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## Socioeconomic Determinants of Decisions and Degree of Crop Diversification Among Smallholder Rice Producers in Côte d'Ivoire

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### ABSTRACT

Crop diversification is a strategy used by producers to address their household food insecurity. This study analyzes the factors that influence households' decision to participate in crop diversification on their plot and the determinants of the level of diversification based on survey data obtained through stratified sampling in the Tonkpi, Poro and Tchologo regions in 2020. The Herfindahl index was used to classify producers according to their degree of crop diversification. Applying the Cragg hurdle regression, the study shows that the decision to diversify crops is positively associated with household size, group membership, male gender, number of farm equipment, access to formal credit, distance from town, and region of residence of the producer and negatively associated with producer age and distance from the plot. The degree of diversification is positively associated with group membership and access to formal credit. The results therefore suggest policies to facilitate access to credit and to train and supervise producer groups in rural areas.

### INTRODUCTION

Defined as the practice of growing more than one crop or enterprise in a given year to increase financial and biological stability, crop diversification is one of the mechanisms to address food security, production and market risks (Rehima *et al.*, 2013). It plays according to some authors (Pingali & Rosegrant, 1995 ; Acharya *et al.*, 2011) a central role in improving food security and is considered an important step in the transition from subsistence to commercial agriculture (Winters *et al.*, 2006). The positive contribution of diversification is also confirmed by Degye *et al.* (2012) who argue that households in the central and eastern highlands of Ethiopia would be able to improve their food security conditions by increasing crop diversification. Crop diversification reduces risk, uncertainty and has a positive impact on soil fertility (Njeru, 2013). The effects of diversification go beyond the agricultural sector. Indeed, it contributes to the creation of off-farm employment, the promotion of economic transformation and structural changes (Haggblade *et al.*, 2010; Reardon *et al.*, 2007; Block & Timmer, 1994).

Thus, several studies have shown the importance of crop diversification against production, income and price risks for farm households. They also have its importance in the transition from subsistence to commercial farming but also that this can be determined by certain environmental (flooding, drought, rainfall frequency), institutional (laws, technical support), cultural or regional (rituals, willingness to change) factors (Windle & Rolfe, 2005 ; Shahbaz & Haq, 2017 ; Ibrahim *et al.*, 2009) and most importantly by certain socio-economic factors (farm size, income, market conditions) (Belay *et al.*, 2017 ; Omer, 2015 ; Rehima *et al.*, 2013) that affect enterprise diversification in each country and region.

In Côte d'Ivoire, research has shown that smallholder farmers dominate the agricultural sector, with plantations averaging between 1.5 and 5 hectare(s) in size and supplying the majority of the country's agricultural products (Riquet & Marita, 2017). In general, these farms have low productivity due to low levels of input use (improved seeds, fertilizers, pesticides) and the effect of hazards and climate change. Thus, to cope with vulnerability, marketing risks and ensure income stability and food security, smallholder farmers often resort to crop diversification. This is the case for smallholder rice farmers in Côte d'Ivoire, where the country is the 6th largest producer behind Nigeria, Madagascar, Tanzania, Mali and Guinea, and where rice accounts for 26% of total food production and nearly 17% of total agricultural employment (FAO, 2021). This paper attempts to contribute to the literature by analyzing the socioeconomic determinants of crop diversification decisions and the degree of crop diversification among smallholder rice farmers in Côte d'Ivoire.

### LITERATURE REVIEW

Studies on the determinants of crop diversification although scarce, can be found internationally. This is the case of Rehima *et al.* (2013) who use data on the 393 randomly selected farm households in three stages in SNNPR region of Ethiopia to study the determinants of crop diversification with Margalef index value as the dependent variable, they estimate farmers' decisions and level of diversification separately by the two-stage Heckman model. The authors find that the factors that affected crop diversification were gender, education and business experience, cooperative membership, resource ownership, characteristics of land owned, access to extension services, and transaction costs. In a similar vein,

