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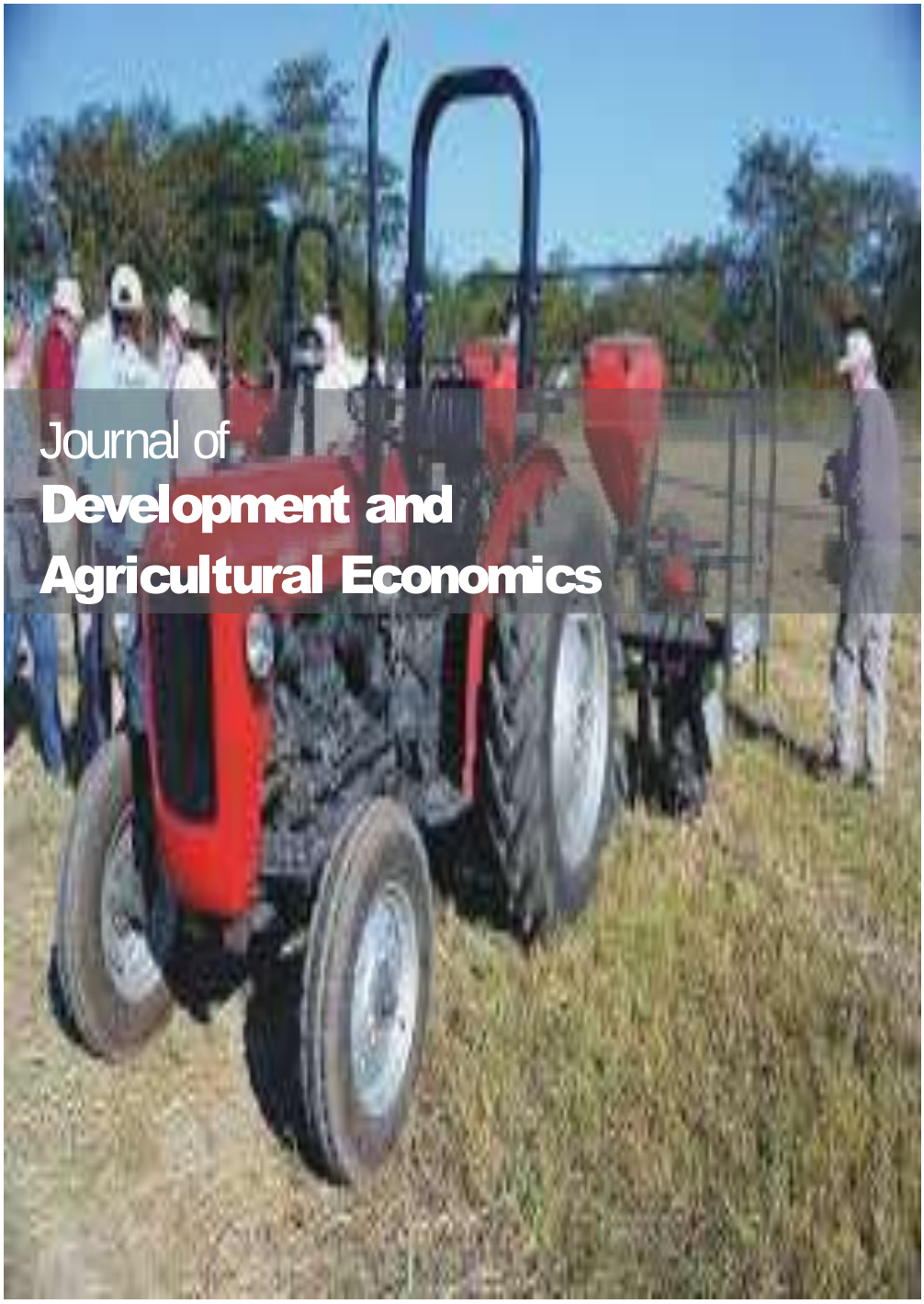

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Full Length Research Paper

Value chain analysis of fruits: The case of mango and avocado producing smallholder farmers in Gurage Zone, Ethiopia

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The study was aimed to analyze avocado and mango value chains actors and identify factors that determine avocado and mango market supply in the selected area of Gurage zone. A total of 259 avocado and mango producers were selected through three-stage sampling technique and 151 traders from different level were used to collect primary data using questionnaire and semi-structured interview. Descriptive and econometrics method of analysis were applied for analysis. Value chain approach analysis result revealed that input suppliers, avocado and mango producer, collectors, wholesalers, retailers, and consumers were the main actors in avocado and mango value chain. The profitability and gross marketing margin approach of market analysis showed that wholesalers received the highest marketing margin (34.62%) and highest profit share (36.75%), while producers received the least marketing margins (15.17%) from avocado and mango trade. Generally, all market participants were operating at profitable level, but producers were relatively disadvantaged from the market as they received lowest share from consumers' price. Moreover, sex of household, land allocated to mango, market distance, farming experience, extension service, market price, and family labor determined mango market supply. Likewise, education level of household, market distance, farm experience, extension service, and family labor affected market supply of avocado. Accordingly, market performance of avocado and mango has shown that producers were relatively disadvantaged and various determinants contributed to reduced market supply of mango and avocado. Therefore, strengthening of extension service and education of farmers, efficient use of family labor, and improvement of farmers' experience and infrastructure is recommended.

Key words: Avocado, mango, value chain.

INTRODUCTION

The fruit crops sub-sector is one of the strategic priorities as it plays a significant role in the local economy as a means of earning livelihoods for farmers, creating jobs and generating foreign exchange revenues in Ethiopia.

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The country puts greater emphasis on increasing production of fruit crops by nearly half at the end of Second Growth and Transformation Plan (GAIN, 2018).

Fruits are important ingredients of Ethiopian kitchen during fasting times. However, per capita consumption of fresh fruits in Ethiopia equals around 7 kg per person per year, which is 8 times lower than the average amount for the East Africa region, which stands at 55 kg per person per year and 21 times far below the World Health Organization (WHO) and Food and Agriculture Organization (FAO) recommended minimum level of dietary intake, and may be due to low income, below capacity production and weak dietary habits resulting from inadequate awareness of nutritional benefit (GAIN, 2018).

The production of fruit crops are estimated at 780,000 metric tons, nearly 760,000 metric tons of which is destined for domestic consumption. Mango (*Mangifera indica* L.) and avocado (*Persea americana* Miller.) are among the dominant fruit crops next to banana in terms of area coverage, total production and export value in Ethiopia. The South Western part of Ethiopia is the key production belt for them. The production of mango and avocados are contributing to 14 and 10% of the national fruit production years, respectively, covering about 18 and 15% of the harvested area of fruit crops in the country, respectively. South Nation and Nationalities (SNNPR), Oromia, and Amhara regional states are the major growing areas of edible fruits. These regions have the largest potential for production increases using rain-fed as well as irrigated commercial farming systems (CSA, 2017).

There has been increased progress in production and consumption of fruits. The production and cultivated land for mango and avocado were increased by half over the last five years (CSA, 2017). However, the national average yield of fruits in general, mango and avocado in particular showed fluctuation and vary across these fruit crops. Hence, yield per hectare for mangos had declined whereas yield of avocados has increased during these five-year periods (GAIN, 2018).

Moreover, fruits are important source of income for millions of households in Ethiopia. This is also true for producers, traders and processors found in the study area. However, sustainability in fruit production like mango and avocado becomes questionable as a result disorganized marketing and value chain actors' coordination system (Nega et al., 2016). Unsustainable supply of these fruits was a result of dynamic changing of the consumers taste in urban areas, rain fed dependent production, and subsistence-oriented level of production is great problem for development of agriculture in developing countries (ACET, 2012).

Gurage zone, where this study was conducted, is one of the potential areas where large varieties and amount of fruit crops were cultivated. However, downstream value chain actors of fruit value chain namely consumers and processors were always constrained by ineffective fruit value chain development, which leads to great price fluctuation, high consumer with low producer price and absence or few market provisions. There is no effectively developed fruit value chain working mechanisms in the study area and most value chain actors were targeted to enhance his/her own benefit, and also compete with other actors with in fruit value chain. This shows that there are certain factors that hinder the producers not to get the direct market chain so as to benefit from better price and also obtain better profit for their resources.

In spite of all the aforementioned constraints, this study was aimed to identify the value chain actors and their role, assess the value share among participants, and identify determinant factors of avocado and mango market supply in the study area.

RESEARCH METHODS

Description of the study area

The study was conducted in Gurage zone (Figure 1). It is located 155 km south of Addis Ababa, capital city of Ethiopia. Abeshge, Cheha and Kebena are among 13 districts under the Zone with a relatively great potential in avocado and mango production. A total population of 73,123, 62,353, and 14,644 were living in Abeshge, Kebena and Cheha, respectively (CSA, 2016).

Data sources and collection methods

The data was collected from primary and secondary data sources using formal and informal sample survey method. Primary data were collected through pre-tested structured and semi-structured interview schedules.

The primary data that were gathered from farmers include educational level, credit and extension service availability, farming experience, cost of production, quantities produced and sold, potential buyer of their product, and price related information, quantity of avocado and mango sold in 2016/17 production year.

