Factors Influencing Households Participation in Agroforestry Practices and on Farm Tree growing and Management in Rajaf County, South Sudan

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ABSTRACT

The purpose of the study was to assess the socio-economic and demographic factors that influence farmers' decisions to participate in tree planting and their management. The study covered four broad sites of Gumbo, Kolye East, Kolye West, and Tokiman of Rajaf County 332 household respondents were randomly surveyed for interviews and their assessed socio-economic data were subjected for descriptive statistics in frequencies, percentages and inferential statistics to determine their level of adoption and significance. The results showed most households were female respondents (54.5%) and over 75.6% of respondents were married with most of them being illiterate (over 79%). Subsistence farming was their main economic activity (80.7%) and source of incomes (80.1%) respectively. These rural farmers (58.13%) owned small parcel of farmlands (2 ha) per family with over 70% of them still using system of inheritance from their forefathers. The average family size was 1-4 members (86.1%).The Chi-square tests and regression analysis indicated household incomes (p=0.00) and labour requirements (p=0.05) had a significantly positive influence on farmers' decisions to grow trees on farms. Therefore, such socio-economic factors are significantly important when studying farmers' behavior especially for their decisions in tree-related activities on farms. Socio-economic factors of farmers play a vital role in influencing their participation and decisions in on-farm tree planting and management in agroforestry practices. Their interest was mainly influenced by sources of food, agroforestry inputs, labour requirements, cooking energy and need for shade other than environmental advantages such as carbon sequestration and conservational aspects. Thus, findings of this study can contribute to wider understanding of farmers' decisions to participate, improve and accept agroforestry programmes for implementing future tree planting and management activities for diverse agroforestry communities.

Keywords: Agroforestry, Socio-economic factors, Logistic regression, Trees/Shrubs, Rajaf County

INTRODUCTION

Generally, when practising tree-based agroforestry systems and management, farmers' socio-economic and demographic factors are considered. These are farmers' experiences and realities that relate to his/her personalities, attitudes, and lifestyle. Numerous studies have focused on socio-economic factors influencing agroforestry practices especially tree growing and management (Mutonyi and Fungo 2011; Baffoe-Asare *et al.*, 2013).

These socio-economic factors have been grouped into agro-based and household demographic characteristics. The needs and values of the farmers can play crucial role in on farm tree growing and management of agroforestry innovations. A report by Ros-Tonen *et al.* (2010) stated that consumptive and non-consumptive products influenced farmer's willingness and preference to grow trees on- farms. It becomes a common socio-economic characteristic influencing farmers' decision to adopt agroforestry practices.

Understanding socio-economic and biophysical dynamics of agro-based characteristics among smallholder farmers can untangle key factors influencing decision making process in households (Matata *et al*., 2010; Baffoe-Asare *et al*., 2013). Most commonly discussed socio-economic factors influencing tree growing and management systems include farmers' gender participation, level of education, farmers'

age, total household size, farmers' income, ethnicity, and occupational status. These are considered farmers demographic characteristics. Other characteristics are agro-based which help the farmer to decide whether or not to plant and manage trees on their farms, and to adopt agroforestry practices. These characteristics range from but not limited to land ownership type, farm size, soil properties, topographical gradients, years of farmers' farming experience, access to extension services and distance to agroforestry farmlands. According to Baffoe-Asare *et al.* (2013), the attributes leading to change due to socio-economics among other factors have the potential to influence farmers' decision on tree-based agroforestry practices and management. On one hand, for instance, Danquah *et al*. (2013) proposed that younger households are more likely to grow and manage trees on farms as influenced by their socio-economic factors and small holder farmers' decision to adopt agroforestry practices. On the other hand, farmers with high level of education and incomes are more likely to involve in tree planting activities on farms. These factors are very important in determining the level of tree planting activities on farms by farmers. However, in South Sudan, particularly in Rajaf County, many agroforestry practices still exist as traditional farming systems which have not been evaluated scientifically.

The notion of cultural conservativeness and rigidity among the communities have adverse effects on the farmers behaviours to adopt to on-farm tree planting activities.Although incorporation of trees and shrubs in food crop systems can help address food insecurity issues and reduce vulnerability of agricultural systems (FAO, 2010), there exists several questions as to whether households with varying farming resources and capacity would choose to cultivate or retain specific tree species for a particular purpose. In this consent, socio-economic development of the rural farmers and their related factors among others need to be considered. This is so because their knowledge and influence to accept or deny to grow trees on farms play a key role in their adoption of the type of agroforestry practices.

Therefore, the main aim of the study was to assess and understand farmers' socio-economic and demographic factors that influence their decisions to participate in tree planting and agroforestry activities and its management on farms.This is very necessary especially when formulating future policies and strategies used for determining farmers socio-economic factors for adoption of agroforestry practices that enhances diversity of trees on farms.

MATERIALS AND METHODS

The study location

The study was conducted in the four sites within Rajaf County of Central Equatoria State in South Sudan. The County is located along the eastern and western banks of River Nile, southeast direction from Juba city between latitudes 4° and 6°N and longitudes 27° and 32° E (Figure 1). It covers a total area of 3,204 km^2 and hosts a total population of about 15,604 people (Sudan Population & Housing Census, 2008).

Vegetation and climate

The area is covered by open woodland and grasslands in the rich moist and tropical and highland ranges. The main tree and shrub species include *Mahogany spp, Acacia seyal, Acacia mellifera, Balanties aegyptiaca, Acacia senegal, Hyphaen ethebaica, Borassus aethiopum, Mangifera indica, Tarmarindus indica, and Azadiractha indica (*Suleiman, 2007).

