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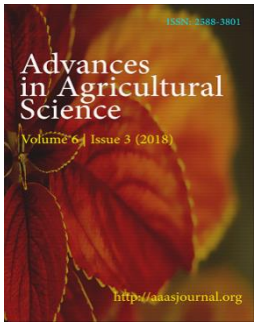

Research Article Open Access

Factors influencing crop diversification strategies among smallholder farmers in cotton production zone in Mali

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ABSTRACT

Smallholder farmers in Sub-Saharan Africa (SSA) seek to improve their livelihood through diversification of crops, livestock production systems and non-farm activities. This study was conducted in the cotton growing areas in Mali, which constitutes the major agricultural production zone in Mali. This study examines crops diversification strategies and identifies the main factors that influence diversification strategies. Cross-sectional data were obtained from 134 selected randomly smallholder farmers in three villages drawn from different agro-ecological zones in Southern Mali. A multinomial logistics (MNL) regression model was used to estimate the main factors that determine diversification strategies of smallholder farmers. Results from MNL model revealed that the age of family head, education level, family size, oxen ownership, farm income per capita and crop pest significantly influenced families' participation in the four diversification strategies. Policy interventions should be employed to encourage and promote profit-oriented activities through diversification strategies. Institutional interventions should be implemented to increase smallholder farmers access to inputs and both agricultural and non-agricultural credit.

Introduction

Economic development, food security and poverty alleviation in developing countries is directly linked to the agricultural sector (Pretty *et al*., 2011; Kassie *et al*., 2012; Mugendi, 2013 Fedoroff, 2015). However, agriculture in the developing countries is for subsistence and mainly undertaken by smallholder farmers who constitute over two-thirds of the global poor, food insecure and most vulnerable population (FIDA, 2011; FAO, 2014). Smallholder farmers in Sub-Saharan Africa (SSA) endured with low income from agricultural production and continue to struggle with food insecurity, poverty and climatic risks. Most of the governments in SSA are faced with the dilemma of achieving food security, while reducing poverty in the face of increasing population, climate change and the associated environmental consequences (Teklewold *et al*., 2013; Vanlauwe *et al*., 2014; Kuivanen *et al*., 2016; Binswanger-mkhize &

Savastano, 2017). Although smallholder farmers in developing countries depend on rain-fed agriculture, they continue to contribute to improvement of rural and urban livelihoods. For instance, in SSA, agriculture employs over 50% of labour force and contributes to an average of about 15% of the total gross domestic product (GDP) (OECD-FAO, 2016).

Smallholder farmers engage in multiple farm and non-farm activities in order to generate income, enhance food security and reduce poverty by utilizing their farms and selling surplus products (Meert *et al*., 2005; Rahut & Scharf, 2012; Senadza, 2012; Tittonell, 2013; Rahut *et al*., 2014; Wan *et al*., 2016). A majority of smallholder farmers undertake more than one activity and generate income from more than one source such as crop diversification, which refers to a mix of farming systems rather than the shift from one given enterprise to another (Babatunde *et al.,* 2008; Babulo *et al*., 2014; Abdullah *et al.,* 2017). Participation in a mix of activities contributes to increased level of smallholder farmers' incomes and maximizes their income (Khatun & Roy, 2012; Sultana *et al*., 2015). Farmers producing cash crops in the developing world diversify their agricultural production systems to increase their incomes, improve and maintain food security and reduce vulnerability to poverty (Kanyua *et al*., 2013; Schroth & Ruf, 2013; Mulwa *et al*., 2017).

Agricultural diversification is one of the strategies for income generation, poverty and food insecurity reduction and improvement of nutritional status of rural population (Ellis, 2000; Barrett, 2001; Reardon, 2001; Fabusoro *et al*., 2010; Makate *et al*., 2016; Barrett, 2001; Ellis, 2000; Fabusoro *et al*., 2010; Reardon, 2001). Diversification involves growing more than one crop and, at the same time, practicing livestock production in order to increase income and enhance livelihoods. However, food crop production, the primary income generating enterprise in rural areas in SSA, is inadequate to enhance the well-being of smallholder farmers. In addition, its contribution to rural livelihoods is hampered by high cost of production (Woldenhanna & Oskam, 2001; Abimbola & Oluwakemi, 2013; FAO, 2014; Gautam & Andersen, 2016). This is attributed to low input use, low mechanization and poor soil fertility which lead to low agricultural output (Baquedano *et al*., 2010; Mariano *et al*., 2012; Sheahan & Barrett, 2017; Asfaw *et* al., 2018). Although agricultural diversification reduces production-related risks and increases farm earnings, few farmers diversify their agricultural activities in SSA. The lack of access to agricultural inputs, equipment and other factors of production as well as institutional constraints are important obstacles to diversification (Kasem & Thapa, 2011; Nguyen, 2017). Low or lack of diversification causes a decline in production of important commodities such as cash crops (cotton), food crops (maize, millet and sorghum) and livestock products. This results in low income, food insecurity and increased poverty levels among smallholder farmers (Ellis & Freeman, 2004; Okoboi & Barungi, 2012; Makate *et al*., 2016). Hence, agricultural diversification is important for the improvement of smallholder farmers' livelihoods because of its potential of providing a reliable source of food and income in rural areas.

