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Challenges Affecting the Adoption of Agroforestry Practices around Chepalungu Forest in Bomet County, Kenya

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Authors' contributions

This work was carried out in collaboration between all authors. Author MMM designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors JH and YOO managed the analyses of the study. Author ASY managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Anthropogenic activities around Chepalungu forest has lead to its reduction in size and has resulted in its degradation. Continued dependency on this forest may result in its total depletion despite its high biological diversity and the value of its natural resources. Farmers in the area have been largely uninterested in adopting agroforestry practice around Chepalungu forest, despite the potential for these practices to reduce demands on the forest. This study identified barriers to adopting agroforestry practices around Chepalungu forest in Bomet County, Kenya. Researchers adopted descriptive survey research design in this study. The study was done in 2016. The study sites were four locations around Chepalungu forest (Bing'wa, Siongiroi, Ndanai, and Abosi), which are 5 km from the forest edge and were selected using simple random sampling method. A total of 377 household questionnaires were administered in the four locations. Chi-Square and Mann Whitney U tests were used in the data analysis. Significance levels were expressed at $P<0.05$ using

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SPSS version 17 software. The results showed that there was a significant association (χ^2= 530.8; P <0.01) between the types of agroforestry practices and challenges affecting the adoption of agroforestry practices. Notable challenges were: damage by animals, damage by man, tree nursery problems, inadequate capital, natural calamities, competing land uses, managerial problems and seed acquisition problems.

Keywords: Agroforestry; challenges; Chepalungu; adoption.

1. INTRODUCTION

Over 60% of forest dependent people in the world are farmers [1]. A significant number of these farmers depend heavily on forest resources for their livelihood [2]. Due to this high dependence on existing forest resources, natural forests are being depleted and the supply of forest products is becoming uncertain [3].

Natural forests in Kenya stand at about 1.2 million hectares, with most of which located in high potential areas where they are facing intense competition with other land use practices [4,5]. The growing population is exerting immense pressure on the forest resources with about 80% of forest dependent people in these areas being farmers [6,7]. Forest ecosystems are fast dwindling in the high potential ecological zones, forcing people to move into forests and other areas which are less endowed in biodiversity [8].

The role of forests in the livelihood of the forest adjacent communities is diverse. Rural forest adjacent communities derive food, medicine and fuel-wood along with non-wood benefits such as spiritual, aesthetic and environmental services provided by forests. Therefore, continued degradation of forests is likely to reduce the forest's capacity to biodiversity and people's socio-economic livelihood [5,9,10].

Chepalungu forest is very important to people living near and far from it by providing both timber and non-timber forest products, but it is highly degraded due to grazing, settlement and farming. In addition, forest excision at Chepalungu cleared important tree species such as *Olea capensis* (Olea) and *Juniperus procera* (Cedar) [11].

Agroforestry, which involves incorporation of trees on farms for subsistence and commercial purposes, is an important land use option that has the potential to deliver similar functions as indigenous and plantation forests while reducing pressure on natural forests [12]. A well managed agroforestry system can also improve the economic and social sustainability of a region [13] by delivering benefits to both landholders and to the wider community. In the short term, it can provide many private benefits, such as increasing the visual amenity of the farm, improved soil stability and in some cases improved productivity of other farm activities [12]. Over the longer term, agroforestry provides landholders with a source of income and a means of diversifying their farming business [5,14]. Agroforestry also offers many potential benefits to the wider community by improving catchment water quality, reducing stream-bank erosion, and increasing landscape biodiversity.

In early 2000s, the Green Belt Movement initiated conservation programmes that included agroforestry initiatives to reduce encroachment and destruction of the remnant forest. However, [15] farmers around Chepalungu Forest did not adopt these agroforestry practices, with less than 33% of farmers taking part. The Green Belt Movement did not provide detailed account of the barriers to agroforestry development in the area and communities adjacent to Chepalungu forest are still dependent on this forest as source of products accessed through destructive activities [15]. This study aimed to address this gap by identifying the barriers affecting the adoption of agroforestry practices around Chepalungu forest.