Secondary data were collected from the Central Statistical Agency, published and unpublished sources, District Agricultural and Natural Resource Office, and Trade and Industry Office of the districts.

Sampling method and sample size

Three stage sampling technique were employed to obtain representative respondents. In the first stage, out of 13 districts in Gurage Zone, 3 districts, namely Abeshige, Cheha and Kebena districts were selected based on their avocado and mango based on their relative production potential. Then, in the second stage, 3 *kebeles (county)* from each district were selected randomly. Finally, out of 3765 avocado and mango producers, 259 were selected randomly using probability proportion to population size sampling technique.

The total sample size (n=259) was determined following a simplified formula provided by Yamane (1967). Accordingly, the required sample size at 90% confidence level with degree of variability of 5% and level of precision equal to 6% were used to obtain a sample size required to represent the true population.

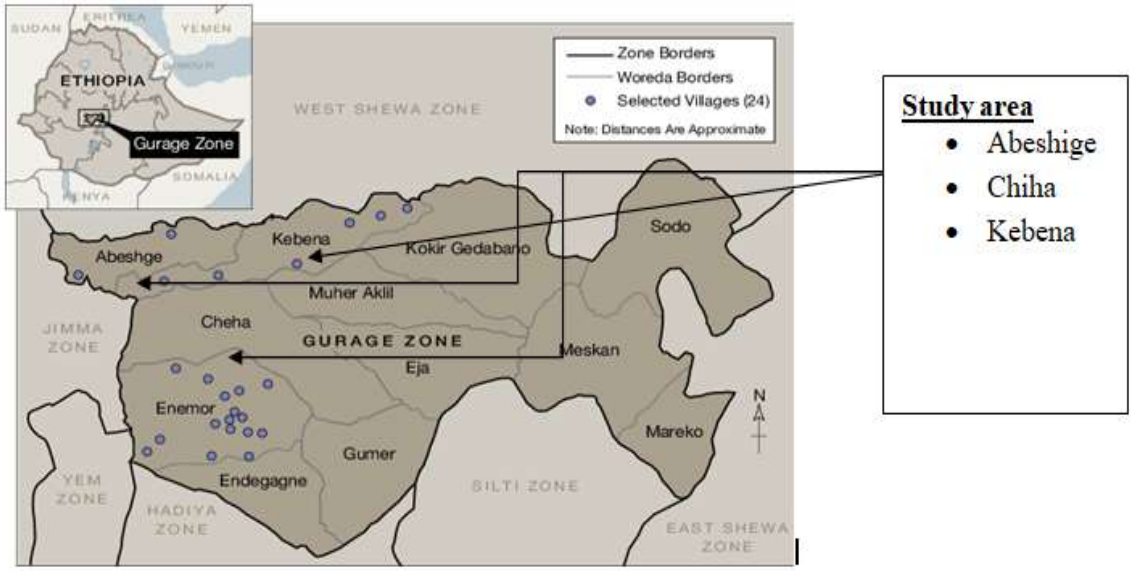

Figure 1. Location Map of study site.

$$n = \frac{\mathrm{N}}{1 + \mathrm{N(e)}^2}$$

Where: n = sample size, N = population size (sampling frame) and e = level of precision.

Using the above formula 85, 83 and 91 farmers producing both fruits were selected from Abeshige, Cheha and Kebena district, respectively. Besides about 46, 11, 20, 50, and 24 collectors, processors, wholesalers, retailers, and consumers were randomly taken, respectively.

Methods of data analysis

Descriptive method of analysis specifically value chain approach and gross margin approach were applied to map the value chain of these fruits and to estimate value share of market participants, respectively. Furthermore, econometrics model was employed to examine factors that had effects on supply of mango and avocado.

Value chain approaches were used to identify actors, their interaction and roles in avocado and mango value chain. The following stages were followed in value chain analysis. In the first stage, the main value chain actors and their roles were identified and mapped. Then, based on the direction of product flow, the existing market channels were designed. Likewise, gross market margin approach was used to analyze value share among avocado and mango participants. Hence, gross market margin in each market participants was calculated as follows (Mendoza, 1995):

$$\textbf{Market margin} = \frac{\textbf{Consumer price} - \textbf{Producers price}}{\textbf{Consumers price}} \textbf{x 100}$$

Producers share from consumer price was calculated as:

$$\text{Producer share} = \frac{\text{Consumer price} - \text{Market margin}}{\text{Consumers price}} \text{x } 100$$

Traders share was calculated as:

$$\text{Traders share} = 1 - \frac{\text{Market margin}}{\text{Consumers price}} \text{x } 100$$

Multiple linear regression model was employed to identify factors affecting market supply of avocado and mango in the study area. The model was selected from other models with the reason that, all sampled mango and avocado producers have been supplied their produce to market. The dependent variables as continuous variables were measured as the amount of avocado and mango marketed by sampled households in 2016/17 production year in quintal. A combination of both quantitative and qualitative explanatory variables was hypothesized and used to determine the significant effect of each set of explanatory variables on the dependant variables. Accordingly, the econometric models were developed based on Green (2003) and specified as below

$Yi = \alpha i + ß_1 Sex + ß_2 Age + ß_3 Family\ size + ß_4 Education + ß_5 familylabour + ß_6\ Distance + ß_7\ Experience + ß_8 labour\ source + ß_9 Extension + ß_{10} Price + ß_{11}\ Diffculty\ buyer + U_i$

Where: Yi= quantity of mango and avocado supplied to market, αi= intercept, βi =coefficient of i^{th} explanatory variable, Ui= disturbance term.

Three most important diagnostic tests were done, namely; heteroscedasticity, specification of error and multicollinearity. Heteroscedasticity problem was observed in data set and then robust command was used to overcome the problem.

RESULTS AND DISCUSSION

Demographic and socio-economic characteristics of farm households

Primary data were collected from a total of 259 sampled

Table 1. Demographic and Socio-economic characteristics of farm households.

Continuous/ discrete variable	Mean	Minimum	Maximum	Standard deviation
Age (year)	49.46	19	67	10.34
Family size (number)	2.35	2	6	2.74
Educational level (year of schooling)	1.75	0	10	3.09
Experience to mango production (year)	11.57	7	31	8.21
Experience to avocado production(year)	12.37	7	25	9.3
Distance from nearest market (walking hour)	0.325	0.1	1.25	0.658
Frequency of extension contact (number)	1.85	0	7	4.25
Dummy/ categorical variables			Proportion	
Sex of a household head (male)			0.847	
Marital status				
Single			0.188	
Married			0.707	
Divorced			0.032	
Widowed			0.073	

Source: Computed from Survey Data (2016/2017).

households found in Abeshge, Cheha and Kebena districts of Gurage zone. The list of variables used in the analysis of the study is given in Table 1. About 84.7% of the respondent was males whereas about 70.7, 18.8, 3.2, and 7.3% of the sample respondents were married, single, divorced and widowed, respectively.

The overall mean age of the sampled respondents were 49.46 years with standard deviation, maximum and minimum age of 10.34, 67 and 19, respectively. The mean year of schooling of respondents was 1.75 years. On average, the respondents were contacted by development agent 1.85 times per year. The average family size of a household was 2.35 and the respondents travelled 0.325 h to reach nearest market to supply mango and avocado. Moreover, the mean mango and avocado production experience of respondents was 11.57 and 12.37 years, respectively.

Map of mango and avocado value chain

As depicted in Figure 2, value chain map involves various linkages among the growers, input suppliers, transporters, and traders of mango and avocado. The value chain map for the three districts followed similar trend and mapped together including main actor, activities and supporters. The map illustrated function of the main actors in the left, main actors on the middle, and supporters on the right side with all of them lying vertically.

Value chain actors and their roles

Mango and avocado value chain actors were those individuals or stakeholders who engaged in any field of activities or service provision either directly or indirectly at any stage of the value chain.

Input suppliers: these could provide inputs for avocado and mango producers. Based on the result obtained from the study, most of avocado and mango farmers used their own seed and organic fertilizers like compost and manure for their production. District agricultural office, primary cooperatives union, other farmers, and local markets were also alternative input providers for farmers in the study area. Takele (2014) also stated that the major sources of inputs for mango production in Ethiopia are farmers by own endeavors, agricultural offices and markets.

Avocado and/or mango producers: these were smallholder farmers who grew mango and avocado, and supplied such to wholesalers, retailers, processors and local collectors. They could perform value addition activities like sorting and transporting to get additional benefit. They would stay in long period in both production and marketing of fruits like avocado and mango and tried to benefit from available opportunities. However, most of the farmers in the study area were challenged by post harvest handling problem, lack of linkage among participants (91.97%), and inability of using technology to produce. According to Bezabih (2010), the producers are mainly smallholder farmers who supply the product to the local traders, cooperatives, retailers and consumers.