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Belay *et al.* ((2017) showed in the case of the Central Rift Valley in Ethiopia that in addition to age, other factors are likely to influence the decision to diversify into crops. The authors examine how smallholder farmers perceive climate change, the coping strategies they practice, and the factors that influence their coping decisions, using the multinomial logit model on primary and secondary data. Results indicate that education, family size, gender, livestock ownership, farming experience, frequency of contact with extension agents, farm size, market access, access to climate information, and income are also the main factors determining farmers' choice of adaptation practices. Fetien *et al.* (2009) find much the same results using the Tobit model. Their results reveal that barley variety diversity was affected by age, age square, male-headed household, number of children, livestock, fragmentation index, farm size, elevation, rainfall, extension and temperature in Tigray, Ethiopia. Benin *et al.* (2004) used censored least absolute deviation (CLAD) estimators and found that land size, proportion of males, ownership of cattle and oxen, farm fragmentation, number of fragmented plots, distance between farms, and regional location (Tigray, Ethiopia) were the significant factors that affected grain diversity in the northern part of the country. Wondimagegn *et al.* (2011) applied the same model as Fetien *et al.* (2009) and found that extension, livestock, market information, access to irrigation, number of farm plots, and farm machinery ownership significantly affected crop diversification in eastern Ethiopia. Other researchers used the generalized linear model (GLM) and ordinary least squares (OLS) model and observed that proximity to town, access to road, education, liquid wealth, and access to irrigation are important factors affecting crop choices in northern Ethiopia (Seid and Seebens, 2008). To find out the determinants of crop diversification in Pakistan, Ashfaq *et al.* (2008) applied a multiple regression model and found that farming experience, education, land size, farm distance from the main road, and farm machinery are the significant factors. For his part, Rahman (2008) used a bivariate Probit analysis and found that crop diversification in Bangladesh was significantly affected by farm assets, access to irrigation, land rental, education, farming experience, infrastructure, and off-farm income. In Central Queensland, Australia Windle and Rolfe (2005) analyzed the determinants of farm diversification using the Nested Multinomial Logit model and found that debt, age, education, number of children, off-farm income, farm size, start-up cost, net income, other crops grown, and risk time were the most important determinants. Another study in Australia Weiss & Briglauer (2000) applied an instrumental variable regression model and found that farm size, part-time farming, education, family size, and district location are significant determinants of farm diversification in Australia. In addition, Ibrahim *et al.* (2009) used a multiple linear regression model and identified that age and education of household heads, extension visits, availability of tractor rental, crop income

and access to roads were the significant determinants of crop diversification in Nigeria. The result of multinomial logistic regression model (MLRM) indicated that age, access to credit and regional location affected crop diversification in Ghana (Aneani *et al.*, 2011).

Acharya *et al.* (2011), on the other hand, analyzed the nature and extent of crop diversification in the state of Karnataka by collecting secondary data over a period of 26 years from 1982-83 to 2007-08. Using the composite entropy index (CEI) and multiple linear regression analysis for different crop groups, they find several results : the crop diversification index of most crop groups is higher in the post-WTO period (1995-96 to 2007-08) than in the pre-WTO period (1982-83 to 1994-95), oilseeds and vegetable crops ; diversification of cash crops has increased sharply after the WTO ; Crop diversification is influenced by a number of infrastructural and technological factors. In addition, the results revealed that crop diversification influences production. The study suggested that the creation of basic infrastructure such as continuous supply of irrigation water, markets, availability of fertilizer, adequate roads and transportation is an essential prerequisite for creating favorable conditions for the process of agricultural development and crop diversification, as most of these parameters influence the nature and extent of crop diversification.