2. MATERIALS AND METHODS

2.1 Study Area

Chepalungu Forest lies on latitude 00° 53' 00" S and longitude 35° 10' 00" E. The study was carried out around Kapchumbe and Siongiroi blocks of Chepalungu forest, Bomet County, Kenya. Chepalungu forest is administratively divided into two management blocks, Kapchumbe (in the South-West) and Siongiroi (in the North-East) (Fig. 1).

The area has medium to long cropping season followed by a medium to short and intermediate

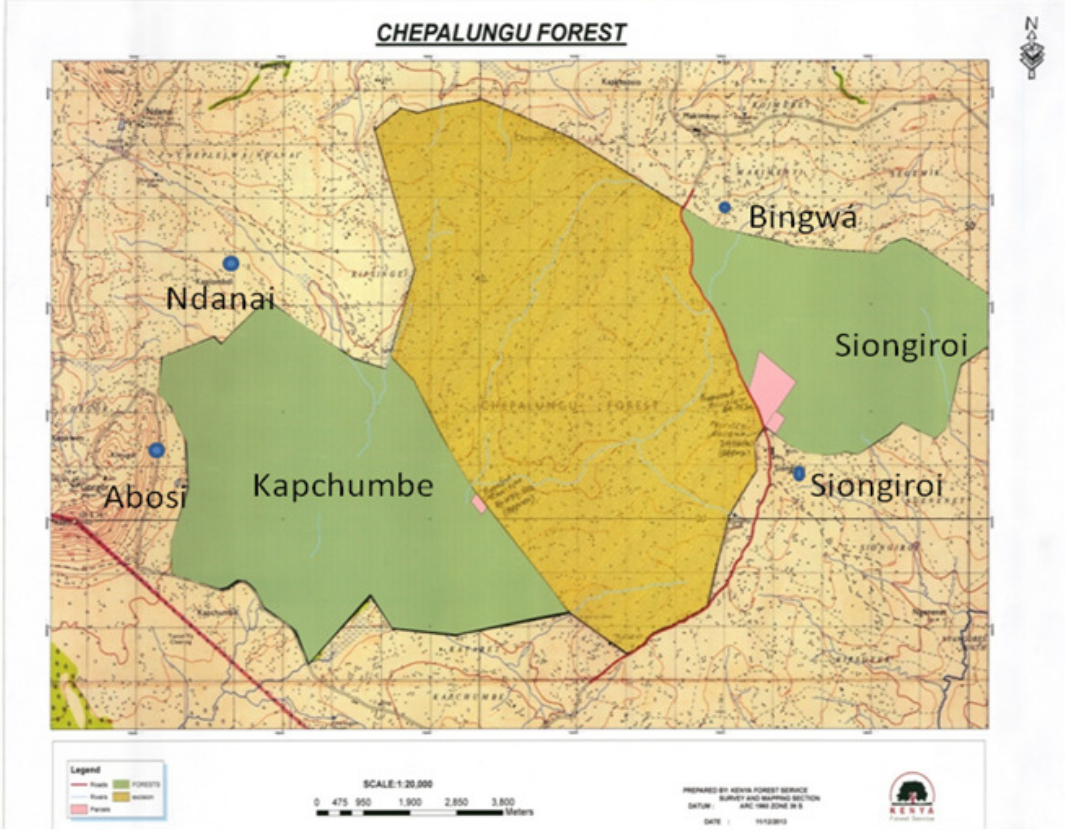

Fig. 1. Chepalungu forest and adjacent sampled settlement locations [8]

rains. The mean annual rainfall is 1200 mm – 1350 mm per year with an altitude range of 1550 m – 2000 m above the sea level. The mean annual temperature ranges from 17.9℃ – 20.5℃.

The soils are predominantly loamy black cotton soils. Maize and marginal coffee crops are the main crops in the area, which occupies almost 18.72 Km² of agricultural land [16].