Local collectors: these were actors collecting mango and avocado fruits either from farmers' farm or other farmers in relatively lower price and supplying it to wholesalers, retailers and consumers. Collecting, buying, assembling, repacking, sorting, transporting and selling

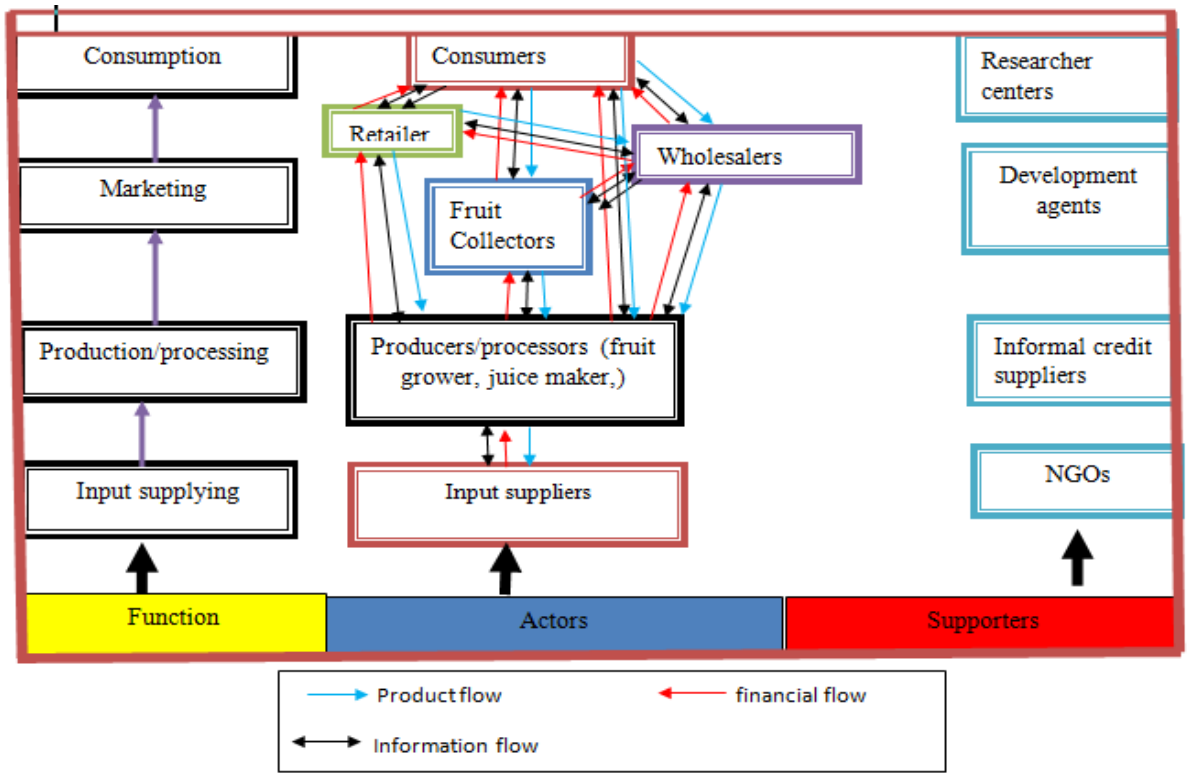

Figure 2. Value chain map of Mango and Avocado in the districts.

were some of the activities done by them. They often received cash from wholesalers either after or before selling. The flow of finance was coming only from the buyer's side. The collected product was mostly supplied to Gubrie, Emdibir and Wolkite Markets which were found in the zone. The traders organize teams of 'brokers' to pick mangoes at the farms and then pack them onto trucks which leave directly for marketing; also, it is an effective operation for the traders; though it does mean that farmers are unable to derive further value from their crop through effective picking, grading, packaging, bulking and marketing (James et al., 2008).

Wholesalers: were those who bought large quantity of avocado and mango and then sell to the other traders. They purchased the fruits from other actors like producers and resold it to retailers (57.1% mango and 55.2% avocado) and consumers (42.9% mango and 44.8% avocado). They also had better information and financial capacity to get bulky commodities rather than other actors.

Retailers: were the main participants, who purchased the fruits from either producers or wholesalers in small volume and delivered them to consumers. They had limited working capital and handling relatively small volume of avocado and mango compared to other traders.

Consumers: were those who bought avocado and mango fruits for consumption. Restaurants, fruit juice householder, travelers, producers and residents were among the consumers in the study area.

Market performance of avocado and mango

Marketing margin and marketing profits were used to analyze the performance of avocado and mango market; and the average purchasing price, marketing cost and selling price were used to estimate the profit margin share of each market actors. Producers, collectors, wholesaler and retailers were important market actors in avocado and mango value chain.

As illustrated in Table 1, the market margin share of avocado producers, collectors, wholesalers, and retailers were 15.17, 16.24, 34.62 and 33.97%, respectively. The profit share of avocado producers, collectors, wholesalers, and retailers were 18.09, 13.41, 36.75, and 31.75% respectively. Likewise, the percentage market share of mango producers, collectors, wholesalers, and retailers were 17.51, 16.27, 36.01 and 30.21, respectively. The percentage profit share of the producers, collectors, wholesalers, and retailers were 21.72, 14.57, 38.31 and 25.40%, respectively. Generally, the performance result implied that all market actors for both fruits were operated at profitable level. The share of producers was less than

traders and consequently producers were relatively disadvantaged from avocado and mango market.

Determinant of marketed supply

Based on multiple linear regression models, the F-value of the model from the analysis was 87.7 and 28.59 for mango and avocado, respectively. This implies that the fitness of the model to explain effect of hypothesized variable was satisfactory and it was significant at 1% significant level. Coefficient of multiple determinations (R^2) showed 65.25 and 56.25% of the variation in the farm level market supply of mango and avocado, respectively were explained by the hypothesized explanatory variables.

The model output (OLS estimation) revealed that, among the hypothesized 11 variables only seven of them, namely sex of household, land allocated for mango, distance to nearest market, farm experience, extension service, price information, and family labor were found to be significantly determined marketed supply of mango.

Sex of household head: This variable had a negative and significant effect on the volume of mango market supply and it was significant at 10% significant level. Male household heads could supply 9.34% less mango to the market than the counterpart, keeping other factors constant. Traditionally, fruit is assumed to be grown around home and more likely to be grown by females. As a result, decision to supply and meeting households' requirement belongs to females.

Land allocated to mango: This variable was significantly and positively related with the amount of mango supplied to the market and it was significant at 1% level. As size of land allocated to mango increased by one hectare, the amount of mango supplied to the market increased by 17.12 qt. This result was similar to the finding by Addisu (2016) and Aman et al. (2014) who found that the size of land allocated for horticultural crops and potato, respectively increased quantity of produce available for sale.

Distance to nearest market: This negatively and significantly affected the market supply of mango at 1% level. As distance between households and nearest market increased by one waking hour, market supply of mango decreased by 1.29 qt keeping other factors constant. Therefore, remoteness to market determined market supply trends of both fruits due to the fact that far market leads to higher market cost and thereby reduces household's interest to produce more fruits for market. This result was consistent with the work of Holloway et al. (1999); Wolday (1994) and Ayelech (2011) who indicated that distance to market caused market surplus to decline.

Experience in mango production: This variable significantly and positively determined mango market supply at 1% significant level. The result revealed that as experience of mango farmer increased by one year, the mango supplied to market increased by 2.46 qt. This result was in line with Abriham (2013) who found that as the farmer's farming experience of vegetable production increased by a year, the market supply of vegetable also increased.

Extension service: This variable was significantly determining marketed supply of mango at 5% significant level. As number of extension contact increased by one additional contact, the marketed supply of mango increased by 2.06 qt, keeping other factors constant. The reason behind this may be as the farmer gets more extension service, they could have full information about the market and supply mango in the market. Study by Ayelech (2011) who revealed extension service avails information regarding technology which improves education that affects the marketable surplus.

Price of mango: This variable was significant at 5% level and positively related with marketed supply of mango. As the price of mango increases by one birr, the quantity of mango supplied to the market will decrease by 24.72 qt, keeping other factors constant. This may be due to the reason that price serves as an incentive for producers to increase production and marketed supply. The result was in agreement with the study by Ayelech (2011) who confirmed that a unit price increase in the avocado market directs to the household to increase yearly avocado sales to market. The result also coincides with the findings of Wolelaw (2005) who stated that as the price for products in the market increased, there will be higher supply of products.

Active labor force: This variable was negatively associated with mango marketed supply and it was significant at 1% level. As family labor increased by one-person, marketed supply of mango decreased by 5.74 qt. Most producers used family labor source for mango production which is characterized by inefficient use of resource including time, thus reducing mango production and productivity. In other word, as production declined, fewer amounts of the products are available for sale and thereby affecting marketed supply. According to Wolday (1994), marketable supply of agricultural product could be affected by family size, access to labor and age.

Similarly, five variables namely educational level, extension service, farm experience, labor sources, and distance from nearest market significantly affected marketed supply of avocado in the study area.

Education level of household: As hypothesized, this variable positively and significantly determines the volume of avocado marketed at 1% significance level. As

years of schooling of household heads in formal education increased by one year, the amount of avocado supplied to market increased by 8.11 qt, keeping other factors constant. This implied that spending more years in formal education would improve household ability to gain new knowledge and encourage producers to be market oriented. This is also in line with previous studies conducted by Ayelech (2011) and Amare (2013), who found that if avocado and pepper producers gets educated, the amount of avocado and pepper supplied to the market increases, respectively.