Temperatures in the area ranges between 30^{o}C to 33^{o}C in the dry season and, drops to an average of 18^{o}C in the wet season (Donat *et al.,* 2014). Rainfall intensity is more than 1200mm per annum that lasts from April to November. Its proximity to Nile River makes it accustomed to seasonal flooding and increased evaporation. Humidity usually exceeds 80% during the rainy season, and drops to below 50% in the dry season (Alrajoula *et al.*, 2016).

Topography and geology/soils

The topographical feature of the area placed the County as an integral part of the hills and mountains agro-ecological zone (Figure 1). The area is characterized by an alluvial geological formation consisting of vetric soils, which are interspersed by alfisols that vary along the lateral range of geological sites (Wel, 2012). Alkaline soil is generally known to be low in organic matter content, high salinity and the clay content ranges below 15 to 40 %.The soil is composed of brownish clay-loams. This soil has combined characteristics of green belt and hills and mountains agro-ecological zones of South Sudan (Williams *et al.*, 2015).

Figure 1. Location of Rajaf County, South Sudan

Population and economic activities

Rajaf County hosts a total population of 15,604 people in the proportion of 8,232 males and 7,372 females irrespective of age class (Sudan Population & Housing Census, 2008). The inhabitants of Rajaf County are predominantly Bari constituting approximately 90% of the population according to 2008 census. The main economic activity of the communities is farming although some activities, such as rearing of animals and fishing, and hunting are also carried out on a small scale. The County has become a very important site for fishing in Central Equatoria State due to its proximity to the shores of River Nile. Even then, its fertile soils potential makes it favorable for agriculture and growth of agroforestry species and natural forest stands (Shilabu, 2008; Mbwiga, 2016). The main food crops grown are sorghum, cassava, maize, groundnuts, sesame, beans and sweet potatoes. Green vegetables are sparingly grown for cash while goats, sheep, pigs, chicken, guinea fowl and cattle are their main domestic animals kept by many households.

Research design, sample size and sampling procedures

This study was a descriptive households' survey and it involved interviews with household heads, farmers groups and individual farmers in the study area. Key informants' interviews (KIIs) and Focused Group Discussions (FGDs) were held with the communities and direct field observations were also undertaken (Shilabu, 2008).

Four payams (sites) of Rajaf County were purposefully selected for the study. From each selected site, three Bomas (villages) were surveyed and 25 households from each Boma were selected randomly and

interviewed. A list of households for each Boma that was retrieved from payam registry was used for random selection of Bomas and their respective households (Shilabu, 2008). At least 74 household respondents from each Payam were interviewed. A total of 332 household respondents were randomly selected from the four Payams. That is 5 % of the total of 6632 households found in the Payam registry (Humphreys & Ahern, 2017). Twenty checklists were administered to key informants who were purposefully selected from relevant government institutions, community leaders, local agroforestry initiatives, extension workers, community-based organizations and NGOs to provide specific information that is relevant to the study (Ayinde, 2004). Members of the Focused Group Discussions were categorized into two distinct groups, men and women of varied age category and formed according to Wel (2012) (Plate 1).This was done with consultation and approval of concerned Payam administrations and local leaders.

Data collection

Prior to data collection, a reconnaissance survey was conducted to give the overall baseline information of the area. This was followed by pre-testing of few field sample questionnaires in order to evaluate its strength or weakness, for clarity checks and to improve its reliability. Where necessary adjustments on the questionnaires would be done and incorporated (Shilabu, 2008).

The household survey focused on household/farmers' socio-economic and demographic information including age, sex, marital status, level of education, occupation, land tenure systems, ways of land acquisition, number of meals, family size, farm size (Shilabu, 2008; Obiri *et al.*, 2011).

Plate 1. Focused Group Discussion held at Kolye West (L) and Gumbo (R)

Household head or any of the willing representatives present was interviewed. For easy understanding of questions and filling of the questionnaires accurately, and to avoid misinterpretation of questions, direct translation other than audio transcription was done for all interviews. The interviews were conducted in local language (Bari) including pidgin Arabic and final responses were translated and then recorded in English (Wel, 2012).

Data analysis

After cleaning of the household raw data, it was entered, managed and coded in excel spreadsheet and later exported to statistical soft wares of Minitab version14 or SPSS version 23 for analysis (Bryman and

Cramer, 2009). Initially, frequencies and percentages from descriptive statistics were examined for each variable to check for entry errors. Corrections were then made upon verification with entries in the household and key informant interview questionnaires. In some cases, data were plotted for verification purposes and preliminary analyses were done in descriptive statistics that included comparing their frequencies and/or percentages (Kabwe *et al*., 2009).

Thereafter, primary categorical data were analysed in inferential statistics including cross tabulation (Chi-Square) test of independence and some analysed using logistic regression to determine the level of significance (Bryman and Cramer, 2009). This was to compare and explain the relationships of various socio-economic and biophysical factors with trailing agroforestry and its performances including demographic factors such as respondents' age, gender, education level, marital status, farm sizes, occupation, land tenure, mode of acquiring land, family size, number of household meals, income levels, and off-farm activity levels (Kabwe *et al*., 2009).