2.2 Target Population

Kapchumbe and Siongiroi blocks of Chepalungu forest are surrounded by six settlement Locations. These locations are Abosi, Bingwa, Siongiroi, Makimenyi, Ndanai and Kongasis. These locations have a population of 80,673 persons occupying 15,849 households [11,17].

2.3 Research Design

The study employed the use of descriptive survey research design in establishing the challenges affecting agroforestry development among the communities living adjacent to Chepalungu forest.

2.4 Sample Size and Sampling Procedures

Simple random sampling technique based on random numbers generated on a scientific calculator was used to select four Locations and households adjacent to Chepalungu forest for the study. The Locations selected were Bing'wa, Siongiroi, Ndanai, and Abosi.

The household sample size in each location was calculated based on formula equation 1 at 0.1 margin error [18]:

$$n = [\frac{\mathrm{N}}{(1+Ne^2)}] \quad (1)$$

Where,

N= population size
n = sample size
e = margin error

Therefore the sample size in each was calculated based on the Location's available households. According to Kenya Bureau of statistics [19], there were 2010, 1820, 2003, and 1157 households in Bing'wa, Siongiroi, Ndanai and Abosi Locations respectively.

Therefore, using equation 1, the sample size in:

Bing'wa = $n = [\frac{\mathrm{N}}{(1+Ne^2)}] = [\frac{2010}{(1+(2010*0.1^2)}]$ = 95.67 households = 96 households

Siongiroi = $n = [\frac{\mathrm{N}}{(1+Ne^2)}] = [\frac{1820}{(1+(1820*0.1^2)}]$ = 94.79 households = 95 households

Ndanai = $n = [\frac{\mathrm{N}}{(1+Ne^2)}] = [\frac{1459}{(1+(142003*0.1^2)}]$ = 93.58 households = 94 households

Abosi = $[\frac{\mathrm{N}}{(1+Ne^2)}] = [\frac{1143}{(1+(1143*0.1^2)}]$ = 91.95 households = 92 households

2.5 Data Collection Procedures

The study used semi-structured questionnaires containing both closed and open ended questions that were administered to sample households. The questionnaires were divided into two sections: Section A sought information on types of agroforestry practices in the area while section B captured information on the challenges affecting the adoption of the various agroforestry practices. The questionnaires were administered to the respondents who lived within 5 km of the forest edge. To administer the surveys, the researchers first explained to the respondents the purpose of the research before giving out the questionnaires, which were then filled by the respondents and collected.

2.6 Data Analysis and Presentation

The responses from household questionnaires were coded and analyzed by identifying relevant qualitative activities and outcomes. The quantitative data was cleaned, coded and analyzed with the help of SPSS version 21 software and using both descriptive and inferential statistics as described below.

The test for variations in challenges hindering agroforestry development was carried out using Chi-Square test of association. Chi-Square Test of association was used to identify factors that are significantly associated with the various agroforestry practices. The null hypothesis was rejected if the computed P was less than or equal to 0.05.

3. RESULTS AND DISCUSSION

3.1 Results

It was found that inadequate capital and competing land uses are the most notable challenges facing adoption of agroforestry practices among farmers living around Chepalungu Forest. Damages by animals affect home-gardens, riparian planting, wind breaks, scattered trees and shade trees. Destruction by human man was associated with home-gardens and wind breaks (Table 1).

Chi-Square test of association indicated that there was a significant association between types of farm forest practices and potential challenges affecting adoption of farm forest practices (Table 2).

It was also found that seed acquisition had no significant association with any type of agroforestry practice. Tree nursery problems were significantly associated with hedgerawing, scattered trees on farms and woodlot practices (Table 3).

The majority of farmers practicing different types of agroforestry practices in the four locations obtain seedlings from tree nurseries (Fig. 2).

Tree nurseries around Chepalungu forest were found to be small in size (Plate 1) due to unavailability of essential production factors like water supply, quality soils, poor road network, and distance to the planting site. The experience of seed collectors is also low, which means they often collect low quality or incorrect seeds, which leads to low quality seedlings being supplied to farmers.