Thapa *et al.* (2017), as far as they are concerned studied the determinants of agricultural diversification using survey data from three rounds of nationally representative Nepal Living Standards Survey in 2010/2011 from a multilevel model was used to study the determinants of agricultural diversification. To estimate the causal impact of agricultural diversification on welfare measures, propensity score and instrumental variable matching techniques were used. The results indicate that factors positively associated with agricultural diversification are female-headed households, caste, mother's education, net buyer status, urban area, remittances, farm size, vegetable garden, improved seeds, telephone and refrigerator. The authors also find a positive impact of agricultural diversification into high-value crops on rural poverty and monthly per capita consumption expenditures. In contrast, the impact is negative for cereal crop producers. Omer (2015), used a multinomial logit model to analyze the determinants of income source diversification strategies of rural households in Burkina Faso. He identifies low, medium, and high diversification strategies as income sources, all carried out around agriculture. The results reveal that the age of the household head, household size, dependency ratio, area, membership in a producer group, amount of credit, agricultural potential of the area, morbidity, distance to a main road, access to a radio, total income, and technical assistance are the key factors in determining the level of income diversification. Abdulai *et al.* (2001) using household-level panel data from a representative sample of rural households in southern Mali and different sources of household income examine the determinants of income diversification.

Applying a conditional fixed effects logit model to control for household-specific effects, the authors find that poorer households have fewer opportunities in non-farm activities such as livestock and off-farm labor, and thus less diversified incomes. Their results also indicate that households living in remote areas are less likely to participate in the non-farm sector than their counterparts closer to local markets, while households with educated heads are more likely to participate in the non-farm sector than those with illiterate heads.

As we can see, there are a variety of approaches to this issue around the world. However, no study in this sense has yet been conducted for Côte d'Ivoire. Given the socio-economic differences that exist between countries, this study comes to fill this gap with an innovative method.

## METHODOLOGY

### Data

This study uses cross-sectional data from a household survey of rice farmers for a pilot study on financial inclusion in the rice sector, commissioned by the World Bank. The Poro, Tchologo and Tonkpi regions were selected because of their importance in rice production and the diversity of the agro-ecological zone. Given the intensity of rice production in the respective villages of the regions, 21, 20 and 19 villages were selected in Poro, Tchologo and Tonkpi, respectively.

Households were selected by stratified random sampling, where each village was considered a stratum, from a shortlist of rice-growing households pre-determined in each village before the survey began. 24 households were randomly selected, resulting in a total of 1440 households being surveyed. However, due to the unavailability of some households, 13 incomplete forms were removed, resulting in a final sample of 1427 households. The survey collected information on the socio-economic and demographic characteristics of farmers (e.g., age, gender, group membership, household composition, etc.), equipment, crops and areas cultivated, access to formal credit, and any other variables relevant to this study. The interviews were conducted with the head of the household or the person responsible for agricultural activities in the absence of the head of the household.

### The Analysis Model

Before determining the factors influencing households' decision to participate in crop diversification, we first calculate a crop diversification index for each farm. To do this, we measure the Herfindahl Index (HI2) that has been used by several authors in the literature (Magurran, 1988 ; Malik & Singh, 2002 ; Sichoongwe *et al.*, 2014 ; Derso *et al.*, 2022), from which we derive the crop diversification index. This index is easy to calculate. The Herfindahl index is measured by first calculating the following proportion :

$$p_i = \frac{S_i}{\sum_{i=1}^n S_i}$$

Where  $p_i$  = proportion of the  $i$ th crop,  $S_i$  = area of the  $i$ th crop.

The Herfindahl index is given by the following formula :

$$HI = \sum_{i=1}^n p_i^2$$

We then derive the crop diversification index (CDI) by the following formula :

$$IDC = 1 - HI$$

If  $IDC = 0$ , then we speak of specialization of the farm ; If  $IDC > 0$ , then there is crop diversification.

Thus, this analysis describes a situation where we observe a continuous distribution on positive values in the case where there is crop diversification and an accumulation of 0 in the case where there is specialization. This situation therefore invalidates the use of standard regression models (i.e. OLS) and requires models capable of handling binary endogenous variables (Derso *et al.*, 2022). Several studies have used the Tobit model (Bellemare & Barrett, 2006 ; Gebremedhin & Jaleta, 2010) to deal with such problems. However, Ground & Koch (2008) attest that the main drawback of this approach is that it imposes a restriction that both diversification decisions are simultaneously influenced by the same set of explanatory variables. In this study, we assume that the crop diversification and diversification level decisions are influenced by different sets of independent variables, so the Tobit model is not recognized.