Distance to the nearest market: Distance from market had a negative and significant effect on the supply of avocado to the market and it was significant at 1% level. This means that as distance from nearest market increased by one hour on foot, the volume of avocado supplied to market decreased by 1.13 qt, keeping other factors constant. The result is consistent with the finding by Abriham (2013) who illustrated the inverse relation distance to market on the cabbage market supply.

Experience in avocado production: It was significant at 10% level and affected the volume of avocado marketed as expected. Thus, the result implied that, as farmer's experience increase by one year, the avocado supplied to market increased by 0.72 qt. This result coincided with works of Ayelech (2011), El et al. (2013) and Addisu (2016) who illustrated that as farmer's experience increased, the volume of avocado, crops supplied and onion to the market has increased, respectively.

Frequency of extension contact: As hypothesized, this positively determines marketed supply of avocado and was significant at 1% level. One more additional contact of extension agent with avocado producers'increases marketed supply of avocado by 2.85 qt. The result implied that number of frequent extension service contact helps producers in availing an up-to date production and market information, which in-turn enhances marketed supply of the fruit.

Active labor force: This negatively and significantly determined the marketed supply of avocado at 1% significant level. As active labor source increased by one person, the quantity of avocado supply to market decreased by 5.9 qt, keeping other factors constant. This might be due to family members acting as source of labor with family members not readily giving due attention to the production decline as a result of carelessness. This may in turn reduce the marketed supply of avocado. This result is in contrast with the finding by Derib (2014) that the positive relation implies that the more the farming household is likely to get access to labor force from any source, the higher is the probability that the family's interest to farm more size of land and produce surplus thereby quantity of supply to the market would increase.

CONCLUSION AND IMPLICATIONS

Input suppliers, avocado and mango producers, local collectors, wholesalers, retailers were identified as a main value chain actor for both fruits. However, value chain of both mango and avocado was ineffective due to poor horizontal/vertical coordination and integration; competition with actors in the chain; inadequate support from enablers and financial institution in the study area. The market performance of avocado and mango has shown that producers were relatively disadvantaged from avocado and mango market and thus it was not performing well. Various determinants contributed towards reduced market supply of mango and avocado. Therefore, an adjustment on significant socio-economic and institutional factors may enhance and increase the market supply of mango and avocado in the study area.

Based on the findings of the study, the following relevant implications were drawn:

i) Strengthening of value chain actors' linkage.
ii) Promoting collective marketing to ensure farmers benefit from produce by collective marketing.
iii) Extension service and farmers' education needs to be greatly strengthened.
iv) Infrastructure like road accesses, continuous price and labor force used information should be improved.
v) Farmers should be trained in their farms to enhance their experience.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Determinants of intensity of uptake of alternative pest control methods: A case of small- scale tomato farmers in Kenya

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Inappropriate use of chemical pesticide in horticultural production is an emerging problem causing undesirable human health and environmental effects in developing countries including Kenya. Thus, objective of this study is to evaluate the determinants of the intensity of uptake of alternative pest control methods among small-scale tomato farmers in Nakuru County, Kenya. Multistage sampling procedure was used to select a sample of 384 tomato farmers. Data were collected using a semi-structured questionnaire administered by trained enumerators. Alternative pest control methods which were identified during the survey were categorized into four groups using principal component analysis. Determinants of the intensity of uptake of alternative pest control methods were estimated using multivariate tobit model. Group membership, age, education and number of training increased the intensity of uptake of alternative methods. Participation in off-farm activities and farm size decreased the intensity of uptake of alternative methods. These results indicate that farmers' awareness that involves comprehensive training programs and enhancing the capacity of farmer groups as change agents is warranted. Moreover, these research findings could also inform policymakers while formulating and implementing targeted interventions aimed at promoting the use of alternative pest control methods that minimize negative health and environmental effects from overuse of pesticides.

Key words: Alternative pest control, pesticides, intensity, food safety, multivariate tobit model.

INTRODUCTION

Tomato, *Solanum lycopersicum* L. is one of the chief vegetable crops in Kenya. It is rich in minerals and vitamins (C) which make it an imperative nutritional component among households in Kenya (Sigei et al., 2014). It is consumed either in raw form (salads) or processed form such as tomato paste or tomato sauce.

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Moreover, it contributes towards poverty alleviation through the creation of employment, income generation and earning foreign exchange (Sigei et al., 2014). Despite its crucial role in the development of the national economy, farmers are faced with insect pest and disease outbreak which is a major production constraint (Waiganjo et al., 2006). They cause crop loss leading to loss of farm income. Some of the common tomato diseases comprise mildew, blight, leaf spots and wilt. Examples of tomato pests include cutworm, leaf miners, nematodes, bollworms, *tuta absoluta*, spider mites, thrips, whiteflies and aphids (Desneux et al., 2010; Mueke, 2015; Sigei et al., 2014). To address this problem, farmers employ numerous methods including chemical methods for crop protection against pests and to prevent crop loss hence increasing agricultural output. However, small-scale farmers heavily depend on chemical pesticides to combat pest problem which has raised public concern due to food safety issues, adverse human health and environmental effects (Macharia et al., 2009; Macharia et al., 2013).

Alternative pest control methods such as mechanical control, planned crop rotation, biological control, cultural control and use of biopesticide could provide a pathway to minimize the use of chemical pesticides leading to improved food safety, human health and conservation of the environment. In spite of efforts by the government and non-governmental organizations to promote use of alternative crop protection methods, the intensity of uptake is still unclear. In addition, the role of risk perception, socio-economic and institutional factors in influencing the intensity of uptake of alternative pest control methods is still not clear in the empirical literature. As the studies focusing on households` determinants of intensity of uptake of alternative pest control methods are limited, thus the objective of this paper is to examine the determinants of the intensity of uptake of alternative pest control methods among small-scale tomato farmers in Kenya. Hence, it is on this background that the study is geared towards filling these knowledge gaps among small-scale tomato farmers in Nakuru County. Knowledge and information acquired through the study will enable policymakers to design effective research and educational programs aimed at promoting an alternative to pesticide use leading to improved human health and conservation of the environment.

Prior studies have described decision on adoption of environmentally-friendly pest management methods as dichotomous choice representing adoption or non-adoption of alternative pest management strategies. In such a scenario, individual practices have been aggregated prior to analysis so to assess the factors influencing the adoption decision. This has yielded useful insights on drivers of adoption of such crop protection methods. However, such models neglect the effect of factors on the intensity of adoption and diversity of pest management practices utilized. Thus using a ratio of number of practices adopted from a portfolio of pest control methods enables us to group farmers into different subgroups hence facilitating the understanding why fewer or more practices are adopted from a specific group and drivers thereof.

First, we use multivariate tobit model to explain factors influencing the intensity of uptake of alternative pest control methods paying particular attention to interdependence and diversity of pest control methods employed by farmers. Our results indicate significant complementarity and substitutability in the decision on the intensity of uptake of pest management strategies. Although there is a plethora of literature on the influence of a host of explanatory variable on adoption of alternative crop protection methods, our study provides new evidence on policy related variables such as farmers' perception of pesticide use hazards. The information acquired through the study could be used to design research and outreach programs geared towards promoting agricultural sustainability through use of eco-friendly crop protection methods.

METHODOLOGY

Study area

The study took place in Nakuru County. It is among the leading tomato producing areas in Kenya with close proximity to Nairobi area which is among the largest urban tomato market. The county is located within the Great Rift Valley. It is situated at latitude 0°13 and 1°10` South and longitudes 35°28' and 35°36' East. The area receives bimodal rainfall. Long rains occur during the months of March to May. Short rains occur during the months of October to November (GoK, 2013). Agriculture is the major economic activity in the region. The main crops grown in the area include tomato, maize, beans, kales, wheat, carrots, peas, onions, french beans, strawberries, and other fruits. Figure 1 represents a map of the study area.

Sampling procedure and the data

The study employed a multistage sampling procedure to select the respondents. First, Nakuru County was purposively chosen. Subukia Sub-county was selected because it is one of the major tomato producing areas as guided by the agricultural extension personnel. Subsequently, Subukia and Weseges wards were randomly selected. Finally, farm households were selected using a simple random sampling method guided by a sampling frame generated by local agricultural extension officers. The sample consisted of three hundred and eighty-four households. Primary and Secondary data were used during the study. Primary data were obtained through a household survey which took place during the month of November 2017. A semi-structured questionnaire which was administered to the respondents by well-trained enumerators through face to face interviews was used for data collection. A pretest of the questionnaire took place before conducted the actual survey to test its suitability. Secondary data were obtained by reviewing the relevant literature. Subsequently, data were coded and entered into SPSS (version 20) and Stata (version14) software for analysis.