RESULTS

Socio-demographic characteristics of the household respondents

The female households' respondents (54.5%) were more than male households' respondents (45.5%) and 75.6% of them were married (Table 1). Most of the respondents, 49.1%, had primary level of education. Those with no formal education, secondary level and had diploma/degrees were 30.7%, 16% and 3.0% respectively. Nearly all interviewed respondents (80.7%) worked in their farms as subsistence farmers. Despite 80.1% of the respondents having farming as their main source of income, only 17.1% of them were involved in small scale commercial businesses to supplement their farm incomes and off-farm employment (Table 1).

Majority of the respondents, 58.1% owned small parcels of farm land 2ha or less per family. Only 10.5%had large parcels of farmland between 5-10 hectares (Table 1). Over 70% of the respondents acquired farmland through inheritance. Some of them, 24.7% leased land and 5.4% privately purchased land. Those who farmed on communal land were 41% and only 8% acquired land privately as freehold land (Table 1).

Most households comprising 49.7% had 4 members and an overall 86.1% having family size between 1-4 members. Only 1.2% households constituted families with 7 members. The majority of the household respondents (93.7%) reported that they ate either once (47.0%) or twice a day (46.7%). Only a few sections of the households (6.4%) ate three times a day (Table 1).

Chi-square tests indicated that household incomes significantly ($p=0.00$) influenced farmers participation in tree growing and agroforestry management practices (Table 2). Although most factors showed statistically non-significant values, number of household meals indicated somewhat positive influence ($p=0.07$) on farmers' decisions to grow trees and agroforestry management practices (Table 2).

Socio-economic factors influencing farmers to participate in agroforestry

The Socio-economic factors influencing households' decision to participate in practising agroforestry activities included source of food, inadequate AF inputs, labour requirements, cooking energy, inadequate AF equipment, and shade as indicated in Table 3.

Logistic regression analysis (Table 4) revealed that, labour requirements had a significantly positive ($p=0.05$) influence on farmers' decision to participate in agroforestry. All the other factors influencing farmers decisions on AF practices are non- significantly related, although they are positively associated (Table 4).

Household participation in planting and management of agroforestry components

In this study, participation of household members in agroforestry planting and management practices were categorized as follows: trees planting, was the sole responsibility of men (92.1%) although there is

Table 1. Socio- demographic characteristics of the household respondents (N=332)

Description	Parameter	Frequency (N)	Percentages (%)
Name of Payam	Kolye East	86	26.0
	Kolye West	86	26.0
	Gumbo	86	26.0
	Tokiman	74	22.0
Sex	Female	181	54.5
	Male	151	45.5
Age	16-25	92	27.7
	26-35	122	36.8
	36-45	84	25.3
	46 & >	34	10.2
Marital Status	Married	251	75.6
	Single	56	16.9
	Separated	11	05.4
	Widowed	06	01.8
	Divorced	01	00.3
Educational Background	Primary	163	49.1
	No formal education	102	30.7
	Secondary	53	16.0
	Higher education	10	03.0
	Vocational education	04	01.2
HH Farm size (ha)	≤2 ha	193	58.1
	3-4 ha	103	31.0
	5-6 ha	24	07.2
	7-8 ha	04	01.2
	9-10 ha	06	01.8
	>10 ha	02	00.6
Income sources	Farming activities	266	80.1
	Business (Trading)	19	05.7
	Brewing local alcohol	14	04.2
	Charcoal burning	10	03.0
	Collect firewood	09	02.7
	Salary	07	02.1
	Fishing	05	01.5
	Hunting	02	00.6
Occupation	Farmer	268	80.7
	Fisherman	08	02.4
	Teacher	04	01.2
	Builder	05	01.5
	Policeman	06	01.8
	Businessman (Traders)	19	05.7
	Student	16	04.8
	Employee (Others)	06	01.8
Family size	1	30	09.0
	2	38	11.4
	3	53	16.0
	4	165	49.7
	5	24	07.2
	6	18	05.4
	7	04	01.2
Types of land tenure	Community land	136	41.0
	Customary	106	31.9
	Leasehold	62	18.7
	Freehold	28	08.4
Mode of land acquisition	Inherited	232	69.9
	Leased it	82	24.7
	Bought it	18	05.4
Number of meals per day	1	155	47.0
	2	154	46.7
	3	21	06.4

Table 2. Chi-square tests of socio-demographic characteristics influencing AF practices

Characteristics	Chi-square (X^2)	Df.	P-value (Significance)	% Expected counts
Sex category	3.011[a]	5	0.70	16.7
Age category	18.718[a]	15	0.23	37.5
Marital status	15.759[a]	20	0.73	70.0
Level of Education	23.212[a]	20	0.28	56.7
Farm size	41.315[a]	80	1.00	81.4
Incomes levels	62.365[a]	35	0.00*	83.3
Occupational category	36.276[a]	35	0.41	85.4
Land tenure	18.135[a]	15	0.26	37.5
Mode of land acquisition	10.395[a]	10	0.41	44.4
No. of HH meals/day	17.434[a]	10	0.07	38.9

* Significant at 0.05, df = degree of freedom

Table 3: Socio-economic factors influencing HH decision to practice in AF activities (N=332)

Socio-economic factors	Frequency (N)	% Cases
Food needs	271	81.6
Inadequate AF inputs	262	78.9
Labour requirements	204	61.4
Cooking Energy	196	59.0
Inadequate equipments	188	56.6
Shade	165	49.7
Soil & water conservation	126	38.0

Table 4. Logistic regression of socio-economic characteristics influencing agroforestry (N=332)

Effect	Likelihood Ratio Tests		
	Chi-Square	df	Sig.
Intercept	0.00	00	.
Cooking energy	3.63	05	0.60
Food needs	9.39	10	0.50
Shade	5.62	10	0.85
Soil	7.70	05	0.17
AF Equipments	3.56	10	0.97
Labour	11.30	05	0.05*
AF inputs	7.72	05	0.17

* Significant at 0.05; Chi-Square=54.35; df=55.
Where, df = degree of freedom, Sig= level of significance

a joint participation (73.8%), agricultural crops were mainly planted and managed by women (84.5%) and children (56.2%) whereas, animal production are majorly managed by children and men as reported by 95.5% and 56.8% of the respondents (Table 5).