To analyze the determinants of rural households' decisions to participate in crop diversification or not and the degree of diversification, we used Cragg's (1971) Hurdle model. The model is a generalization of the Tobit model, where two separate stochastic processes determine participation and quantitative decisions. The model is also flexible, assuming no restrictions on the components of the independent variables in each phase of estimation, and allows for separate determination of participation and extent of crop diversification (Burke, 2009). Yami *et al.* (2013) state that this model requires a joint application of the probit and truncated regression models sequentially or simultaneously.

Following Derso *et al.* (2022), the theoretical basis for the estimation framework of Cragg's (1971) Hurdle model is based on the probit model where the probability of crop diversification at observation  $t$ , is given by :

$$P(E_t) = \int_{-\infty}^{x_t'\beta} (2\pi)^{-1/2} \exp\left(-\frac{z^2}{2}\right) dz$$

$$C(z) = \int_{-\infty}^z (2\pi)^{-1/2} \exp\left(-\frac{t^2}{2}\right) dt$$

Where  $X_t$  is a vector  $K \times 1$  of variables exogenous to observation  $t$  and represents a vector of parameter estimates and  $C(z)$  is the cumulative unit normal distribution.

The probit model is the first step that reflects a producer's decision to participate or not in crop diversification. The second step concerns the level of diversification to be applied to the acreage. This decision can only be measured for non-zero values in the first decision, thus estimated by the truncated regression. Thus, Matshe & Young (2004) and Kefyalew (2012) propose the double-Hurdle model, which is as follows :

$$div_i^* = z_i^* \alpha + \varepsilon_i, \quad Q = X_i' \beta + \mu_i$$

$$\begin{pmatrix} \varepsilon_i \\ \mu_i \end{pmatrix} \sim N \left[ \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & 0 \\ 0 & \rho^2 \end{pmatrix} \right]$$

$div_i^*$  is the latent variable for the binary dependent variable taking the value 1 for crop diversification and zero otherwise. Q is the latent variable reflecting the number of diversified crops.  $z_i^*$  and  $X_i'$  represent the

explanatory variable vectors,  $\alpha$  and  $\beta$  represent the parameters to be estimated, and  $\varepsilon_i$  and  $\mu_i$  are the error terms for the decision and level of crop diversification respectively.

Since the producer is faced with 2 decisions, the first decision is handled by a probit model (Kefyalew, 2012) such that the binary dependent variable representing the diversification decision is defined as :

$$div_i^* = \begin{cases} 1, & \text{if } IDC > 0 \\ 0, & \text{if } IDC \leq 0 \end{cases}$$

The diversification level decision is defined by:  
 $Q = \max(Q^*, 0)$

### Study Variables

The literature mentions that the decision and extent of crop diversification practices depend on demographic, socioeconomic, farm attributes, and institutional factors

**Table 1 :** Definition of study variables

Variables	Definitions	Expected signs
Dependent variable		
CDI	Crop Diversification Index	
Explanatory variables		
Male	Binary variable taking the value 1 if the producer is a man and 0 if not	+
Age	Variable continue	-
Instruction	Binary variable that takes the value 1 if the producer is educated and 0 if not	+
Member of a farm group	Binary variable taking the value 1 if the producer belongs to a group and 0 if not	+
Household size	Continuous variable designating the number of people in the household	+
The value of the farm equipment	Continuous variable denoting the log value of agricultural equipment owned by the household	+
Distance to the parcel	Continuous variable denoting the distance between the household and its plot	-
Size of the plot	Continuous variable denoting the total area in hectares	+
Distance	Continuous variable designating the distance between the village and the town	+
Availability of mechanization services	Binary variable taking the value 1 if there is a tractor service in the village and 0 if not	+
Farmer	Binary variable taking the value 1 if the producer's main job is farming and 0 if not	+
Formal credit	Binary variable taking the value 1 if the producer has access to formal credit and 0 if not	+
Region	Binary variable designating the geographical location	+/-

Source : Author

(Moffatt, 2005 ; Kefyalew, 2012 ; Derso *et al.*, 2022 ; Thebulo *et al.*, 2022). Thus, the factors selected for this study are : age, gender, education level, farm group membership, household size, plot distance, plot size, distance to town, availability of mechanization services, value of farm equipment, producer's main job, access to

formal credit, and geographical location of the producer. The expected signs of the variables on the decision and level of diversification are shown in Table 1.