Several studies have attempted to describe the factors that may influence smallholder farmers in developing countries to diversify. Results indicate that education level, farmers resource endowment, agro-ecological and institutional factors constitute major constraints to farm and non-farm income diversification (Jansen *et al*., 2006; Mariano *et al*., 2012; Rahut & Scharf, 2012; Piya & Lall, 2013). The understanding of smallholder farmers' decisions to participate in a particular strategy from among the available choices should put into consideration the enabling factors or constraints. Smallholder farmers' choices for agricultural diversification are determined not only by agricultural production systems but also by low soil fertility, climate conditions and income among others. Likewise, it is rare for farmers in the rural areas of developing countries to sustain their livelihoods from one source of income. Most

farmers in rural areas depend on a diverse portfolio of activities. Moreover, smallholder farmers may engage in crop and livestock production in order to overcome food insecurity and poverty (Ellis, 2000; Ellis & Freeman, 2004; Mariano *et al*., 2012).

Smallholder agriculture dominates the agricultural sector in Mali. About 80% of Malian farms are smallholder farms (Staatz *et al*., 2011). Southern Mali is the major agricultural production region in Mali. The region covers 12% of Malian geographical territory and is occupied by about 7.4 million people General Census of Housing and Population (RGPH,2009). This is around 51% of a total population of 14.5 million people (RGPH, 2009). The importance of Southern Mali in Malian agricultural production is due to its climatic conditions. Southern Mali zone supplies the rest of country with agricultural products. Cotton is the major cash crop grown in the region and constitutes the main source of income. The region is the Malian food basket and provides the majority of livestock products in the country (Ba *et al*., 2011). However, agricultural productivity in the region is hampered by limited resources and dependency on rainfall. Furthermore, despite the importance of cotton to the national economy, smallholder farmers in the region face several livelihood and agricultural production challenges. These include low access to agricultural inputs, climate change, food insecurity, poverty and malnutrition. Many of these challenges have been depicted in the literature as major factors that hinder the socioeconomic progress of smallholder farmers in SSA (Woldenhanna & Oskam, 2001; Teklewold *et al*., 2013; Meraner *et al*., 2015).

Despite the critical role played by Southern Mali in the Malian agricultural growth, little attention has been drawn to understanding factors that drive smallholder farmer diversification of income sources. A few studies have attempted to establish the socioeconomics determinants of production (Abdulai & Crolerees, 2001). Also, several studies have been conducted, focusing on agriculture and climate condition in cotton belt of Mali (Sanogo *et al*., 2016; Traore *et al*., 2013; Traore *et al*., 2015). Therefore, this paper analyses the factors affecting crop diversification strategies amongst smallholder farmers in cotton growing zone of Mali using Multinomial logistic regression. The study contributes to the understanding of crop diversification in cotton growing of Mali. It is underlined the following hypotheses; socioeconomic factors have no significant influence on the level of diversification in cotton growing zone of Mali and institutional factors have no significant effect on the level of diversification in cotton growing zone of Mali.

Methodology of research

Study area

The study was conducted in Southern Mali. The selection of the study area was justified based on a number of reasons. Southern Mali has a well-developed and diversified agricultural sector compared to other regions in Mali. Secondly, the region receives enormous public and private investment in agriculture. For instance, the Malian Company of Textile Development (CMDT) which is in charge of cotton production has over the years encouraged agricultural production through promotion of smallholder farmer access and use of farm inputs. The access and use of technologies such as improved seeds, manure, crop residues, composting among others have resulted in significant improvement in smallholder agriculture compared to other regions. Lastly, Malian agriculture is rain-fed and Southern Mali has favourable agro-ecological conditions that support diverse agricultural productions systems.