Table 1 summarizes the variables that are used in the

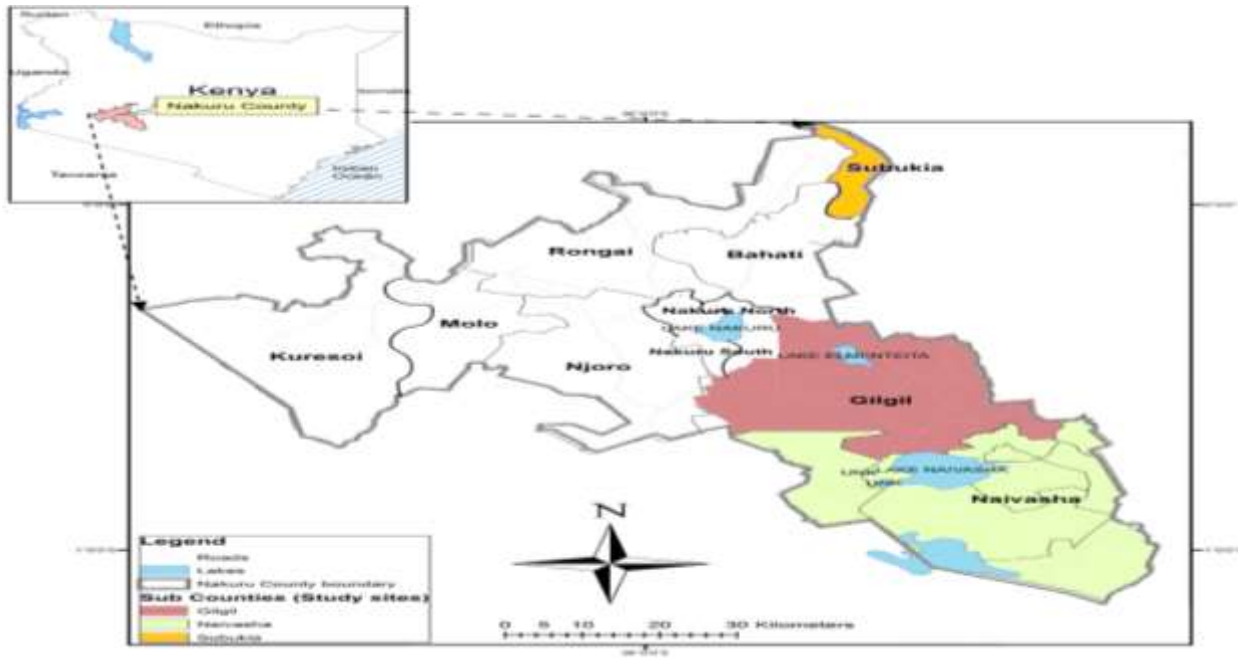

Figure 1. Location of the study area in Nakuru County, Kenya.

Table 1. Description of variables in the multivariate tobit model.

Variable	Description
Dependent	
Intensity of uptake	Ratio of the number of practices adopted from each group of alternative pest management methods (ranging from 0 to 1)
Independent	
Age of household head	Age of the household head in years
Gender of household head	Gender of the household head where 1= male, 0 = otherwise
Education of household head	Number of years of schooling of the household head
Household size	Number of people living in the household for the last six months.
Off-farm income	Participation in the off-farm activity where 1= yes, 0 = No.
Farm size	Total farm size in acres
Risk perception with respect to human health	Perceived pesticide use hazards on human health where 1=strongly disagree, 2= disagree, 3= uncertain, 4 = agree, 5= strongly agree.
Group membership	Number of groups that the farmer belongs to.
Extension contact	Number of contacts with extension service provider.
Credit access	Access to credit where 1= yes, 0= otherwise
Training	Number of training on pest management that the farmer participated in.
Customer orientation	Attitude towards customer`s demand during tomato production and marketing where 1=strongly disagree, 2= disagree, 3=uncertain, 4=agree, 5= strongly agree.
Information source	Dummies of the main primary source of information on pesticides use and agriculture in general (fellow farmers, pesticide retailer, pesticide company and media).

econometric analysis. They were derived from review of previous studies (Zyoud et al., 2010; Hashemi and Damalas, 2011; Kassie et al., 2013; Rahman, 2013; Khan and Damalas, 2015; Mengistie et al., 2015; Riwthong et al., 2016; Sharif et al., 2017). Risk perception with respect to human health and customer orientation was measured using a five-point Likert scale ranging from 1(strongly

disagree) to 5(strongly agree). To generate a score for each concept, several items relating to each construct were analyzed using factor analysis. The results from factor analysis are presented in Appendix A Table A1. Cronbach`s alpha coefficients were evaluated to check the reliability of the unobservable concepts (Mackenzie et al., 2011). The composite reliabilities of the constructs ranged from 0.40 to 0.54. The Kaiser-Meyer-Olkin (KMO) test (values ranged from 0.50 to 0.67) showed that the sample was relatively adequate and suitable for factor analysis. In addition, continuous explanatory variables were subjected to variance inflation factor test (Appendix A Table A2) to examine the problem of multicollinearity. The VIF values were less than the recommended threshold value of less than 5 (Hair et al., 2011) hence multicollinearity was not an issue (Table 1).

Analytical framework

Farmers use a variety of alternative methods in crop protection. Examples of alternative (non-chemical) pest control methods include; cultural methods, biological control and use of biopesticides. Cultural methods involve pest management by manipulation of the environment or implementation of preventative practices. It includes; planting disease-resistant varieties, planned crop rotation, weeding, pruning and mulching to mention but a few. Biological methods refer to use of other organisms to manage pests (insect, weeds and diseases). It involves predation, parasitism, herbivory and other natural mechanisms. Biopesticides are crop protection products which are obtained from natural materials such as animals, plants, and bacteria. Thus farmers are faced with various pest control methods which may be adopted simultaneously and or sequentially as supplements, complements or substitutes. This implies that the number of methods adopted may not be independent but interdependent. Therefore, farmers will choose a set of strategies that maximize expected utility. Accordingly, the decision on the extent of adoption is multivariate and applying univariate approach might exclude relevant information contained in interdependent and concurrent adoption decisions (Ali et al., 2012).

Consistent with Mugi-Ngenga et al. (2016), the study initially employed Principal Component Analysis (PCA) to categorize different pest control strategies into groups. It is a statistical technique for discovering unidentified trends and simplifying the description of a bundle of interrelated variables by decreasing dimensionality of data. It performs a covariance analysis between factors and identifies a pattern of association between variables which in this case are pest control strategies.

Subsequently, multivariate tobit model was used to analyze the role of risk perception, socio-economic and institutional characteristics on the intensity of uptake of non-chemical pest control methods. The model concurrently estimates the effect of a set of explanatory variables on each of the dependent variables while allowing the stochastic error terms to be interrelated (Ma et al., 2006; Gillespie and Mishra, 2011). Contrary, univariate tobit models ignore such correlation of disturbance term as well as the relationship between the intensity of adoptions of diverse pest control strategies. This might lead to bias and inefficient estimates. The multivariate regression can be written as follows (Ali et al., 2012);

$$Y_{ij}^{*} = X_{ij}\beta_i + \varepsilon_{ij}, \text{ Where, j= 1,..,M and i = 1,…,n} \quad (1)$$

$$Y_{ij} = Y_{ij}^{*} \; if \; Y_{ij}^{*} > 0, 0 \; if \; otherwise \quad (2)$$

Where, j=1,..., M represents available alternative pest control strategies.

Y_{ij}^{*} = A latent variable which captures the unobserved preferences; X_{ij} = a set of independent variables (risk perception, socioeconomic and institutional characteristics); ε_{ij}= stochastic error term and Y_{ij}= observable variable denoting the ratio of the number of strategies adopted from available alternatives.

Equation 2 was estimated due to the latent nature of the dependent variable.

RESULTS AND DISCUSSION

Characteristics of farm households

Table 2 presents a brief description of interviewed households. The results show that small-scale tomato production is mostly male-dominated and with elderly people. The farm household heads had acquired a basic education (at least primary education) which is important in making farm decision relating to crop protection.

The farmers had an average of five members per household and seven years of farming experience. Majority of them cultivates land less than a hectare in area and belonged to at least one farmer group. In addition, the respondents had a minimum of one training program and had at least one contact with the extension service provider. The majority of respondents acquired information from other farmers.

Identifying and grouping alternative (non-chemical) pest management methods

In this study, majority of the farmers were using cultural methods as an alternative technique for dealing with the pest problem. However, none of the farmers utilized biological controls and biopesticides. Failure to use some of the alternatives to chemical pesticides was attributed to unavailability (41.93%), lack of awareness of other methods (28.13%), being ineffective (19.01%) and costly to use (10.94%). Ten non-chemical crop protection methods actively used by farmers were identified at the field during the survey. To facilitate further econometric analysis, identified practices were classified into four groups (components) using principal component analysis (Table 3).

The approach involves categorizing related practices into components to facilitate subsequent analysis by fitting the groups into the model and drawing conclusion. Unlike conventional techniques of grouping practices, use of principal component approach is favorable in drawing conclusion about a cluster in cases where few practices may represent the entire group. The approach is useful in reducing the dimensionality of data without losing much information. To arrive at the four principal components, orthogonal varimax rotation method (Goswami et al., 2012) was used so that lesser number of highly interrelated practices would be classified under each cluster for easy interpretation and generalization about

Table 2. A summary of household characteristics.