## RESULTS AND DISCUSSION

### Household characteristics by crop diversification status

The descriptive statistics for our sample are presented in Table 2. The observation of the table indicates that there is a significant and systematic difference between participants and non-participants in crop diversification. The average age of the head of household is 46.64 with, male with low education level. On average, crop diversification adopters are younger, better educated, and belong to producer groups much more than non-adopters. In addition, the household size and value of equipment of crop diversification adopters are larger than non-

adopters. The average distance between the residence of households and their plot is 3.65 minutes (logarithmic value). On average, the distance between villages and the city is 25.79 minutes and respondents are mainly farmers. The average size of the total plot held by the household is 8.06 ha. A very small number of producers (14.8%) have access to formal credit and diversification adopters have more access to formal credit than non-adopters. Finally, producers in the Poro and Tonkpi regions practice more crop diversification than those in the Tchologo region.

**Table 2 :** Descriptive statistics of respondents' characteristics

Variables	All	Specialization	Diversification	Difference	P-value
Male	0.915	0.839	0.959	-0.121	0.000
Age	46.64	47.478	46.158	1.32	0.049
Instruction	0.401	0.348	0.431	-0.084	0.002
Member of a farm group	0.619	0.586	0.639	-0.053	0.044
Household size	5.817	5.104	6.228	-1.123	0.000
The value of the farm equipment	4.628	4.515	4.692	-0.176	0.000
Distance to the parcel	3.654	3.680	3.64	0.040	0.370
Size of the plot	8.067	11.866	5.883	5.983	0.411
Distance	25.786	24.341	26.617	-2.277	0.009
Availability of mechanization services	0.659	0.770	0.595	0.174	0.000
Farmer	0.912	0.881	0.929	-0.049	0.002
Formal credit	0.148	0.090	0.181	-0.091	0.000
Region					
Poro	0.324	0.311	0.331	-0.020	
Tchologo	0.385	0.495	0.323	0.173	
Tonkpi	0.291	0.194	0.347	-0.153	

Source : Author

**Determinants of the crop diversification decision**

The results of the decision model are listed in Table 3. The quality statistics show that the model is significant overall. The Wald chi-square is 276.535 ( $p < 0.01$ ), indicating that the independent variables jointly explain farmers' decision to participate in crop diversification. Thus, the model is a good fit.

The results indicate that the decision to diversify crops is influenced by : age, gender, membership in a farm group, household size, distance from the plot to the household, distance to town, value of farm equipment, access to formal credit, and geographic location of the producer.

Gender has an effect on the decision to diversify crops. Being male increases the probability of participating in crop diversification by 27%. In our study area, it was found that most women did not have enough financial means to produce multiple crops compared to men. In addition, some women reported that they did not have enough time to devote to multiple crops due to domestic duties.

The coefficient on age is negative and significant at the 10% level, implying an inverse relationship between producer age and the decision to diversify crops. The results indicate that increasing producer age by one year reduces the probability of diversification by 0.2%. This

result corroborates those of Lighton *et al.* (2016) and Derso *et al.* (2022). These authors suggest that older farmers are not able to properly manage their farms and typically rely on old farming systems. In addition, a farmer's ability to bear risk decreases as age increases.

Membership in a farm group has a positive and significant effect on the decision to diversify crops. Being a member of a producer group increases the probability of diversifying crops by 5.7%. This is because group members have access to information about the technology from their friends. Those who have already tried the technology share information about the benefits they received (Thebulo *et al.*, 2022).

The coefficient on household size is positive and significant at the 1% level, implying that an increase of one person in the household leads to an increase in the probability of diversifying by 2.7%. This is because the members of a household represent the potential availability of labor for the producer. Thus, the more labor in the household, the more likely the producer will engage in crop diversification.