Three villages that were randomly selected from three districts located in different agro-ecological zones in cotton growing areas in Mali (Figure1). Beguene (old basin) is a village in Bla district in the northern part of Southern Mali. The main agricultural enterprise in Beguene is based on cotton, which is the grown as cash crop, maize, sorghum, millet and livestock (cattle, sheep and

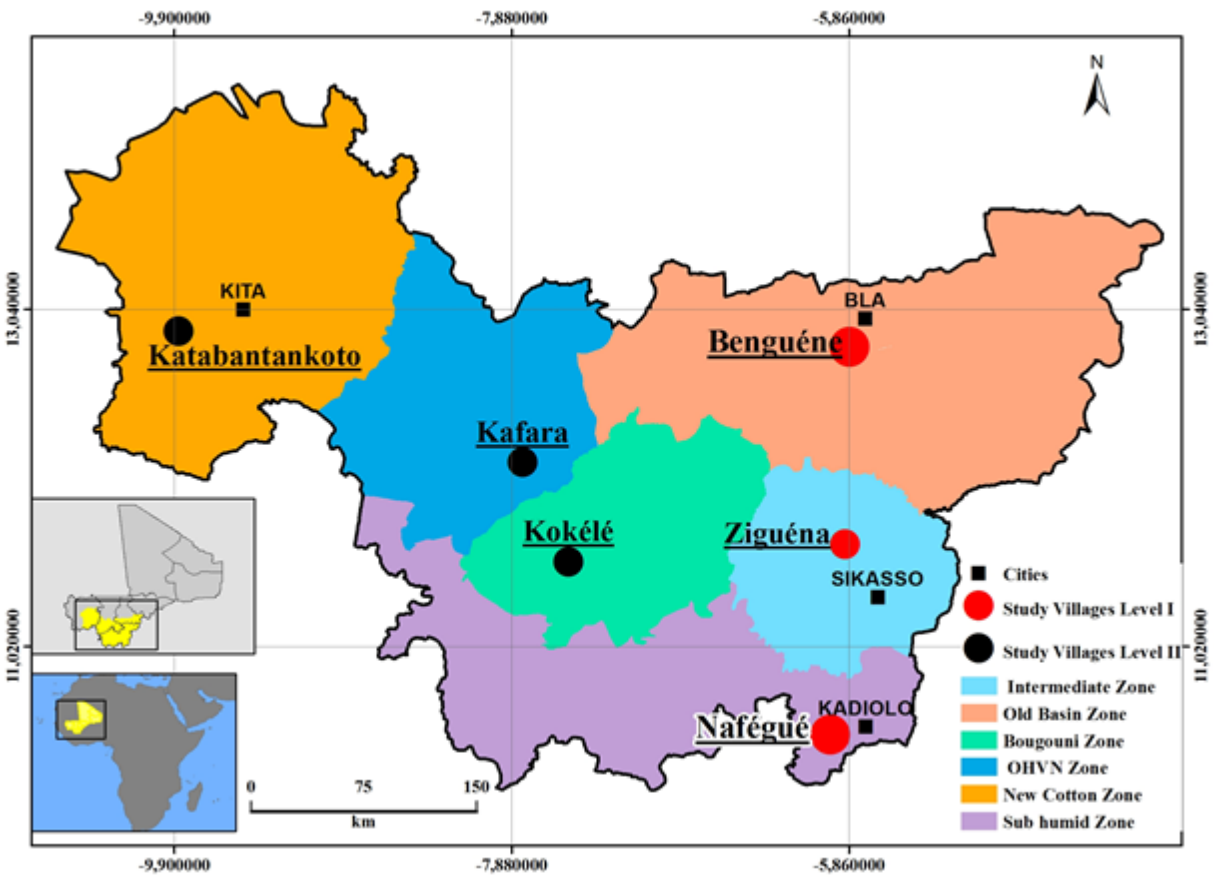

Figure1. Location of villages in the study area

Source: (Traore *et al*., 2016)

Table 1. Description of explanatory variables and expectation of sign

Explanatory variables	Description	Expected sign
Age	Age of family headed	+/-
Family size	Number of family members	+
Education	Level of formal education	+
Farm income	Income from all farming activities	+
Non-farm income	Income from all off-farm activities	+
Oxen (livestock)	Oxen ownership	+
Land size	Land size (ha)	+
Land ownership	Land ownership	+
Lagriinput	Low agricultural inputs used	-
priceinputs	Agricultural input prices	-
Crop pest	Crop pest infestation	+
Access to credit	Access to agricultural inputs credit	+
Extension services	Access to agricultural extension services	+

goat) production. Beguene is characterized by high population pressure on natural resources and low soil fertility. The area receives an average annual rainfall of around 850 mm, with high inter-annual variability. The second village, Ziguena (intermediate or centre), is located in Sikasso district and is characterized by low population pressure on natural resources. Ziguena receives an annual rainfall of about 1000mm. Cotton, maize, sorghum, millet and livestock production are the dominant agricultural activities in Ziguena. The last village is Nafegue which is located in Kadiolo district in Southern part of the cotton growing zone. Nafegue receives an average rainfall of more than 1200mm per year. Agricultural activities in Nafegue include cotton, maize, millet, sorghum and livestock production. Besides the main agricultural enterprises, there is also rice, groundnut and cowpea production in cotton growing zones in Mali.