Household decision making in harvesting and/ or sales of agroforestry components

Harvesting and sale of tree crops is influenced by decisions of men and children 84.2% and 66.5% respectively (Table 6). Decision to harvest and sell agricultural crops on farms was usually done by almost

every household member that included husband, wife, children and joint efforts of family members reported by 63.4%, 60.1%, 57.7% and 87.3% of the respondents respectively (Table 6). Whereas, livestock sales is the sole responsibility of husbands and children (Table 6).

Table 5. Participation in planting and management of agroforestry components (N=332)

Household member	Tree		Crop		Animal	
	(N)	(%)	(%)	(N)	(%)	(N)
Husband	292	92.1	135	41.9	138	56.8
Wife	97	30.6	272	84.5	43	17.7
Children	65	20.5	181	56.2	232	95.5
All family members (jointly)	234	73.8	206	64.0	87	35.8

Table 6. Categories of people participating and in harvesting and sales of agroforestry components (N=332)

Household member	Tree		Crop		Animal	
	(N)	(%)	(%)	(N)	(%)	(N)
Husband	271	84.2	199	60.1	208	69.6
Wife	56	17.4	210	63.4	51	17.1
Children	214	66.5	191	57.7	223	74.6
All family members (jointly)	104	32.3	289	87.3	28	9.4

DISCUSSION

The fact that not many factors tested were found to be significantly associated with AF management decision, it might be that influencing farmers' decision to practise agroforestry was essential to ensuring higher adoption. Although many socio-economic factors were found to not have statistically significant levels in predicting farmer's decisions to grow and manage trees on farms. The study has categorically shown that factors such as gender, age, marital status, education levels, farm sizes, land tenure types, ways of land acquisition, and number of meals influence farmer's decisions to grow and manage trees in agroforestry practices differently.

According to Danquah *et al. (*2013), these factors have long been examined as potential determinants of every landowner's propensity to tree growing and agroforestry management decisions. Thus, the socio-demographic characteristics of the respondents are discussed.

Sex and marital status of the respondents

Since most households are female-respondents (Table 1), it becomes clearer that all the decisions taken within households are vested on women. The high population of women is a result of the conflict that erupted in 2013 and 2016 which made many women to lose their husbands and they were left widows. Polygamous families are also common in South Sudan that live as nuclear families and not as extended families (Wel, 2012). In addition, as many household respondents interviewed were married women, this gender imbalance showed that a proportion of them were divorced, separated or widowed by the conflicts.

The findings from this study also indicated there is a relative involvement of both sexes in agroforestry activities. This could be due to AF practices increasingly becoming a landscape for widows in most communities in South Sudan (IPS, 2011). This further showed that since women lack sufficient additional farm labour, farm credits, land and tree tenure rights in other cultural societies, AF have become less

productive since agroforestry practices are labour intensive technologies that require supplementary labour from men.

In any case, when a family lacks male labour force for intensive AF practices especially during the peak periods of planting and harvesting, there would be low AF production outputs (Wel, 2012). As such FAO (2010) argues that women in South Sudan lack access to productive resources such as access to land ownership due to customary laws that favour men in patriarchal societies. Therefore, women in Rejaf work in their farms without the help and support of men. This may lead to low farm outputs and hence render most families to become food insecure.

Educational levels of the respondents

Given that 79.8% of household respondents are illiterate (Table 1), therefore, the farmers in the area rely mostly on knowledge passed to them by their forefathers in managing agroforestry systems and practices. Since development of successful farming systems is a prerequisite for practicing either conventional agriculture or agroforestry activities, indigenous knowledge becomes a necessity in a society with no improved AF systems and technologies (Oni, 2015). Formal educational levels have also been assumed by many authors to directly correlate with the adoption decisions and willingness of farmers to plant agroforestry trees or to involve in agroforestry activities. However, evidence from this study has shown little relationships as majority of the population is illiterate or have little formal education. Ignorance and lack of awareness on agroforestry activities therefore, does not increase the likelihood of individuals to plant and manage trees in agroforestry systems at large scale (Oni, 2015).

The findings also indicated that most farmers lack knowledge in agroforestry activities that greatly influences their participation in AF practices. The fact that lack of knowledge limits tree growing and management efforts of agroforestry farmers is fully supported by Lambert and Ozioma (2011). Extension methods and ways of giving knowledge could also play an important role in disseminating reliable information and knowledge on adoption of AF systems and practices (Chija, 2013; Kabiru *et al.,* 2018).

However, it appears in some cases, that extension staff or agents had poorly briefed local farmers on the technical aspects of AF practices such as alley cropping and boundary planting. This has resulted in inadequate and misleading technical advice to local farmers especially in important matters like species selections, soil analysis and management of AF tree species such as weeding, hedgerow pruning regimes, pollarding and thinning (Mishra & Mishra, 2017).

