MEMBER*), education in years (*EDUCATIONL*), land tenure (*TENURE*), age of household head (*AGE_HHD*), square of age of household head (*AGE2_HHD*), training on tree planting (*TRAIN*), receiving extension services (*EXTENSION*) and replanting trees after cutting (*REPLANT*). Respondents with missing data were excluded, yielding 429 observations. The model was appropriately specified with a significant *P*-value of $P \leq 0.05$ likelihood ratio and chi-square of 23.11, indicating that the variables included in the Ordered Logistic model best specified the functional relationship in the model.

Table 4
Perceived changes in on-farm trees adoption and forest condition (%).

Observed changes	Arabuko Sokoke	Aberdares	Cherangany	Kakamega	Average
On-farm trees planted					
More trees	88	83	74	68	**78**
No change	6	15	24	31	**19**
Fewer tress	6	3	2	1	**3**
Total	**100**	**100**	**100**	**100**	**100**
Condition of the forest					
More trees	80	82	67	94	**81**
No change	11	11	21	5	**12**
Fewer tress	8	8	12	1	**7**
Total	**100**	**100**	**100**	**100**	**100**

Source: Author's computation from the 2015 Survey data.

Table 5
Regression results.

DEP tree cover	Coef.	Odds ratio	P > z
Aberdares	−0.234	0.791	0.698
Cherangany	1.068	2.911	0.13
Kakamega	−1.108	0.33	0.189
CFA_MEMBER	**−1.189**	**0.305**	**0.018**
GENDER	−0.716	0.489	0.302
EDUCATION	**0.146**	**1.157**	**0.032**
TENURE	**−0.880**	**0.415**	**0.082**
AGE_HHD	**−0.188**	**0.828**	**0.074**
TRAIN	0.504	1.655	0.307
EXTENSION	**0.839**	**2.314**	**0.081**
FARMSIZE	−0.004	0.996	0.634
REPLANT	0.760	2.138	0.385
AGE2_HHD	**0.002**	**1.002**	**0.057**
/cut1	−3.892		
/cut2	−2.969		

Source: Author's computation from the 2015 Survey data.

The results of Ordered Logistic Regression analysis show that being a member of CFA and having higher level of education were significant at the 5% level, with a $p = 0.018$ and 0.032, respectively, while land tenure, increased age and visit by extension officer were significant at 10% levels with $p = 0.082$, 0.057 and 0.081, respectively.

The variables, CFA membership and education are significant at 5% level of significant while Land tenure, Extension services and age are significant at 10% level of significant. The results tell us that, all other things held constant, education, extension services and age tend to positively positive influence on farm tree planting. Being a member of CFA, having land tenure and having land farm size reduced the likelihood of having more on-farm trees and therefore adoption. With CFA membership, the odds of increased on-farm trees versus the combined no change and decreased on-farm trees was 0.31 times greater, given the other variables are held constant in the model.

Increased number of years in education of the household head increased the likelihood of having more on-farm trees and therefore adoption. An extra year of education of the household head, holding all other factors constant, increased the odds of more on-farm trees versus the combined no change and decreased on-farm trees by 1.16 times.

Having a title deed as a proxy for land tenure reduced the likelihood of having more on-farm trees and therefore adoption. With complete land ownership, the odds of increased on-farm trees versus the combined no change and decreased on-farm trees was 0.42 times greater, given the other variables are held constant in the model.

Visits from extension officers on the farms increased the likelihood of having more on-farm trees and therefore adoption. Extension visits increased the odds of increased on-farm trees versus the combined no change and decreased on-farm trees by 2.31 times, holding all other variables constant.

While insignificant, being in Cherangany catchment increased the likelihood of more on-farm trees compared to Aberdares. The likelihood decreases for Aberdares and Kakamega catchments.

4.5. Effect of co-management on on-farm tree planting

The Marginal Effects results for the Ordered Logistic Regression are presented in Table 6. According to the results, extension services increased the likelihood of a farmer falling within the category of declined on-farm trees by 15.9% and increased the likelihood of increased on-farm trees by 20.6%. Increasing a farmer's education by one year had a 2.9% likelihood of a farmer falling in the category of declined on-farm trees and 3.6% likelihood of increased on-farm trees. Land ownership increased the likelihood of a farmer falling within the category of a decline in on-farm trees by 16.9% but decreased the likelihood of falling within the category of more on-farm trees by 21.6%.

Membership in a CFA increased the likelihood of a farmer falling in the reduced on-farm trees by 21.1%, increased the likelihood of having no change by 7.3%, and reduced the likelihood of increased on-farm trees by 28.4%. This depicts a high degree of dependence on common forest resources by CFA members. Location Marginal Effects indicated that being in Cherangany reduced the likelihood of a farmer falling within the category of reduced on-farm trees by 17.6% but increased the likelihood of falling within the increased on-farm trees by 25.1%.

5. Discussions

Using a cross-sectional survey data, this study investigated the factors that determine the participation of forest-dependent communities in

Table 6
Marginal effects.