Sampling procedures and data collection

This study is based on cross-sectional survey data that were collected from farming families across three villages located in different agro-ecological areas in the cotton growing zones in Mali. The study used multistage sampling technique. It involved a combination of purposive, stratified and simple random sampling procedure. The first stage involved purposive selection of three districts in the cotton growing area. In the second stage, one commune from each district was randomly selected, thus obtaining a total of three communes. In the third stage, a source list was obtained from the cotton producer cooperatives. Farming families were then randomly sampled using proportionate to size sampling procedure. The total population of farming was 66, 67, and 69 for Beguene, Ziguena, and Nafegue respectively. A total sample of 134 farming families was selected from the three villages using the formula by Yamane (1967).

$$n = \frac{N}{1 + N(e)^2} = \frac{202}{1 + 202(0.05)^2} = 134 \quad (1)$$

where n is the sample size, N is the total number of families in the three villages, e is the level of significance at 5% confidence level and 1 is the constant value. The unit of study was based on farming families where only men are involved and registered in cotton cropping in Mali and possess factors of production. This is attributed to the criteria of admission to the cooperatives. For instance, it is mandatory for the member to allocate at least 0.5 ha of land under cotton. In the study area, women do not own land.

Data were then collected using structured questionnaires through one on one interview. Data were collected on the socio-economic factors (gender, age, education level, livestock ownership, land ownership and productive physical assets), institutional factors (access to agricultural inputs, credit and extension services) and bio-physical factor (field location). The analytical techniques used included descriptive statistics such as mean and standard deviation and multinomial logistics regression.

Econometric model specification and estimation of multinomial logistic regression

Econometric models such multivariate probit or logit, multinomial probit, nested logit, conditional fixed effects logit, among others are useful for analysis categorical outcomes. In the study, multinomial logit (MNL) is appropriate for analysis of categorical dependent variables when farmers have to choose only one outcome from among the set of crop diversification strategies. As opposed to MNL, the above econometric models allow the possibility of simultaneous choice of dependent outcome (Greene, 2002; Wooldridge, 2002). The choice of the MNL model was also backed by previous related studies that applied the same model in estimating the effects of socioeconomic and institutional factors on crop diversifications (Jansen *et al*., 2006; Rahut *et al*., 2014;Belaye *et al*., 2017).

Multinomial logistics (MNL) regression is an analytical method that is commonly used to analyse smallholder farmers' choices of agricultural strategies. It allows analysis of decisions across more than two categories (Greene, 2002; Wooldridge, 2002). The MNL model is also used in assessing the choice of alternative combinations of strategies in smallholder crop and livestock production systems (Babulo *et al*., 2014; Deressa *et al*., 2009). The model is used to analyse the factors that influence smallholder farmers' decisions to diversify crop enterprises in cotton growing zone of Mali.

The Simpson Index of Diversity (SID) was used to characterize and measure the degree of diversification at smallholder farmer level (Joshi *et al*., 2003; Fabusoro *et al*., 2010; Ahmed *et al*., 2015). The measure of diversification is based on the area (hectare) of land under the main crops (cotton, maize, millet and sorghum). Livestock owned by smallholder farmers is expressed in terms of Tropical Livestock Units (TLU). The SID ranges between zero (0) and one (1) where 0 denotes specialization and 1 means extremity of diversification. The SID general formula is given as:

$$SID = 1 - \sum_{i=1}^{n} P_i^2 \quad (2)$$

where SID denotes Simpson's Index of the Diversity, P is the proportion of enterprises coming from i^{th}, n is number of enterprises $(n = 1, 2, ..., 5)$ Following the random utility model (RUM), we assume that smallholder farmers aim to maximize their income, U_i, by comparing the income generated by j alternative strategies. The expected income, U_{ij}^{*} that the smallholder farmer derives from engaging in strategy j is a latent variable determined by the observed farming family characteristics X_1 and unobserved ε_{ij}. Therefore,

$$U^{*}_{ij} = X_{ij}\beta_j + \varepsilon_{ij} \quad (3)$$

Where β_j is the parameter associated with X_j that remains constant across alternatives and ε_{ij} is a random disturbance term that capture intrinsically random choice behaviour, measurement or specification error and unobserved attributes of the alternatives.