Variable	Mean	Std. Err.
Age of Household head	40.375	0.5934
Gender of household head (male=1)	0.7813	0.0211
Education of household head	10.8333	0.1446
Household size	4.3854	0.0934
Participation in off-farm activities	0.4219	0.0252
Farm size (acres)	1.7945	0.0710
Group membership	1.2630	0.0574
Extension contacts	1.0833	0.0486
Access to credit	0.4115	0.0251
Training	0.8984	0.0474

Table 3. Principal components of alternative methods of pest management.

Practices	Components				Communalities(%)
	1	2	3	4	
Crop residue destruction	0.785	0.065	-0.069	0.068	0.64
Irrigation	0.901	0.062	0.025	0.011	0.82
Efficient use of fertilizer	0.701	-0.366	0.049	0.015	0.64
Pruning	0.057	0.812	0.029	-0.032	0.67
Use of traps	0.004	0.827	-0.014	0.021	0.69
Intercropping	-0.023	-0.082	0.835	-0.017	0.74
Mulching	0.008	0.102	0.668	0.096	0.60
Weeding	0.146	-0.027	0.632	0.150	0.61
Crop rotation	-0.003	0.019	-0.003	0.910	0.83
Improved crop varieties	-0.055	0.013	0.064	0.837	0.74
Eigenvalues	2.006	1.274	1.124	1.051	
% Eigen values contribution	22.286	14.159	12.491	11.677	
Cumulative percentage	22.286	36.445	48.936	60.613	

Extraction method, Principal Component Analysis; Rotation method, Varimax with Kaiser Normalization.

the group. Consequently, Kaiser criterion was taken into consideration where components with Eigenvalues greater than one were retained (Kaiser, 1958). In this case, only variables with high factor loadings (greater or equal to 0.03) were considered for interpretation of the varimax rotation (Kamau et al., 2018). The clusters and their corresponding factor loadings (coefficients of linear combinations) are presented in Table 3.

With regard to the percentage of explained variance, the retained components explained 60.61% variability in the dataset. This presents a good fit indicating that the results from principal component analysis explained the data. Visually inspecting each column in Table 3 facilitates in understanding the contribution of each component in explaining the variability in the dataset. The first component explained 22.29% of the variance while the second, third and fourth components explained 14.16, 12.49 and 11.68% correspondingly.

Taking a closer look at each column in Table 3 helps to describe each cluster based on the strongly related practices. The first group (Component 1) comprises crop residue destruction, irrigation and efficient use of fertilizer all with positive factor loadings. Pruning and use of traps both with positive loadings belong to the second cluster (Component 2). The third component constitutes intercropping, mulching and weeding all with positive loadings. Finally, crop rotation and use of improved crop varieties belong to the fourth cluster both with positive coefficients of linear combination. The communality column represents the aggregate variance of each variable retained in the four components. In this case, all items in the principal components meet the minimum criteria (communality of above 0.6) as they accounted for more than sixty percent of the variance in the components (MacCallum et al., 2001). Table 4 provides a summary of groups of non-chemical pest control methods.

The most used cluster of alternative pest management

Table 4. Descriptive statistics of non-chemical pest management methods.

Categories of alternative methods	Percentage of users	Constituents
Crop management practices	98.70	Crop residue destruction Irrigation Efficient use of fertilizer
Preventive measures	97.14	Crop rotation Use of improved crop varieties
Control measures	95.32	Weeding Intercropping Mulching
Mechanical methods	66.23	Pruning Use of traps

methods was crop management practices with 98.7% of farmers utilizing it (Table 4). This group constitutes crop residue destruction, irrigation and efficient use of fertilizer. Maintaining field sanitation through crop residue destruction reduces the build-up of pests and spreading of insect and diseases to other crops. Avoidance of water stress through irrigation facilitates suppressing pest population which thrives well due to inadequate provision of water. Provision of adequate nutrients through fertilizer application that enhances crop growth alters soil pH, hence reducing crop susceptibility to pest (Filho et al., 1999; Mills and Daane, 2005; McGovern, 2015).

The second cluster (Table 4) with the highest number of users (97.14%) was preventive measures. It includes crop rotation (Banjo et al., 2010) and use of improved crop varieties (Karungi et al., 2011). Use of improved crop varieties (insect and disease resistant varieties) enhances crop resistance against pest attack while crop rotation minimizes pest population by altering their source of food or host (Veisi, 2012; Abang et al., 2014). The third group was control measures which entailed weeding, intercropping and mulching (Banjo et al., 2010; Karungi et al., 2011; Bangarwa and Norsworthy, 2014) whose percentage of user was 95.32%. Weeding eradicates weeds and exposes soil-borne pests to natural enemies by bringing them to the ground. Intercropping reduces the attractiveness of the main crop to potential pests and may also act as a cover crop, hence preventing the growth of weeds. Similarly, use of mulch helps in controlling the growth of weeds and improves soil fertility (Knox et al., 2012) and regulates soil moisture by reducing water evaporation. Finally, the least used component (Table 3) was mechanical methods (66.23%) which comprised pruning and use of traps which belong to the mechanical method. For instance, removal and destruction of infected parts of the plant by pruning subdue pest reproduction and dispersion. For example, use of traps to capture and eradicate insects (for instance sticky traps) or trap crops to attract pest away from the desired crop contributes towards a reduction of the pest population by altering its habitat (Khan and Damalas, 2015; Jebapreetha et al., 2017).

Determinants of the intensity of uptake of alternative pest management methods

In order to determine the extent of usage of each group of non-chemical pest management methods by farmers, the number of methods used by a farmer in each group was expressed as a ratio of the total possible number of methods in each group (ranging from 0 to 1). The ratio was used as a proxy for the intensity of uptake of alternative (non-chemical) methods. Subsequently, multivariate tobit model was employed in estimating the determinants of the intensity of uptake of alternative pest management methods. Table 5 presents the results from multivariate tobit model. Majority of the correlation coefficients are strongly significant. The maximum correlation in absolute term is 39% which is relatively low. This indicates that the multivariate tobit model specification is vital, and disregarding such correlations would have led to inconsistent parameter estimates. Results from Table 5 indicate that there is significant complementarity (positive correlation) and substitutability (negative correlations) between the intensity of adoption decisions. Further confirmation from likelihood ratio test (Chi^2 (6) = 72.3927, p<0.01) of joint significance of correlation coefficients of the error terms rejects the null hypothesis of the independence of adoption decision, showing that it is more efficient to use multivariate tobit than the univariate tobit models. Moreover, Waldi *Chi-square* test results ($\chi^2(60)$ =171.63, p=0.0000) indicates that the model fitted data well and all the relevant variables were incorporated into the model.

From Table 5, the age of the household head had a

Table 5. Parameter estimates of multivariate tobit model.

Variables	Crop management practices		Mechanical methods		Control measures		Preventive measures	
	Coefficient	R.S. E	Coefficient	R.S.E	Coefficient	R.S.E	Coefficient	R.S. E
Socioeconomic characteristics								
Age of household head	0.0023	0.0015	0.0032	0.0033	0.0037***	0.0014	-0.0011	0.0016
Gender of household head	0.0146	0.0370	0.0657	0.0818	0.0016	0.0382	0.0362	0.0369
Education of household head	0.0045	0.0055	0.0278**	0.0118	0.009	0.0056	0.0133**	0.0067
Household size	0.0129	0.0092	0.0180	0.0185	0.0065	0.0092	-0.0006	0.0092
Participation in off -farm activities	-0.0562*	0.0308	0.0385	0.0715	0.0112	0.0349	-0.0026	0.0302
Farm size	0.0017	0.0119	-0.009	0.0291	-0.0310**	0.0125	0.0067	0.0091
Farmer perception								
Risk perception with respect to human health	0.0040	0.0124	0.0504*	0.0259	0.0094	0.0134	0.0184	0.0145
Institutional characteristics								
Group membership	-0.0002	0.0133	-0.0042	0.0298	-0.0129	0.0127	0.0309**	0.0137
Number of extension contacts	0.0106	0.0176	0.0635	0.0407	-0.0133	0.019	-0.0023	0.0172
Access to credit	-0.0151	0.0324	0.0515	0.0679	0.0124	0.0329	-0.0233	0.0314
Number of training	-0.0028	0.0194	0.0438	0.044	0.0392*	0.0207	-0.0101	0.0183
Customer orientation	-0.0232	0.0149	0.0359	0.0292	-0.0162	0.0163	0.0379**	0.018
Informal information sources[1]								
Pesticide retailer	-0.0560*	0.0323	0.0189	0.0734	0.0467	0.0327	0.0152	0.0318
Pesticide company	0.0434	0.0699	-0.0462	0.2073	-0.0368	0.0663	0.0208	0.0593
Media	0.0364	0.0817	0.0961	0.1767	-0.0529	0.0614	0.0924	0.0651
Constant	0.5334***	0.0892	-0.3475*	0.2082	0.3620***	0.0950	0.6187***	0.1125
Model diagnostics								
Number of observations	384							
Waldi Chi^2 (60)	171.63***							
Log pseudolikelihood	-468.01							
rho12	-0.3935***	0.0506						
rho13	0.0289	0.0507						
rho14	0.0174	0.0541						
rho23	0.1315**	0.0534						
rho24	-0.0605	0.0560						
rho34	-0.1061**	0.0485						
Likelihood ratio test of rho12 = rho13 = rho14 = rho23 = rho24 = rho34 =0: Chi^2 (6) = 72.393, Prob. > Chi^2 = 0.0000								