Managerial Problems: Tree Managerial problems were significantly associated with woodlot and scattered trees onfarms (Table 4). Over 36% of respondents in the four locations were unaware of silvicultural practices like pruning, thinning and pollarding (Fig. 3).

Table 1. Challenges affecting adoption of agroforestry practices in Chepalungu

Types of agroforestry practice	Response (%) on major challenges							
	Damaged by animals	Damaged by man	Seed acquisition	Tree nursery problems	Managerial problem	Inadequate capital	Competing land use	Natural calamities
Home-garden	52.9	5.9	0.0	0.0	0.0	23.5	5.9	11.8
Riparian planting	50	0.0	0.0	0.0	0.0	25.0	25.0	25.0
Wind breaks	0.0	40.0	0.0	0.0	0.0	0.0	21.4	40.0
Hedgerowing	0.0	0.0	0.0	42.9	0.0	28.7	0.0	0.0
Scattered trees	64.3	0.0	0.0	21.4	28.6	7.1	0.0	7.1
Shade trees	66.7	0.0	0.0	0.0	0.0	0.0	33.3	0.0
Boundary planting	0.0	0.0	28.6	0.0	0.0	21.4	28.6	0.0
Woodlot	0.0	0.0	0.0	0.0	87.5	0.0	12.5	0.0

Table 2. Chi-square tests of association

	Value	df	Exact Sig. (2-sided)
Pearson Chi-Square	5.308E2[a]	63	0.000

Table 3. Chi-square tests on individual challenges in Chepalungu

Types of agroforestry practice	Response on Major Challenges							
	Animaldamage	**Mandamage**	**Seed acquisition**	**Nursery**	**Managerial**	**Capital**	**Competing land use**	**Natural calamities**
Home-garden	X^2= 23.54, P<.001	X^2= 18.097 P=.045	X^2= 4.042, P=.050	X^2= 12.762, P=.077	X^2= 45.500, P=.094	X^2= 17.225, P=.002	X^2= 3.752, P=.453	X^2= 24.798, P=.<.001
Riparian Planting	X^2= 41.017, P=.001	X^2=9.007, P=.134	X^2= 5.223, P=.091	X^2= 8.073, P=.067	X^2= .318, P=.980	X^2= 41.017, P=.001	X^2= 17.717, P<.001	X^2= 15.517, P=.037
Wind breaks	X^2= 21.401, P<.001	X^2= 22.500, P<.001	X^2= 1.755, P=.670	X^2= 8.276, P=.292	X^2= 45.500, P=.094	X^2= .947, P=.824	X^2= 17.342, P=.040	X^2= 27.423, P=.020
Hedgerawing	X^2= 6.802 P=..301	X^2= 4.544 P=.395	X^2= 8.229 P=.327	X^2= 45.401, P=<.001	X^2= 6.766, P=.330	X^2= 10.541 P=.001	X^2= .545, P=.946	X^2= 9.171, P=.411
Scattered Trees	X^2= 44.870 P=.031	X^2= 9.155 P=.467	X^2= 1.053 P=.818	X^2= 10.111 P=.011	X^2= 67.300 P=.025	X^2= 16.855, P=.770	X^2= 3.333, P=.102	X^2= 11.001, P=.067
Shade Trees	X^2= 9.870 P=.007	X^2= 1.041 P=.820	X^2= 1.261 P=1.000	X^2= 3.709 P=.308	X^2= 91.500 P=1.000	X^2= .705, P=.970	X^2= 132.900 P=.001	X^2= 8.760, P=.094
Boundary planting	X^2= 2.238 P=.556	X^2= 3.709 P=.900	X^2= 13.350 P=.029	X^2= 4.012 P=.206	X^2= 2.715, P=.096	X^2=26.981 P=.009	X^2= 51.500 P=<.001	X^2= 4.981, P=.100
Woodlot	X^2= 8.602 P=.547	X^2= 1.494E2 P=.390	X^2= 73.018 P=.623	X^2= 3.720 P=.717	X^2= 10.955, P=.360	X^2= 14.900 P=.290	X^2= 12.271 P=<.001	X^2=11.759, P=.075