The value of the agricultural equipment owned by the household (level of wealth) has a positive and significant effect at the 1% threshold on the diversification decision.

When the value of equipment increases by 1 FCFA, the probability of diversifying increases by 11.6%. This is because crop diversification requires considerable investments that poor producers cannot afford.

The coefficient on distance to plot is negative and significant at the 5% level, implying an inverse relationship with the diversification decision. The results indicate that an increase of 1 min in distance to the plot reduces the probability of diversification by 3.2%. This result is consistent with Sichoongwe *et al.* (2014). In reality walking time to the plot reduces the time spent working on the plot. Thus, producers who have their plot far from their residence, will have little time to devote to work on their plot, which reduces the possibility of growing other crops. They therefore prefer to diversify into the nearest plots because of the time, security and management. Furthermore, the distance of the household's residence from the city has a positive and significant effect at the 1% level on the household's decision.

In our study area, this is due to the fact that households that are far from the city do not have access to the urban market, thus reducing their choice in terms of the diversity of foods available. Thus, to protect themselves from this, these households engage in crop diversification

and consequently reduce transaction costs. This result is consistent with Dessie *et al.* (2019).

Access to formal credit has a significant and positive effect on producers' decisions. Having access to formal credit increases the probability of participating in crop diversification by 12.8%. This result is consistent with Thebulo *et al.* (2022). When a producer has access to credit, he or she has enough resources to carry the risk of diversification and to invest in several crops at once. Geographic location has a positive and significant effect on producers' decisions.

The fact that a producer resides in the Poro and Tonkpi regions increases the probability of participating in crop diversification by 7.2% and 40.4% respectively compared to those residing in the Tchologo region. Thus, the probability of participating in diversification in the Tonkpi region is higher than in the other regions. This is due to the fact that the Tonkpi region benefits from favorable agro-climatic conditions compared to the other northern regions where soils are not very fertile with low water retention capacity and irregular rainfall during the rainy season. Producers in these regions are therefore reluctant to take the risk of investing in crop diversification for fear of a sudden cessation of rainfall.

**Table 3 :** Factors influencing the crop diversification decision - probit model

Variables	Coefficients	Sdt. Err	Marginal effects	Sdt. Err
Male	0.869***	0.150	0.270	0.045
Age	-0.006*	0.003	-0.002	0.001
Instruction	-0.064	0.087	-0.020	0.027
Member of a farm group	0.185**	0.083	0.057	0.026
Household size	0.087***	0.015	0.027	0.004
The value of the farm equipment	0.375***	0.070	0.116	0.021
Distance to the parcel	-0.103**	0.049	-0.032	0.015
Distance	0.008***	0.003	0.002	0.001
Farmer	0.169	0.127	0.053	0.039
Formal credit	0.414***	0.113	0.128	0.035
Region				
Poro	0.232**	0.102	0.072	0.031
Tonkpi	1.303***	0.119	0.404	0.032
Constant	-2.915***	0.436		
Pseudo r-squared	0.158		Number of obs	1427
Chi-square	276.535		Prob > chi2	0.000
Akaike crit. (AIC)	1497.170		Bayesian crit. (BIC)	1564.834

Source : Author

### Determinants of the level of crop diversification

Table 4 presents the results of the second stage of the Cragg (1971) double-hurdle model. The use of truncated regression ensures that the coefficient estimates are interpreted in terms of the likelihood between the dependent variable (degree of diversification) and the independent variables. Thus, it was not necessary to generate marginal effects as in the first stage of the model. The results indicate that the coefficient for the age of

the household head is negative and significant at the 10% level, implying an inverse relationship between the age of the household head and the level of crop diversification. An increase of one year in the age of the household head reduces the level of diversification by 0.1%. This is explained by the fact that older producers are unable to manage several crops at once.

Membership in a producer group has a positive and significant effect at the 5% level, implying that

membership in a producer group increases the degree of diversification by 1.5%. In our study area, this can be explained by the fact that producer groups constitute mutual aid rotation groups in the members' plots. In this way, each member benefits in turn from the labor of his or her group for the various cultivation operations on his or her plot.