To describe the MNL model, let P_{ij} *(j=1,2,3,4)* denote the probability associated with cropping activity choices of a smallholder farmer i with:

$j = 1$ if the smallholder farmer combines cotton plus maize, $j = 2$ if the smallholder farmer combines cotton, maize and millet, $j = 3$ if the smallholder farmer combines cotton, maize, millet and sorghum and $j = 4$ if the smallholder farmer only practices food crop production.

Following Greene (2002), the MNL model is given as:

$$P_{ij} = \frac{Exp(X_i\beta_j)}{\sum_{j=1}^{4} Exp(X_i\beta_j)} \quad (4)$$

Given a convenient normalization that solves the indeterminacy problem inherent in equation 3 is $\beta_j = 0$, then MNL model can be rewritten as:

$$P_{ij} = \frac{Exp(X_i'\beta_j)}{1 + \sum_{j=1}^{4} Exp(X_i'\beta_j)}, \text{ j = 1,2,3,4.} \quad (5)$$

Where β_j is a vector of coefficients on each of the independent variables X_i. This can be estimated using maximum likelihood. For this study, the diversification strategies or their probabilities are described in Table 2. Crop diversification strategies. Unbiased and consistent parameter estimates of the MNL in Eq. (4) require the assumption of independence of irrelevant alternative (IIA) to hold. Specifically, the IIA assumption requires that the

probability of using certain diversification strategies by the smallholder farmer needs to be independent of choosing other strategies. The premise of the IIA assumption is the independent and homoscedastic disturbance terms of the basic model.

Description of explanatory variables

The study grouped the explanatory variables into three categories Table ***1***. First, family characteristics include the age, education level, family size, non-farm income and farm income. The second category of predictor variables is factor endowments which include ownership of oxen and land. Last, institutional variables include access to credit and agricultural extension services. The description of explanatory variables used in the MNL model is given below. The description of the predictor variables and the hypothesized direction of relationship with diversification are as follows.

Ages of family headed: Captures the age of the principal decision maker in years. Age of the household head plays an important role in diversification into several enterprises since it can be used to indicate farmer's experience in different farming systems. It is expected that the age of the family head increases the probability of engaging in multiple agricultural enterprises.

Family size: Refers to the number of people working together and sharing a common pool of resources. Family size might positively influence diversification strategies in agriculture. The study hypothesizes that large family size increases the probability of smallholder farmers diversifying agricultural production systems. Large family size implies availability of labour which allows participation in multiple farm activities.

Education level of family head: Refers to the literacy level of the family head. It is considered as an important factor of agricultural diversification strategies. A family headed by a highly educated member is more likely to diversify into different agricultural enterprises owing to the available knowledge on different crop and livestock enterprises and the importance of diversification to family income and food security.

Farm and non-farm income: Indicates the financial position of smallholder farmers. We hypothesize that farm and non-farm incomes positively influence diversification because it enables farmers to have increase access to farm inputs. Increased access to inputs then enhances the level of diversification.

Oxen ownership: Livestock is an important physical asset because it represents an important source of capital for smallholder farmers. Oxen constitute an important part of agricultural systems in Southern Mali because it is the primary source of animal power. It is expected that ownership of oxen positively influences diversification into different crop production systems.

Farm size and land ownership: Land is an important factor in agricultural production and can be considered as a proxy for family wealth in Southern Mali. Possessing large sizes of arable land increases the probability of diversification into different cropping systems.

Access to agricultural inputs use: Access to farm inputs induces smallholder farmers to diversify their activities. The quantity of chemical fertilizer used per hectare is still low in Southern Mali due to the high prices. Smallholder farmers have to be members of cotton cooperatives so as to access important inputs.

Input prices: it is an important factor for crop diversification. It is hypothesized that high inputs prices negatively influence diversification due to liquidity constraints.

Crop pest: Crop pest is an important constraint in agricultural production. It is hypothesized that crop pests influence farmer decision to diversify. A farmer may diversify into different crops to cushion against output declines of another crop as a result of pest infestation.

Extension services: Extension services provide technical information and advice to farmers. It contributes to the dissemination of agricultural information, knowledge and skills, thereby enhancing the uptake of different agricultural technologies. It is expected that increased access to extension information and advice encourages diversification.