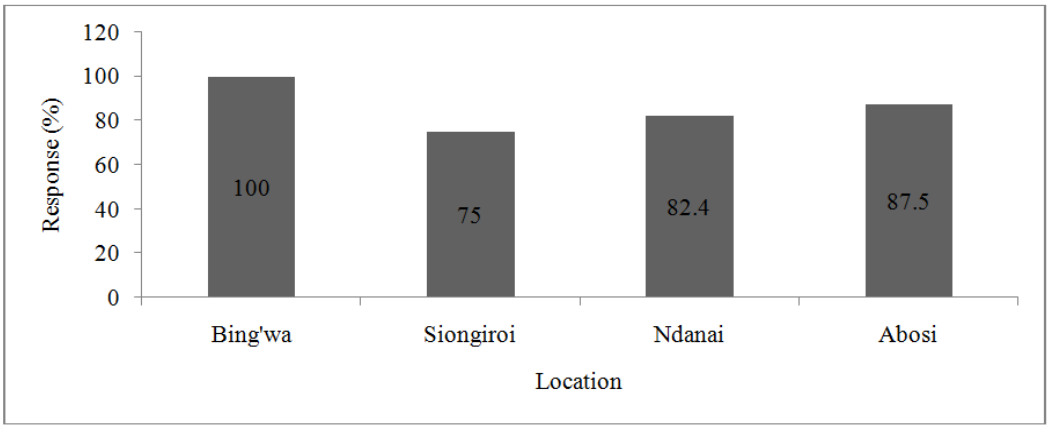

Fig. 2. Respondents obtaining seedlings from tree nurseries

Plate 1. A tree nursery in Bing'wa location in April, 2016

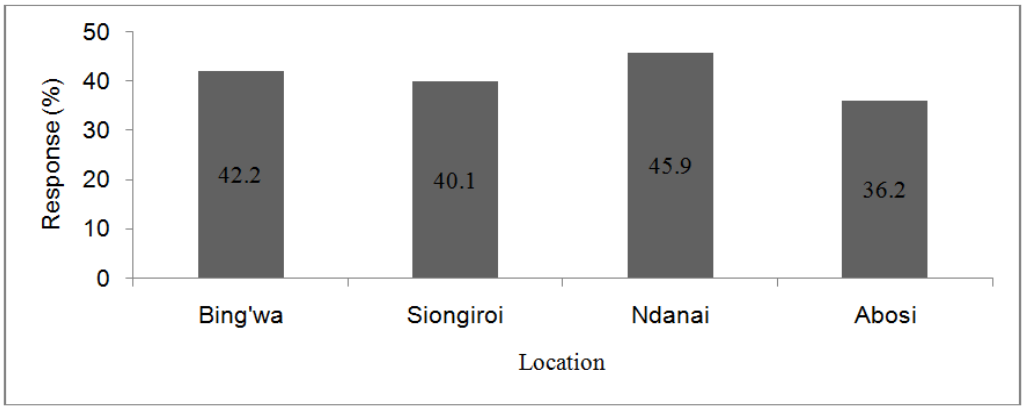

Fig. 3. Unawareness level of silvicultural practices in Chepalungu as at 2016

Inadequate Capital: Inadequate capital was significantly associated with home-garden, riparian Planting, wind breaks, shade trees, and boundary planting.

Competing Land Use: Competing land usewas significantly associated with riparian planting, wind breaks, shade trees, boundary planting, and woodlot practices.

Natural Calamities: Natural calamities were significantly associated with home-garden, riparian planting, and wind breaks.

3.2 Discussion

The most notable challenges facing farmers practicing agroforestry could be categorized into Damages by Animals and Human beings, Seed Acquisition and Tree Nursery Problems, Managerial Problems and Inadequate Capital, Competing Land Use, Natural Calamities.