In order to be conversant with technical issues, it would be wise and appropriate for extension workers or staff to understand the socio-economic aspects that are likely to influence local participation in tree growing and management of AF practices as well as experience in participatory works. The local farmers only have valuable knowledge about the land and its uses, local tree species available, environment and the economics behind them as they apply in their farms (Arnold and Dewees, 2014).

It is also nonetheless clear that due to the love for highly and continuously paid jobs accessible in urban areas, the few learned indigenous people of Rajaf County, who could be change agents of agroforestry activities had tended to leave villages for town in search of white-collar jobs. This has therefore, probed many problems in agroforestry sector in relation to adoption of improved systems /practices of agroforestry as it needs specific application of knowledge and skills. This statistical information on education is essential and significant as it influences the level of uptake of a new agroforestry practice, systems and/ or technology (Oli *et al.*, 2015; Bani and Damnyag, 2017).

With all other socio-economic factors kept constant, people with formally high educational qualifications are more likely to grow and manage trees on farms and other agroforestry practices than the uneducated ones, although education levels of this study showed statistically non-significant values. These results are also in line with Oli *et al.*, (2015) findings. Therefore, researchers need to embark on awareness and work in close collaboration with the immediate land users so that promising tree species and AF systems are easily identified and the available knowledge of the local people about their economy and local environment is comprehended (Kabiru *et al.*, 2018).

Occupational and age category of respondents

The main occupation of nearly all interviewed HHs is subsistence farming (Table 1). This might be attributed to lack of credit and poor transport facilities for starting businesses in other products. The predominance of subsistence farmers in Africa was also reported by Sunam and Goutam (2015) who found that70-80% of the population in developing countries were mainly subsistence peasant farmers. It is because of these farming systems that there is likelihood of farmers' inspiration and motivation to incorporate, or retain and manage trees in their farms for diversity of AF components.

The finding also compares agreeably with Dzorka (2016), who reiterated that in subsistence farming system, continuous production of food to satisfy household demands for daily livelihoods is a must. He further discussed that other factors such as alternation of farming seasons (dry and rainy seasons) and the intensity of rainfall (superficially acceptable or unacceptable) also influence peasant farming (Sunam and Goutam (2015).

The age category of respondents in the area (Table 1) showed that youth dominate the population in the area as compared to the aged. This statistics on age further indicated that tree growing and management activities in agroforestry systems are more likely to be adopted by younger farmers who may view long term future returns from investments in trees as benefits. This would also encourage more farmers to accept and adopt modern agroforestry practices in future because in context, people of age range between 18-35 years are considered more productive in relation to labour intensive agroforestry technologies. Reversibly, this results also implies that, although this youthful age category seemed sufficient enough, their participation in agroforestry activities would be limited by low family size available in households (Table 1). This result agrees with that of Kiptot and Franzel (2012) who also reported that age category determined the productivity in economies, labour supply and participation in agroforestry practices as most households use local family labour.

Socio-Economic Factors Influencing Farmers' Participation in Agroforestry Activities:

The following factors influence participation in AF activities:

On-farm and off-farm incomes sources of the respondents

Apparently, as large proportion of households worked on farms and sold the farm produce for cash, farming became their main source of income (Table 1).

The level of incomes was found to be statistically significant (p=0.10) in influencing farmers' participation in agroforestry activities (Table 2). However, despite participating in AF farming, some HHs are involved in some forms of commercial businesses to supplement their farm incomes with off-farm employments such as trading, brewing local alcohol, charcoal burning, collect firewood, and fishing (Table 1). These sources of income also depended on the occupational category of the HH respondents. Henceforth, serving as their main indicator of livelihoods and welfare status. The results are in conformity with the findings of Maruod *et al.* (2014) and Fadl *et al.* (2015) who also stated that AF constitutes major source of income for over 80% of the population in the Sudan.

Households' farm sizes and land availability

Majority of the respondents were small holder farmers who practised small-scale subsistence farming in their small farms of sizes approximately 2 ha per family (Table 1). The small farm size might be due to problems of land tenure, lack of land rights, high population density and customary land laws. Although farm size is negatively associated with agroforestry adoption (p=1.000), it had no statistically significant influence on adoption decisions on agroforestry practices (Table 2).

In most developing nations as evident from this study, majority of farmers cultivate small-sized farms. Consequently, farmers' immediate priority in these countries is to devote all of their small portion of land

for food production to meet their subsistence needs (Glover *et al.,* 2013). In contrast to the current findings, elsewhere in Nigeria, similar studies by Oni (2015) found that farm sizes positively influenced farmer's decisions to plant and manage trees in most agroforestry practices but without statistically significant influence in predicting the adoption decisions.

Although some of those households in Rajaf County had sufficiently large landholdings to convert some of it for tree planting, the farmers may be limited in their decisions for integrating trees on farms, partly due to insufficient labour, coupled with limited access to agroforestry information, land tenure and general lack of resources (Matata *et al.*, 2010).

Generally, in South Sudan, the government legislation considers land as a property of both the state and community. Yet none of the payams surveyed had "title deeds" but rather had only customary rights of occupancy from their ancestors or forefathers as individual user, clan or community land through family lineage known as inheritance. A similar study on land tenure documented by Ayamga *et al. (*2016) supports this finding. It is because of these that most households depend on the small viable plots of farmland to produce food for their household daily livelihoods.