The coefficient on the number of youth in the household is negative and significant at the 10% level, implying an inverse relationship between the number of youth (adolescents) in the household and the level of diversification. The results indicate that an increase of one youth in the household reduces the degree of diversification by 0.5%. In our study area, this is explained by the fact that young adolescents are still dependent on the household and do not yet constitute an active labor force for the household.

The value of agricultural equipment (wealth) held by the household has a positive and significant effect at the 1% threshold, implying that an increase of 1 FCFA in the value of equipment increases the degree of diversification by 2.1%. Similarly, access to formal credit increases the level of diversification by 2.3%. This is because producer wealth and access to formal credit allow the producer to access essential productive resources such as inputs and quality land, and also to finance hired labor.

A surprising result is that the coefficient on total household plot size is negative and significant at the 1% level, implying an inverse relationship between total area and the level of crop diversification. When total household area increases by 1 ha, the degree of

diversification decreases by 0.2%. In our study area, this is explained by the fact that larger farmland requires more management skills, inputs and draught power, households are not always able to produce multiple crops (Assefa & Gezahegn, 2010). This finding is contrary to those of Benin *et al.* (2004), Fetien *et al.* (2009), Rehima *et al.* (2013), and Derso *et al.* (2022)

Distance to town has a negative and significant effect at the 1% threshold on the level of crop diversification. The results suggest that a one-minute increase in distance to town reduces the degree of diversification by 0.1%. This result is contrary to those of Dessie *et al.* (2019). In our study area, this is because distance from town reduces access to agricultural technologies such as improved seeds and fertilizers, discouraging any desire to increase the number of crops to be produced.

Finally, the availability of mechanization services, such as tractor services, has a significant and positive effect on the level of crop diversification. The availability of mechanization services in the producer's production area increases the degree of diversification by 4.4%. This is because mechanization is an effective way to reduce the time required to establish each crop in order to meet the agricultural calendar. In our study area, the sowing and harvesting periods for several crops coincide (rice, coffee - cocoa, etc.). In addition, these crops must be planted as soon as the first rains come. All of this creates crop competition. The availability of mechanization services in the village makes it possible to carry out planting, harvesting and post-harvesting operations of crops while respecting the agricultural calendar to avoid enormous losses.

**Table 4 :** Determinants of Level of Crop Diversification - Truncated Regression

Variables	Coefficients	Sdt. Err
Male	0.012	0.017
Age	-0.001*	0.000
Member of a farm group	0.015**	0.007
Household composition		
Number of children	-0.002	0.002
Number of youth	-0.005*	0.003
Number of adults	0.001	0.004
Number of elderly	-0.004	0.009
The value of the farm equipment	0.021***	0.006
Distance to the parcel	-0.003	0.004
Size of the plot	-0.002***	0.001
Distance	-0.001***	0.000
Availability of mechanization services	0.044***	0.008
Formal credit	0.023***	0.009
Constant	0.356***	0.038

Source : Author

## CONCLUSION AND RECOMMENDATIONS

The objective of this study was to analyze the determinants of the decision and degree of crop diversification among smallholder rice farmers in Côte d'Ivoire. Overall, the

study found significant factors influencing the decision and degree of diversification, such as age, household size, gender, farm group membership, value of farm equipment, distance to plot and town, total plot size, and

geographic location. The positive influence of access to formal credit on the decision and degree of diversification provides an incentive to improve access to formal credit for small-scale producers by improving the credit offer of microfinance institutions through flexible credit terms and closer ties to local branches. In addition, the availability of mechanization services in production areas encourages producers to increase their level of diversification. Thus, agricultural entrepreneurship programs should be initiated and encourage the installation of small and medium-sized agricultural enterprises in the field of mechanization. Finally, the creation of producer groups should be initiated and encouraged in order to facilitate information sharing and the adoption of new technologies. However, despite these satisfying results, this study did not establish the effects of participation in crop diversification on household income. It may be that producers who specialize make a much larger gain than their counterparts. Future studies could therefore address this issue in the case of Côte d'Ivoire.

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