3.2.1 Damages by animals and human beings

Domestic animals including sheep, goats and cattle destroy farm forest trees by stepping on seedlings or eating shoots. Human beings engage in various activities that ffects the on-farm trees directly and indirectly, either by cutting trees and using mechanical cultivation like tractors or by polluting the soil through the use of chemical fertilizers, herbicides, and insecticides. The results concur with Maynard et al. [20], indicating that some chemical fertilizers make it difficult for micro-organisms in the soil to produce nutrients naturally; hence making soils unsupportive to plant growth. This result also supports the global trend of clearing scattered trees on farms to allow mechanized farming [21].

3.2.2 Seed acquisition and tree nursery problems

Seed acquisition is not a significant challenge because above 82% of farmers obtain planting materials from locally established private nurseries. However, tree nursery face a number of problems due to inadequate water supply, poor road network and inexperienced seed collectors. Such challenges emerge because privately established tree nurseries in Chepalungu Forest neighborhoods are small and often have inadequate capital to ensure production of quality seedlings. According to Nyoka et al. [22], agroforestry in developing countries is held back by the supply of low quality seeds, seedlings, cuttings or propagules, resulting in less fruit, timber and shade quality. [23] adds that inadequate experience among local seed collector in Africa is high, and eventual results is low quality planting materials that lowers the survival rates of trees and effectiveness of agroforestry initiatives.

3.2.3 Managerial problems and inadequate capital

Inadequate managerial knowledge of silvicultural practices like pruning, pollarding, and thinning is a significant challenge facing agroforestry programmes in Chepalungu Forest neighborhood. This is coupled with inadequate capital to undertake adequate land preparation and disease control among other tree management practices. The results support Walters et al. [24], suggesting that the quality of silvicultural practices vary between communities, with some farmers practice better silvicuture than others, due to variations in the understanding of silvicultural practices. Poorly managed on-farm forests affect the quality of products and services, which eventually discourages farmers from engaging in agroforestry [23].

3.2.4 Competing land use

Agroforestry faces significant competition from other profitable land-uses such as cropping. As agroforestry practices like scattered trees on-farm compete with crops for limited resources water and nutrients, farmers prefer cutting trees to maximize their farm yields through farm crops. These findings concur with that of [25] who found that on-farm forestry was reducing in Trans-Nzoia County as farmers preferred maize production that was perceived to be more profitable. Also Mandila et al., Wafuke Nkamleu and Manyong [26,27,28] found that adoption of agroforestry was hampered by preference for other profitable land use activities like crop farming.

3.2.5 Natural calamities

Natural calamities including strong winds and pests like aphids, which attack Cypress trees, dissuaded farmers from planting trees on their farms in the study area. This is because natural calamities destroy established trees, resulting in huge losses. These losses discourage farmers from planting trees on their farm. According to [29], natural disasters including fires, droughts, cyclones & typhoons, and diseases have both direct and indirect impacts on agroforestry. Floods make land unsuitable for vegetation

growth, while diseases and hurricanes destroy trees on-farms.

4. CONCLUSIONS AND RECOMMENDATION

The main challenges affecting the adoption of agroforestry by communities living adjacent to Chepalungu Forest include: Damages by animals and human beings, seed acquisition and tree nursery problems, managerial problems and inadequate capital, competing land use, natural calamities. If these challenges are left unaddressed, they will threaten the conservation and regeneration efforts directed to Chepalungu Forest. This is because such challenges will discourage adoption of agroforestry practices, leading to a situation where the community will entirely depend on Chepalungu Forest. Total dependence on the forest will lead to unsustainable harvesting in the forest that will eventually lead to forest degradation.

The findings of this study suggest that education, capacity building and training is vital to enhancing the success of agroforestry programmes. This is because some of the challenges like competing and use, managerial problems and inadequate capital can be curbed through education, capacity building and training on the proper arrangement of trees on farm and using the cheapest practices available The study therefore recommends that forest extension officers should educate private tree nursery owners on the best nursery practice, while the Bomet county government should improve the road network into the rural areas to enhance ease of movement these officers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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