Land tenure and modes of land acquisition

Land tenure and its security has long been a driver to tree planting and management decisions in long term maintenance and practice of agroforestry activities. Furthermore, empirical evidences from tropical countries consistently indicate that secure land tenure has influence over adoption decisions (Arbuckle *et al.,* 2009). In Rajaf County, most of the land is under traditional customary land system and therefore, cultivation rights are mainly inherited rather than owned. This inheritance linage showed that most farmers would lack sufficient farmlands for tree cultivation (Table 1) due to the long-term returns/benefits expected from investment in tree related projects.

Leasehold tenure was attributed to the high demand for more farmland to increase productivity. This may be prompted by the high population increase caused by the massive movement of internally-displaced persons (IDPs) into the area due to wars and tribal conflicts (Wel, 2012). Immigrants and IDPs do not possess land rights in the new areas of settlement. The need for surplus food and high incomes by farmers to support their households made farmers buy or lease land parcels. However, the continued aspect of land inheritance in the area seems unworthy to accommodate large scale tree and AF production because farmers lack proper land titles as securities and cannot apply for loans.

In other villages, cultivation rights are inherited rather than ownership, thus, long term investment such as tree planting programmes on farm lands must be in consultation with respective families or clans before acquisition. It therefore, became obvious that farmers with secured rights to land are more likely to participate in on-farm tree planting activities than those farmers who inherited or without secured land rights (Adane, 2016).

Although the land tenure system adopted by Rajaf people is still governed by customary ownerships and some under lease agreements (Table 1), these tenure systems (communal, customary and leasehold) do not offer security for continued ownership and control. This would affect future adoption of long-term agroforestry production strategies and investments since some agroforestry components take long gestation period to mature.

The current findings also reveal that it is necessary to harmonize land tenure systems as was suggested by the communities. Since most HH farmers in Rajaf County lack rights to land ownerships, it has made them dislike adopting new agroforestry technologies. As farmers' rights to land ownerships and property rights are missing, better land use management, tree planting activities and natural resources management become limiting to most households (Parwada *et al*., 2010; Place *et al*., 2012).

In this case, farmers should be encouraged to obtain land titles to act as securities and incentives while investing in activities such as tree growing and agroforestry practices. Therefore, acquisition of land should be through various land regulation systems resulting in different land ownerships (Fadl *et al.,* 2015).

Household size, labour requirements and frequency of meals

In this study, most households had four family members and so household labour required for intensive agroforestry activities is anticipated to be low within those households. This further discourages farmers to get involved in tree growing and management of agroforestry practices as low labour leads to low farm outputs (Table 4). As majority of farmers lack awareness and access to information through extension services, adoption decisions to agroforestry practices become limited (Sanou *et al*., 2017). With limited number of family members to provide labour for intensive tree growing and agroforestry management activities, coupled with inadequate extension services and limited access to agroforestry information as stated by Kabiru *et al.*, (2018), many people tend to forego agroforestry for other practices such as crop and animal production. It was further anticipated that the larger the family size, the more labour is available not only for agricultural productivity but also for non-agricultural activities such as agroforestry and the reverse is true according to Zeweld *et al*. (2017). Kiptot and Franzel (2012) also reported similar findings that to measure productivity in economies with low labour availability, average family size and length of stay determine the labour supply and participation in agroforestry practices as most households use local family labour. Chija (2013) also found that when farmers have access to extension services such as trainings and awareness, these become their most critical motivating factors to participate in tree growing and management of agroforestry practices.

Over 50% of the household respondents agreed that harvest from agroforestry farms were not enough to sustain their household needs. Because of this, they had to sell some of their farm produce to buy missing HH foods, work for others, use salaries, go fishing, and cultivate various crops or rear animals as viable compensation options. The insufficiency in production also affected the number of meals per day; each family ate only once or twice a day (Table 1). The few meals per day is an indication of inadequate resources, poor market performance, low level of employment, low incomes earnings, large family sizes and excessive expenditures due to many family responsibilities.

It was found that the number of meals eaten per day per family was positively associated with AF practices even though its effects in predicting farmers decision to participate in tree planting and agroforestry management activities was statistically insignificant (Table 2). The area is advantageously situated along the river Nile for the local people to continuously cultivate the major food crops including green vegetables, even in the drier seasons under irregation. Since fishing being a supplementary activity, it was accessed only by few household farmers for being important in their diet and nutrition. The current findings agree with Wel (2012) who argued that inclusion of vegetables in diets improve household's food security and nutrition.

Household participation and decision making in tree planting and harvesting of agroforestry components

Tree planting program or AF activity had long been an initiative of men in most traditional African societies including people living in Rejaf County (Table 5). However, most households of Rajaf communities have joint family members' participation in tree planting activities although children generally do light farm work. Traditional beliefs and cultures of many African societies including that of the Bari people assign planting trees and rearing animals as men's responsibility (Table 5). Women as housewives are confined to routine tasks such as food production, tending of crops, harvest, and sale of crops, fetching firewood, and other domestic chores such as cooking, keeping children and attending to visitors (Kiptot and Franzel, 2011).

The household's decision to participate in tree planting and harvesting AF products is attributed to the need to diversify farm outputs having multiple functions for continuously generating family income, food and cooking energy(Table 3). This finding corroborates with Zeleke (2009) and Chija (2013), who reported that agroforestry practices hold more components resulting in diversified alternative sources (i.e. there is always a secured next component in case of failure of one component).