Results and discussions

Description of dependent variables

The dependent variable in the empirical estimation is the combinations of crop diversification strategies. The combinations that smallholder farmers were engaged in are provided in Table 2. The sampled smallholder farmers were grouped into four categories based on their diversification strategies. Accordingly, those who diversified into cotton and maize represented 24.63% of the sampled farmers. Cotton, maize and millet combination was practiced by 29.10% of the sampled farmers. A combination of cotton, maize, millet and sorghum was practiced by 39.55% of the sampled farmers. About 6.72% of the sampled smallholder farmers were only engaged in food crop production.

Field location characteristics

The average level of diversification was 0.6 implying that agricultural production systems were well diversified. Table 3 presents soil type in the study area based on farmer perceptions. Sampled farmers reported four types of soils: clay, sand, gravels and silt. There was also a combination of soil types which was dominated by sand and silt and silt and clay. About 9% of farmers' fields are located on clay soils. This type of soil has a good potential for food and cash production. The gravel type of soil was reported by about 12% of the farmers and was ranked second after sand plus silt. The combination of two types of soils, sand plus silt, was the most dominant in the study area. About 74% of farmers' fields were reported to be composed of the combination. The rest of fields were located on sand and silt plus clay at 4% and 1% respectively. The diversity of land allocated to crops across the different types of soils indicates that field location plays an important role in the diversity of cropping systems. On average, farmers had three fields of land. This represents about 72% of total cultivated land area of the sampled farming families.

Summary statistics

Table 4 provides the summary statistics of family characteristics, endowment and institutional variables used in the analysis. On average, the family head was 56 years old. The average farming family size was 23 people. The average number of oxen owned was 4 oxen per family. On average, the total land size under the main crops (cotton, maize, millet and sorghum) was averagely 11.51 ha per farming family. Smallholder farmers practiced various non-farm activities such as informal trade, traditional gold mining, casual work, and handcraft among others. The average annual earnings from non-farm activities was about USD 665.36 compared to annual farm income of about USD 60. Turning to education, about 51% of farmers had at least primary education while 49% reported that they did not attend formal school.

The survey results showed that about 46% of farmers thought that they used sufficient quantities of agricultural inputs against 54% who thought otherwise. About 77% of sampled farmers reported that the price of agricultural inputs was high. This could be attributed to the tendency of the cotton company to charge interest on the inputs supplied on credit to its contracted farmers. About 53% of sampled farmers indicated that cotton and maize outputs were severely affected by pests despite interventions by the cotton company. Most of the cultivated land in the study area, about 85%, is owned by the family. About 15% of the cultivated land area is freely used (no rental fee) by immigrants and others related people. Turning to institutional

Table 2. Crop diversification strategies

Diversification strategies	Percentage of farmers	Share of cotton	Share of food crop
Cotton +Maize	24.63	44	56
Cotton +2Food crop	29.10	50	50
Cotton +3Food crop	39.55	48	52
Food crop only	6.72	0	100

Table 3. Fields location per soil types in the study area (farmer perceptions)

Soil types	Field1(ha)	Field2 (ha)	Field3 (ha)	Percent %
Clay	127	49	0	9
Gravels	202	42	1	12
Sand	71	16	0	4
Sand+ silt	1045	357	92	74
Silt + clay	17	11	2	1
Total	1462	475	94	100

Table 4. Summary and descriptive statistics of explanatory variables

Explanatory variable	Mean	S.D			Description
Age of family headed	56	15.022			Continuous
Family size	23	19.112			Continuous
Oxen	4	2.851			Continuous
Nonfarm income	371269	744503			Continuous
Income per capita	33252	30576			Continuous
Farm size (ha)	11.51	8.31			Continuous
Qualitative descriptor			Frequency	Percent	
Education		Yes	66	51	Dummy
		No	68	49	
Low inputs used		Yes	62	46	Dummy
		No	72	54	
Agricultural price inputs		Yes	103	77	Dummy
		No	31	23	
Crop pest		Yes	71	53	Dummy
		No	63	47	
Land ownership		Yes	114	85	Dummy
		No	20	15	
Access to credit		Yes	107	80	Dummy
		No	27	20	
Access to extension services		Yes	120	90	Dummy
		No	14	10	

Note: the exchange rate at the time of survey was 558 FCFA (Franc of the African Financial Community) for USD1

factors, about 87% and 90 % of the sampled smallholder farmers expressed that they had no problem accessing extension and credit services respectively. The farmers indicated that they were trained on good agricultural practices and crop production by field agents from the cotton milling company.