***, **,* represents significant at 1, 5 and 10% levels respectively; 1 the base category source of information is fellow farmers. R.S.E = robust standard error. rhoij = correlation between error terms of any pair of multivariate tobit equations.

positive influence on the intensity of uptake of control measures at 1% significant level. Control practices such as weeding, intercropping and mulching are relatively labour-intensive and capital-intensive methods. To carry out these activities, a farmer may need capital to hire additional labour, purchase materials for mulching or seeds for intercropping. Thus, older farmers who may have accumulated social and physical resources over time may adopt higher numbers of control practices than young farmers who may lack such resources. Another possible explanation could be young farmers (unlike older farmers who solely rely on agriculture for income) may lack adequate time needed to implement activities such as weeding which require long working hours since they are engaged elsewhere (non-farm activities). This increases their preference for chemical methods which are considered less time consuming and more effective than alternative methods, hence lower number of control practices adopted. Similarly, In Greece, Damalas and Hashemi (2010) observed that young farmers displayed higher intensities of adoption of pest management practices related to Integrated Pest Management (IPM) than old farmers.

Education of the household head had a positive influence on the intensity of uptake of mechanical and preventive methods at 5% significant level. Preventive methods such as the use of improved crop varieties and mechanical methods (for instance, use of traps and pruning) require knowledge about the pest, the environment, and management techniques as well as special skills which can be acquired through formal education. Education increases information access, processing capability and the ability to apply the acquired information. As a result, better-educated farmers are able to implement such methods with ease which increases the number of practices adopted as compared to their counterparts. The findings are consistent with Khan and Damalas (2015) results on factors influencing cotton farmer`s adoption of an alternative to chemical pest control in Pakistan.

Participation in off-farm activities negatively influenced the intensity of uptake of crop management practices at 10% significant level. Crop management practices probably have a high demand for labour and management time spent on the farm. Therefore, farmers engaging in non-farm activities divert labour and time away from crop management activities which lower the number of crop management practices adopted. This observation is in line with Brauns et al. (2018)'s findings where participation in off-farm activities was positively associated with increased use of pesticides (decreased use of traditional hand weeding method) by farm households in China. Another possible explanation for the negative relationship could be due to a lower allocation of non-farm income to crop management activities as compared to non-agricultural activities which lead to a lower number of crop management practices being adopted. For instance, allocation of a higher proportion of off-farm income to household expenditure (due to large household size) reduces the available funds for investment in agricultural activities leading to a lower number of crop management practices adopted.

Farm size had a negative effect on the intensity of uptake of control measures at 5% significant level. Control measures such as weeding and mulching require higher investment in labour, and .as farm size increases it may become less feasible for the resource-poor farmers to meet the higher weeding labour and mulching materials requirement of the land under cultivation probably due to increased production cost and competition of labour with other farm activities. As a result, lower number of control practices will be adopted by farmers as farm size increases. On the other hand, small-scale farmers in Kenyan rural areas mostly rely on family labour to lower opportunity cost which increases the number of control practices adopted due to cheap family labour. In contrast, Zulfiqar and Thapa (2017) observed that increase in farm size resulted in higher number of land preparation and sowing practices being adopted by cotton farmers as a component of an innovative cleaner production alternative.

Farmer's pesticide use risk perception with respect to human health had a positive influence on the intensity of uptake of mechanical methods at 10% significant level. Farmers` negative attitude towards synthetic pesticide use due to previous adverse human health experience might motivate them to seek alternative methods of crop protection which do not endanger their health and the environment. For instance, previous ill-health experience as a result of chemical pesticide use may increase farmers` concern over health status hence increasing preference for an alternative to chemical methods. Mechanical methods such as use of traps and pruning are eco-friendly and thus may not pose a threat to human health unlike use of chemical pesticides. This increases the number of mechanical methods adopted by farmers who have heightened risk perception. Khan and Damalas (2015) associated heightened risk perception with the adoption of alternative pest control methods. In contrast, Tu et al. (2018) observed that farmers with higher risk perception were less likely to adopt eco-friendly rice production in the Vietnamese Mekong Delta due to fear of failure (uncertainty) of the new eco-friendly practices to achieve the desired outcome

Membership to a group positively influenced the intensity of uptake of preventive measures at 5% significant level. To adopt higher numbers of preventive measures such as use of improved crop varieties and crop rotation, a farmer may require credit, relevant information, training and other essential services. These services are easily accessible through cooperative membership due to economies of scale which enhance success in number of preventive practices adopted. Furthermore, group membership creates linkages which

facilitate the exchange of ideas, experiences and new innovations which can increase the number of preventive practices adopted. These findings are consistent with Tu et al. (2018)'s findings where membership in the agricultural club had a positive influence on adoption of eco-friendly rice production in Vietnam such as integrated pest management methods.

Participation in training programs had a positive effect on the intensity of uptake of control measures at 10% significant level. To adopt a higher number of control techniques such as mulching, weeding and intercropping requires knowledge on the pest, its habitat and ways of suppressing it. This information can be accessed by participating in training. Demonstration of new methods through training programs enhances farmer`s skills and confidence in the new methods which may increase the number of control practices adopted. Correspondingly, Khan (2009) observed that participation in training was positively correlated with the likelihood of adoption of alternative pest management practices in Pakistan. Similarly, Williamson et al. (2003) reported that farmers who had undergone training (relative to untrained farmers) preferred alternative crop protection methods over synthetic pesticides as they had acquired information on adverse human and environmental effects of pesticide use through training.

Customer orientation had a positive influence on the intensity of uptake of preventive measures at 5% significant level. Customer orientation involves understanding customer`s needs and creating value for the customers by offering high quality and safe food to others. To satisfy these needs (for instance large fruit size, blemish free andchemical free goods) a farmer may seek alternative methods of crop protection which are less detrimental to consumer health. Utilizing improved crop (such as high yielding and pest resistant) varieties and practising crop rotation may contribute towards meeting the customers' demands by minimizing chemical pesticide application due to health and food safety concerns. In return, farmers will gain access to lucrative markets offering premium prices for their products. Consequently, increased revenue due to the high market demand for their products will motivate farmers to adopt a higher number of preventive measures. Prior studies (Cameron, 2007; Buurma and Velden, 2016) have highlighted consumer demand as one of the major drivers of adoption of IPM.

Finally, pesticide retailer as a source of information had a negative effect on the intensity of uptake of crop management practices at 10% significant level. Efficient use of fertilizer, optimal provision of water through irrigation and maintaining sanitation through crop residue destruction may require special knowledge on crop production which the pesticide retailer may be lacking probably due to low levels of education or lack of training. This lowers the number of crop management practices adopted by a farmer who relies on pesticide retailer for information. Furthermore, pesticide retailers who are driven by profit motive are more likely to promote synthetic pesticide use and provide information on how to use the product relative to alternative methods which decrease the adoption of crop management practices. On the contrary, farmer to farmer exchange of information and ideas facilitates higher uptake of number of crop management practices probably due to vast knowledge on local production conditions acquired through farming experience as well as trust since they are known to each other. Additionally, the farmers providing information instil confidence in other farmers as they demonstrate new practices acquired through training, thus leading to the higher adoption of crop management practices. Similarly, Wagner et al. (2016) observed that farmers who relied on pesticide dealers for information on pest management were more likely to use synthetic pesticides than other alternative methods.

CONCLUSIONS AND POLICY IMPLICATIONS

Findings revealed that farmers` risk perception, socio-economic and institutional factors influenced the intensity of uptake of alternative pest control methods. The significant factors in explaining the intensity of uptake of crop management practices were participation in non-farm activities and access to information through pesticide retailer. The intensity of uptake of mechanical methods was significantly explained by education of household head and farmers` pesticide use risk perception. With regard to the intensity of uptake of control measures, age, farm size and participation in training were significant predictors. The intensity of uptake of preventive measures was significantly explained by education, group membership and customer orientation.

Technical support aimed at promoting the use of non-chemical methods could be provided through the farmer association to enhance access to information and relevant services. Local farmer institutions and service providers should be supported since they play a vital role in providing information, access to market and other relevant services. In addition, creation of awareness of alternative to synthetic pesticide through farmer groups and partnership with local service providers (such as pesticide retailers) to enhance uptake of non-chemical pest management methods is necessary. Provision of participatory training programs/seminars on alternative crop protection methods (for instance through farm demonstrations and farmer field schools) which are tailored to meet the specific farmers` needs could accelerate the adoption. Finally, promotion and implementation of new efficient integrated pest management approaches and other alternative methods via relevant government and non-governmental information dissemination channels to enhance effective

adoption and reduce synthetic pesticide use to a bare minimum. Integrated pest management method is an all-inclusive technique which cost-effective, eco-friendly, guarantees yields and contributes towards sustainable agriculture.