The study has determined the factors influencing farmers' decision to adopt tree planting initiatives and agroforestry practices in their farms in Rejaf County of Central Equatoria State. These factors categorized into socio-economic factors provided opportunity for farmers to express their willingness to plant trees on farms and draw their interest over adoption decision to participate in various agroforestry practices. Although most explanatory variables on farmers' participation and adoption decisions for tree planting and agroforestry activities were not supported by the estimated model, labour, incomes and number of meals. They were only found to provide statistically significant values. This study offers analysis into socio-economic factors of smallholder farmers influencing their household's adoption decisions that should be given much attention in order for them to accept and get involved in on-farm tree component integration (agroforestry practices) programmes. This further shows that before planning and starting any agroforestry activity campaigns and awareness, careful considerations of the farmers' socio-demographic/economic and biophysical characteristics should be considered. In addition, the choice, preference and acceptance of farmers to continuously participate in trees/shrubs planting on farms would play a vital role as they are influenced by potential profits, food needs, and availability of agroforestry inputs, labour requirements and number of meals. Such information is useful for guiding reforestation / aforestation programmes for rehabilitation and restoration of degraded agricultural lands; and future formulation of policies for farmers' adoption of on-farm tree growing and agroforestry technologies.

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REFERENCES

Adane, S. A. (2016). *Barriers to smallholder plantation development in off-reserve forest areas in Ghana: A case study in three selected forest district*. Doctoral Degree Dissertation, Faculty of Renewable Natural Resources, Kwame Nkrumah University of Science and Technology, Ghana.

Alrajoula, M. T., Al Zayed, I. S., Elagib, N. A. and Hamdi, M. R. (2016). Hydrological, socio-economic and reservoir alterations of ErRoseires Dam in Sudan. *Science of the Total Environment*, **566:** 938-948.

Arbuckle, J. G., Valdivia, C., Raedeke, A., Green, J. and Rikoon, J. S. (2009). Non-operator landowner interest in agroforestry practices in two Missouri watersheds. *Agroforestry Systems*, **75(**1), 73-82.

Arnold, J. M. and Dewees, P. A. (2014). *Farm Trees and farmers: Responses to agricultural intensification*. Routledge.

Ayamga, M., Yeboah, R. W. N. and Ayambila, S. N. (2016). An analysis of household farm investment decisions under varying land tenure arrangements in Ghana. *Journal of Agriculture and Rural Development in the Tropics and Subtropics (JARTS)*, **117**(1): 21-34.

Ayinde, I. A. (2004). Socio-economic and Health Effects of Pesticide Use in Cowpea-based Production Systems in Kano and Ogun States, Nigeria. *Draft PhD Dissertation*.

Baffoe-Asare, R., Danquah, J. A. and Annor-Frempong, F. (2013). Socioeconomic factors influencing adoption of CODAPEC and cocoa high-tech technologies among small holder farmers in Central Region of Ghana. *Journal of Experimental Agriculture International*: 277-292.

Bani, B. K. and Damnyag, L. (2017). Farmers' Willingness to Pay for the Provision of Ecosystem Services to Enhance Agricultural Production in Sene East District, Ghana. *Small-scale Forestry*, **16**(4): 451-467.

Bryman, A. and Cramer, D. (2009). *Quantitative data analysis with SPSS 14, 15 and 16: A guide for social scientists*. Routledge.

Chija, M. N. (2013). *Adoption status and management of agroforestry systems and technologies by communities: a case study of Kasulu district, Kigoma, Tanzania*. Doctoral Degree Dissertation, Sokoine University of Agriculture, Tanzania.

Danquah, J. A., Kuwornu, J. K. and Pappinen, A. (2013). Analyses of socioeconomic factors influencing on-farm conservation of remnant forest tree species: evidence from Ghana. *Journal of Economics and Behavioral Studies*, *5*(9): 588.

Donat, M. G., Peterson, T. C., Brunet, M., King, A. D., Almazroui, M., Kolli, R. K. and Nada, T. A. A. (2014). Changes in extreme temperature and precipitation in the Arab region: long-term trends and variability related to ENSO and NAO. *International Journal of Climatology*, **34**(3): 581-592.

Dzorka, G. (2016). *Food Self-Sufficiency and Partnership in Agricultural Production in Ghana: A case study of the Fievie Rice Project*. Master's Degree Thesis, the University of Bergen.

Fadl, K. E. M., Mahmoud, S. E. and Hamad, Z. M. (2015). Farmers' perceptions towards agroforestry systems in North and South Kordofanstates, Sudan. *International Journal of Environment*, **4**(2): 53-67.

FAO (2010). The State of Food Security in the World: Addressing food insecurity in protracted crises. Accessed March 20, 2011 at: (http://www.fao.org/publications/sofi/en/).

Glover, E. K., Ahmed, H. B. and Glover, M. K. (2013). Analysis of socio-economic conditions influencing adoption of agroforestry practices. *International Journal of Agriculture and Forestry*, **3**(4): 178-184.

Humphreys, J. and Ahern, A. (2019). Is travel based residential self-selection a significant influence in modal choice and household location decisions? *Transport Policy*, **75**: 150-160.

IPS, (2011). South Sudan Inter Press Services: More Gender Representative Leadership.

Kabiru, S., Hassan, S., Hadi, R., Umar, U. A., Musab, I. and Bello, M. (2018). Limiting Factors Affecting Agroforestry Adoption in Butta Sub-County, Manafwa District, Uganda. *Asian Journal of Advances in Agricultural Research*, **6**:1-9.