	Pr (DEP_tree cover = 1) – Less trees		Pr (DEP_tree cover = 2) – No change		Pr (DEP_tree cover = 3) – More trees	
	dy/dx	P > z	dy/dx	P > z	dy/dx	P > z
Aberdares*	0.046	0.703	0.012	0.684	−0.058	0.698
Cherangany*	−0.176	0.067	−0.075	0.205	0.251	0.091
Kakamega*	0.250	0.222	0.014	0.701	−0.263	0.140
*CFA_MEMBER	0.211	0.010	0.073	0.071	−0.284	0.010
GENDER*	0.156	0.339	0.019	0.258	−0.175	0.279
EDUCATION	−0.029	0.033	−0.008	0.128	0.036	0.032
TENURE*	0.169	0.075	0.047	0.152	−0.216	0.072
AGE_HHD	0.037	0.075	0.010	0.169	−0.047	0.074
TRAIN*	−0.105	0.329	−0.021	0.263	0.125	0.300
EXTENSION	−0.159	0.074	−0.046	0.153	0.206	0.072
FARMSIZE	0.001	0.641	0.000	0.617	−0.001	0.634
REPLANT*	−0.168	0.424	−0.017	0.425	0.185	0.354
AGE2_HHD	0.000	0.058	0.000	0.153	0.000	0.057

Source: Author's computation from the 2015 Survey data; (*) dy/dx is for discrete change of dummy variable from 0 to 1.

on-farm tree planting and the effects of participation in forest co-management on the adoption of on-farm tree planting in Kenya. We found that a majority, 64.5% of the respondents are members of CFA and therefore participate in forest co-management. These findings suggest that participation in forest conservation is taking root in forest-dependent communities but participating in co-management has not influenced the community's preference for on farm tree planting.

The findings of the study show that across the selected forest sites, CFAs have been created to increase community participation in forest management. In practice, however, communities have limited user rights, as much power and authority are reserved by the government forest management agency, KFS. Although communities have access to certain products, these are generally of low value and access can be revoked by the Director of KFS. Reluctance to cede power to CFAs constrains their effectiveness in managing forest resources. Further, the fact that CFAs exist at the discretion of the KFS suggests that current co-management arrangements do not represent full devolution according to Ostrom's (1990) principles. This situation discourages farmers from investing in on-farm tree planting. Our results support the hypothesis that having previously received extension services is an indicator of willingness to participate in forest conservation and therefore on-farm tree farming.

The just average level of participation in CFA and low level of adoption of on-farm tree farming show that CFAs are yet to attain universal membership and appropriately influence communities in on farm tree planting. This resonates with similar studies in the subject area. For example, studies by Nijnik et al. (2010) showed poor uptake of tree-planting by landowners in Scotland, as land tenure used to be a barrier to afforestation (Warren, 2002), along with economics, management, and administration of the land conversion (Towers et al., 2006). Also, farmers are preoccupied with agriculture (Burton, 2004). Owing to this land use activity, they perceive themselves as "stewards of the countryside" (Towers et al., 2006). Thus, social, and psychological factors are a cause of farmers' reluctance to plant trees. Also, social innovations in forestry can result in providing a range of benefits for local communities (Nijnik and Sarkki, 2019).

According to the results of our study, the relationship between household's level of education and its willingness to participate in forest conservation is positive. The finding of a strong positive effect of education on participation in on farm tree planting supports the findings of Jumbe and Angelsen, 2007 that people with formal education – especially retired public servants and politicians due to their understanding of the importance of conserving forests, are more likely to participate in in tree planting and therefore could motivate other villagers to participate as well.

The differences in observed changes in on-farm tree planting were found to be significant at $P \leq 0.10$ with a Pearson Chi-square value of 10.78, which implied that there was a significant association between forest sites and changes in on-farm tree planting since the respondents began participating in CFA activities. In other words, changes in on-farm tree planting were dependent on the study site. This was attributed to the unique challenges relating to co-management of forest resources across the four study sites and being at different levels of implementing forest reforms. This was corroborated with discussions with community members during FGDs.

Finally, our study indicates that receiving extension services was related to willingness to participate in forest conservation. This suggests that the extension training is important in influencing the community's attitudes regarding forest co-management. Thus, extension services for forest-dependent communities should be designed with more information on the recipients' needs and situations.

6. Conclusions

The purpose of this study is to contribute to the understanding on the factors that affect participation in forest co-management and the effects of participation in forest co-management on the adoption of on-farm tree planting. Furthermore, this information would assist in the development of appropriate policy frameworks to ensure successful implementation of inclusive, participatory, and sustainable forest conservation initiatives in Kenya. The factors identified as influencing participation in forest co-management and participation in on-farm tree planting included education, age of the respondent and access to extension services. From the results of the regressions, we conclude that while education and extension services are key in influencing on-farm tree planting, membership to CFAs as a means of forest co-management has not facilitated adoption of on-farm tree planting. Although CFAs offer opportunities for community training and extension services, there is no evidence to show that they have facilitated adoption of on-farm tree planting by individual members.

Nevertheless, the results of this study should be interpreted with caution because the study involved only a cross-sectional sample of 475 households, covering a relatively small part of the four forest sites in Kenya. Thus, a larger scale study preferably using a longitudinal data that includes an in-depth analysis of forest governance and the interactions of social and economic factors is necessary. Such a study would provide more comprehensive information towards the development of better targeted policy instruments for sustainable forest management. Nevertheless, we consider this study as likely to help in developing forest conservation policy options that could contribute to improving the livelihoods of forest-dependent communities in the study sites. Finally, we acknowledge the limitations of our work in the sense

that our study assessed the factors that affect adoption of on-farm tree planting using Ordinary Logistic Regression and the effect of participation in co-management on the adoption of on-farm tree planting. The effects of participation in co-management on on-farm tree adoption should be evaluated further using either propensity score matching or endogenous switching model. We plan to tackle these issues in our future studies.

Appendix A. Supplemenary data

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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