Econometrics analysis

Multinomial logistic regression was used to determine factors influencing choice of alternative diversification strategies. Food crop production was selected as the base category with full results from the MNL presented in Table 5. The model was highly significant as indicated by likelihood ratio test (LR χ^2 (30)= 119.72, p = 0.000), suggesting strong explanatory power of the model. The variables were tested for multicollinearity using the variance inflation factor (VIF). The variance inflation factors for all variables were less than 10, indicating absence of multicollinearity. Out of the ten explanatory variables included in the model, four variables influenced farmers' decision to diversify into a combination of cotton and maize. Five variables influenced diversification into a combination of cotton and two food crop (maize and millet) and cotton and three food crop (maize millet sorghum).

Age of family head

This variable was positively and significantly associated with the probability of diversification at 5% and 10% significance levels. Elderly farmers were more likely to either engage in cotton and maize, cotton and two food crops or cotton and three food crop production relative to only engaging in food crop production. This implies that the likelihood of diversification into several crop enterprise increases with age of the farmer. This probably implies that older farmers put much emphasis on family food security and increased income. Besides producing food crops for consumption purposes, older farmers engage in cash crop production in order to earn additional income. On the other hand, these three groups of smallholder farmers are large families and get inputs through their participation in cotton production. This allows farmers to apply a significant proportion of the inputs on maize, the main cereal crop. This also implies that the older heads of families are interested in maintaining cash crop production and also seek to feed the family while younger heads of families are mainly interested in ensuring food self-sufficiency. This finding is consistent with results of studies by Deressa *et al*. (2009), Teklewold *et al*.(2013), Meraner *et al*. (2015) and Gautam & (Andersen, 2016) who found that age positively affected diversification decisions. On the other hand, Hassan & Nhemachena (2008) and Aneani *et al*.(2011) indicated that the age of smallholder farmers increased the probability of diversification in order to improve livelihoods.

Family size

This variable had a positive and significant effect on the probability of diversification at 5% significance level. This implies that large families are more likely to grow a mixture of cash and food crops. Large families are able to engage in multiple cropping systems as compared to smaller families. In cotton growing zone of Mali, access to factors of production such as land and labour contribute to smallholder farmers' decisions to diversify. Therefore, family size has a significant association with these diversification strategies in agricultural production systems. This finding is in line with results reported by Kassie *et al*. (2012), Piya & Lall (2013) and Babulo *et al*. (2014) who found that families with high labour availability are more likely to diversify into several agricultural enterprises.

Education level

Table 5. Multinomial logistics regression model on crop diversification strategies

Explanatory variables	Cotton+ Maize		Cotton+2FC		Cotton+3FC	
	Coef.	P>z	Coef.	P>z	Coef.	P>z
Age	0,308	0.042**	0,297	0.049**	0,286	0.058*
Family size	1,171	0.033**	1,135	0.038**	1,167	0.033**
Education	4,574	0.218	7,612	0.038**	8,591	0.019**
Oxen	2,898	0.072*	3,331	0.039**	3,258	0.044**
Ln nonfarm	0,322	0.191	0,398	0.111	0,368	0.141
Lagriinput	-3,237	0.239	-2,699	0.330	-2,360	0.396
hcostagriinput	-4,711	0.404	-6,650	0.238	-6,879	0.222
Ln income per capita	0,500	0.067*	0,394	0.107	0,503	0.051**
Crops pest	-4,852	0.121	-5,423	0.085*	-4,736	0.133
Extension	-6,514	0.995	-6,148	0.995	-5,294	0.996
Constant	-21,167	0.983	-20,098	0.984	-22,159	0.982
Base category		Food crop				
Number of observation		134				
LR Chi2(30)		119.72				
Prob > Chi2		0.000				
Pseudo R2		0.357				
Log likelihood	-107.987					

Note: **, * significant at 5% and 10 % of probability levels respectively.

Table 6. Hypotheses test statistics of model

Hypotheses	Chi2	p- Value	Decision
H_1: $\mu_1 = 0;\ H_a : \mu_1 \neq 0$	32.11	0.006***	H_1 rejected
H_2: $\mu_2 = 0;\ H_a : \mu_2 \neq 0$	2.04	0.564	Fail to reject H_2

Note: H_1 = null hypothesis and H_a = alternative hypothesis for socioeconomic factors and significant at 1% level and H_2 = null hypothesis and H_a = alternative hypothesis for access to agricultural extension services

Education is an important factor influencing diversification of livelihood strategies. The education level of the family head positively and significantly influenced diversification of crop enterprises. Well educated heads of family were more likely to engage in cotton and two food crop (maize and millet) and cotton and three food crop production compared to food crop growers. Similarly Onya *et al*. (2016), Zereyesus *et al*. (2016) and Asfaw *et al*. (2018) found that highly educated smallholder farmers were more likely to engage in several enterprises in order to improve their livelihoods. In addition, the finding is consistent with Jansen *et al*. (2006), Rahut & Scharf (2012) and Rahut *et al*. (2014) who found a positive relationship between education level and income diversification strategies.