Kabwe, G., Bigsby, H. R. and Cullen, R. (2009). Factors influencing adoption of agroforestry among smallholder farmers in Zambia.Paper presented at the 2009 New Zealand Agricultural and Resource Economics Society (Inc.) NZARES Conference, Faculty of Commerce, Lincoln University, New Zealand.

Kiptot, E. and Franzel, S. (2012). Gender and agroforestry in Africa: who benefits? The African perspective. In: *Agroforestry-the future of global land use* (pp. 463-496). Springer, Dordrecht.

Kiptot, E. and Franzel, S. C. (2011). *Gender and agroforestry in Africa: are women participating?* Nairobi: World Agroforestry Centre.

Lambert, O. and Ozioma, A. F. (2011). Adoption of improved agroforestry technologies among contact farmers in Imo State, Nigeria. *Asian Journal of Agriculture and Rural Development*, **2**(1): 1-9.

Maruod, M. E., Elkhidir, E. E., Mahmoud, T. E. and Breima, E. E. (2014). Food Security and Resource Allocation among Smallholders Farming Households in Arid Zones (Rain-fed Sector) in North Kordofan State, Sudan. *Scientia*, **2**(1): 41-47.

Matata, P. Z., Ajay, O. C., Oduol, P. A. and Agumya, A. (2010). Socio-economic factors influencing adoption of improved fallow practices among smallholder farmers in western Tanzania. *African Journal of Agricultural Research*, **5**(9): 818-823.

Mbwiga, J. (2016). *Classification of chagga agroforestry homegardens and their contributions to food, income and wood energy to communities of Rombo District, Tanzania*. Doctoral Dissertation, Sokoine University of Agriculture, Tanzania.

Mishra, R. and Mishra, Y. D. (2017). Challenges and Strategies to Address Food and Livelihood Security in Agroforestry. In:*Agroforestry* (pp. 817-832). Springer, Singapore.

Mutonyi, S. and Fungo, B. (2011). Patterns of agroforestry practices among small-holder farmers in the Lake Victoria Crescent Zone (LVCAEZ) of Uganda. *Research Journal of Applied Sciences*, **6**(4), 251-257.

Obiri, B. D., Agyeman, V. K., Kyereh, B., Nutakor, E., Obeng, E. and Britwum, S. (2011). Perception and participation of local communities in tree planting initiatives. *Ghana Journal of Forestry*, **27**(3): 80-93.

Oli, B. N., Treue, T. and Larsen, H. O. (2015). Socio-economic determinants of growing trees on farms in the middle hills of Nepal. *Agroforestry systems*, **89**(5): 765-777.

Oni, F. O. (2015). *Factors influencing farmers' willingness to engage in agroforestry practice in Ekiti State, Nigeria*. Doctoral degree dissertation, University of Nigeria,Nsukk Figure 1a, Nigeria.

Parwada, C., Gadzirayi, C. T., Muriritirwa, W. T. and Mwenye, D. (2010). Adoption of Agro-forestry Technologies among Smallholder Farmers: A Case of Zimbabwe. *Development and Agricultural Economics Journal*, Vol. 2(10), pp. 351-358

Place, F., Ajayi, O. C., Torquebiau, E., Detlefsen, G., Gauthier, M. and Buttoud, G. (2012). Improved policies for facilitating the adoption of agroforestry. In *Agroforestry for Biodiversity and Ecosystem Services-Science and Practice*. InTech Open: https://ideas.repec.org/h/ito/pchaps/60861.html

Sanou, L., Savadogo, P., Ezebilo, E. E. and Thiombiano, A. (2017). Drivers of farmers' decisions to adopt agroforestry: Evidence from the Sudanian savanna zone, Burkina Faso. *Renewable Agriculture and Food Systems*, 1-18.

Shilabu, M. D. T. (2008). *The contribution of agroforestry to household food security and income generation in Maswa District, Shinyanga region*. Doctoral Dissertation, Sokoine University of Agriculture (SUA), Tanzania.

Sudan Population and Housing Census, (2008).

Sulieman, H. M. (2007). Mapping and modelling of vegetation changes in the southern Gadarif region, Sudan, using remote sensing.

Sunam, R. K. and Goutam, K. R. (2015). Agrarian Future (s) of Rural Nepal: Revitalizing Peasant Agriculture? *Himalaya, the Journal of the Association for Nepal and Himalayan Studies*, **35**(1): 12.

Wel, P. (2012). *The Potential of Agroforestry for Peace building: the case of Jonglei, South Sudan*. Doctoral Degree Dissertation, Faculty of Capacity Development and Extension, University of Guelph, Ontario, Canada.

Williams, M. A., Usai, D., Salvatori, S., Williams, F. M., Zerboni, A., Maritan, L. and Linseele, V. (2015). Late Quaternary environments and prehistoric occupation in the lower White Nile valley, central Sudan. *Quaternary Science Reviews*, **130**: 72-88.

Zeleke, A. W. (2009). Status of traditional agroforestry and its future potential development as buffer zone agroforestry for the natural forest conservation in Burkitu Peasant Association, Oromia, Ethiopia. Unpublished MSc Thesis. Hawassa University, Wondogenet College of Forestry and Natural Resource, Wondo Genet, Ethiopia.

Zeweld, W., Van Huylenbroeck, G., Girmay, T. and Speelman, S. (2017). *Impacts of social and psychological issues on adoption behaviour for agroforestry systems, crop rotation and compost fertiliser in the Northern Ethiopia* (No. 728-2017-3151).