Oxen ownership

Livestock (oxen) had a positive and significant influence on the probability of diversification at 5% and 10% significance levels. An increase in the number of oxen owned by smallholder farmers

increased the likelihood of diversifying into cotton and maize, cotton and two food crops and cotton and three food crops as opposed to engaging only in food crop production. Oxen constitute the main source of animal power for agricultural work. All agricultural work such as ploughing, seeding and transportation of farm input and output utilizes animal power. Oxen ownership permits cultivation of larger areas of arable land and provides manure, an important farm input. This explains the low use of tractor and others machineries in Southern Mali. This finding is consistent with Cunguara and Darnhofer (2011), Ghimire *et al*. (2014) and Khonje *et* al. (2015) who suggested oxen provide animal power for ploughing in rural areas in SSA due to lack of tractors and small size of cultivated land area.

Farm income per capita

Farm income had a positive and significant relationship with diversification into cotton and maize and cotton and three food crops at 10% and 5% significance levels respectively. Higher incomes allow farmers to have access to critical productive resources such farm assets, inputs and land which increase the likelihood of crop diversification. The extra income earned by farmers from one crop is also important in providing financial resources that are used for diversification into other crops. This finding underlines results by (Basantaray & Nancharaiah, 2017) who indicated that crop diversity is strongly associated with significantly higher farm income.

Crop pest

Threats to production (pests) were negatively and significantly associated with diversification into cotton and two food crops at 10% level. The possible explanation for this negative direction in the relationship between crop pest and crop diversification is that pests cause crop damage which discourage diversification into cotton and two food crops. The food crop may be prone to the same pests, dis-incentivizing farmers from diversifying. This finding is inconsistent with Murrell (2017) who reported that diversification of crops has a potential of suppressing and breaking down pest lifecycles.

Hypotheses

Table 6 provides test results of the two hypotheses. The test statistics for hypothesis 1 (Chi2 = 32.11; p value = 0.006) suggest that socioeconomic factors considered in this study such as age of family, family size, oxen education, non-farm and farm income jointly influence crop diversification. Therefore, we reject the null hypothesis and conclude that socioeconomic factors significantly influence crop diversification. Further, the test statistic for Hypothesis 2 (Chi2 =2.04; p = 0.566) suggest that the coefficient of extension services is not statistically different from zero. Therefore, we fail to reject the null hypothesis and conclude that extension services have no significant influence on crop diversification.

Conclusion and policy implications

The study used cross-sectional data to analyse the factors that influence diversification strategies among smallholder farmers in Southern Mali. Agriculture in Southern Mali is characterized by mixed farming where cotton constitutes the main source of income. Findings show that farmers in Southern Mali engage in four diversification strategies such as cotton and maize; cotton maize and millet; cotton maize, millet and sorghum and food crop production. The share of cotton in the total cultivated land was 44%; 50%; 48% and 0% across the four systems respectively. The results also show that 74% of fields were located on sand and silt soils while the rest were spread across silt and clay, sand, clay and gravel soils at 1%; 4%; 9% and 12% respectively. Most of the results are reasonably consistent and in line with the previous studies. The MNL regression model revealed that the likelihood of diversification strategies is positively influenced

by farmer and family characteristics and factors endowment. The estimates show that the ages of family head, education level, family size, oxen ownership, income per capita and crop pests significantly influenced smallholder farmers' participation in the four diversification strategies. The results also indicate that smallholder farmers with larger family size were more likely to diversify into three diversification strategies compared to farmers only engaging in food crop production. Similarly, farmers owning oxen were more likely to diversify into cotton and maize. cotton and two food crops and cotton and three food crops.

The policy implication of these findings is to encourage smallholder farmers to diversify their agricultural production system in order to achieve food self-sufficiency and enhance family income. In addition, having a cash crop and engaging in food crop production and livestock rearing contribute to the reduction of extreme poverty, malnutrition and food insecurity. Policy interventions should encourage and promote better access to agricultural inputs and improve options for diversification. Future research has to consider implementation of adequate and sustainable agricultural technologies in order to provide pathways for diversification of crop enterprises.

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