ABBREVIATIONS

GoK, Government of Kenya; **IPM,** Integrated Pest Management.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Appendix A

Table A1. Factor analysis for describing human health risk perception and customer orientation concepts.

Constructs	Items	Factor Loadings	*CR*	*AVE*	KMO
Human health risk perception	Pesticide use is harmful to farm family health.	0.68			
	Pesticide use is harmful to the user`s health.	0.63			
	Pesticide use is harmful to other farmer`s health.	0.63			
	Improper pesticide use causes acute illness.	0.66	0.54	0.42	0.67
Customer orientation	It is important to have a strong focus on understanding customer`s needs during tomato production	0.80			
	It is vital to have a strong emphasis on customer commitment during tomato production.	0.80	0.40	0.64	0.50

CR= Composite Reliability, AVE = Average Variance Extracted, KMO =Kaiser-Meyer-Olkin.

Table A2. Variance inflation factor test results for continuous explanatory variable.

Variable	VIF	1/VIF
Age of household head	1.39	0.721675
Education of household head	1.18	0.844372
Household size	1.23	0.811646
Farm size	1.11	0.89881
Risk perception with respect to human health	1.04	0.964776
Group membership	1.07	0.93149
Extension contacts	1.36	0.737077
Training	1.37	0.728637
Customer orientation	1.05	0.954596
Mean VIF	1.2	

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Determinants of household transition into and out of poverty in Benin

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This study tries to determine the differentiated factors of households' transition to poverty in Benin. It was carried out on a sample of 6424 households making up data from the integrated modular survey on household living conditions. Descriptive analysis and econometric modeling as Stata 12 was used. From the results of this study, it appears that the geographical location of households in cotton and rice fields increases their chances to emerge from poverty. That reflects the positive effect of a good agricultural season on household living standard. Increasing the household size increases the household's risk of entering or remaining poor.

Key words: Poverty, differentiated factors, transition, Benin.

INTRODUCTION

According to empirical studies, three groups of factors explain the dynamics of poverty, namely: socio-economic factors (education, employment, vulnerability to shocks), demographic factors (age, household size) and geographical factors (living place).

During the last decades, poverty has enlightened due to unmatched policies with daily realities. Indeed, after their national sovereignty, the constraints related to macroeconomic imbalances of young African economies led most governments to adopt the Structural Adjustment Programs (SAP) in 1980s under Bretton Woods institutions leadership. These measures have made it possible to clean up the macroeconomic framework of African states, particularly through the reduction of public spending, anti-inflationary measures and financial reforms.

However, the SAP is being criticized in Africa. The mixed results of the impacts of SAPs depend on the level of analysis and macroeconomic dynamics. In fact, the first planning actions related to development in African countries were very centralized and the State ensured optimal sovereignty. But the oil crisis of 1979 and 1993 weakened the expenditure of the States which were heavily indebted to assume their responsibilities. In this national and international context, the proposals of the Bretton Wood institutions and the World Bank have been quickly accepted by these countries as a solution to the crisis. This involved ensuring national autonomy through the balance of payments, improving the terms of trade and creating favorable conditions for increasing local production and consumption. The results of the SAPs on the countries that have applied it remain at the macro-economic level more positive and at the microeconomic level very negative. Indeed the organizational system, the type of governance and the level of education did not favor the change that should come as support. These

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measures have more contributed in destroying African households living conditions. In fact, the SAPs created new constraints, including the privatization of state-owned enterprises that led to higher unemployment, lower wages, higher prices for goods and services, financial reforms and anti-inflationary measures which have increased interest rates, limiting the access of small producers to credit. Faced with this new degrading situation, the World Bank and the International Monetary Fund (IMF) have proposed a Poverty Reduction Strategy by supporting developing countries to produce and implement documents and strategies for poverty reduction. Benin complied with these reforms in the year 2003 with the document of growth strategies for the reduction of poverty. These strategies are today in their third generation.

The first generation of these PRSs was implemented for the period 2003 to 2005 and made progress, but the gain in terms of poverty reduction was not significant since poverty still affected many Benineses (R Benin, 2007). To correct the situation, the Government of Benin implemented two more generations of PRSs that proposed poverty reduction strategies which aimed in achieving inclusive economic growth (PRSP II for 2007-2009 and PRSP III for the period 2011-2015). For that purpose, several actions have been implemented including the Micro-Credit Program for the Most Poor (MCPP) which aims to promote the creation of small income-generating activities and empower women and the poorest.

These strategies have certainly made significant progress in the economic field, illustrated in particular for the period from 2007 to 2015, by an average growth of 5.2%, a control of inflation within the limits set by the Pact of WAEMU Convergence Framework (World Bank, 2015). Despite these recorded performances, the phenomenon of poverty has remained insensitive to development efforts. According to INSAE (2015), 40.1% of Benineses were poor in 2015 compared to 37.5, 35.2 and 36.2% respectively in 2006, 2009 and 2011. These statistics show the acuity of the phenomenon in the daily life of Beninese households. Moreover, poverty is a transitory phenomenon because 41.2% of individuals are in temporary poverty (22.3% entering and 18.9% leaving) against 15.5% in permanent poverty. By the time the government is making the improvement of people's living conditions its priority, it's therefore critical to understand why households enter poverty, why did they leave it and why did they remain in. This would help to redirect existing policies or develop more effective anti-poverty policies.

Also, the decentralization programs adopted since 2003 are part of the same order of ideas with the integration, this time, of the local communities in the process of development. These decentralization programs were reinforced by imposing on the various municipalities to have a Communal Development Plan (PDC) that would reflect the development vision of the communal authorities in consultation with the central government.

Despite all these efforts, poverty remains Benin's household's daily realities. Indeed according to INSAE (2014), poverty affected 40.1% of Beninese in 2015 against 37.5, 35.2 and 36.2% respectively in 2006, 2009 and 2011. Moreover poverty is similar to a transitory phenomenon because 41.2% of individuals are in temporary poverty (22.3% incoming and 18.9% out) against 15.5% in permanent poverty in 2009 (INSAE, 2014). These statistics thus testify of the sensitivity of households' living standard at certain events. Given this fact, it is important to determine the events at which households' living standard is sensitive in order to understand how they affect the transition made by households in poverty. What is the effect of the geographical location of a household in a cotton producing department on the level of poverty? What is the effect of the geographical location of a household in a department with low potential for rice production on the transition made by it in poverty? What is the influence of the increase in household size on the transition made by the household?

Considering that socio-economic, demographic and geographical factors influence poverty, the following assumptions have been made:

H1: The likelihood of household performing positive transitions (exit) increases when living in a cotton-producing department.
H2: The probability of household making a negative transition (entry or stay) increases when it lives in a department with low potential for rice production.
H3: Increasing the size of a household increases the likelihood of the household making negative transitions.

LITERATURE REVIEW

The poverty studies focused on the determinants of the dynamics of poverty over a year or several years and very little on the aspect raised by this work. This paper first analyzes the dynamics of poverty and then the mobility of households (entry, exit, stay) in poverty between two periods.

Analysis of the concept of poverty

According to Aho et al. (1997), poverty is defined as a state of long-term deprivation of well-being deemed inadequate to live decently. This may take the form of a lack of monetary resources, a lack of education and health, or lack of freedom, difficulties in accessing infrastructure, inability to participate in a community or the lack of a sense of belonging to a given society. It is

the multiple facets of this state of deficiency that explain its multi dimensionality and grouped in monetary and non-monetary dimensions.

The monetary dimension of poverty is addressed by the dominant theory for more than two centuries of Welfarist. Well-being is exclusively on the notion of utility, where monetary resources determine its level. Poverty is defined as "a socially unacceptable level of income". Monetary poverty expresses an aspect of standard of living and is the result of insufficient economic resources to live decently; resulting in insufficient consumption. It is the expression of a level of well-being that is too low. It is based either on income or on consumption translated into monetary value. This approach is dominant and most used by international institutions, notably the World Bank. The theory of well-being is the reference for the analysis of monetary poverty. In practice, economic well-being is not directly quantifiable because economic agents have different preferences; it is by virtue of this that the monetary approach to poverty is based on the use of income or consumer spending as a measure of well-being. Thus, a person is considered to be poor when living below a monetary threshold of well-being, that is, when its income or consumption expenditure is below the monetary threshold adopted by the community. For developing countries, this threshold set by the World Bank is around $ 1.25 a day (World Bank, 1990).

However, not all dimensions of poverty can be assessed by a monetary measure: for example, what price should be allocated to the consumption of public goods, the intensity of social relations or, more generally, the quality of life? It is probably to overcome these difficulties that a number of measures of poverty are based on non-monetary criteria.

Non-monetary dimension of poverty takes into account conditions of existence; including the nature of housing, access to health and education, the enjoyment of capital (physical, human, and social, etc.) (Fraisse-D'Olimpio, 2009; Organisation de Coopération et de Développement Economique, 2001; Guillard, 2010). This new dimension, which appears as a more qualitative view of poverty, is called a non-monetary approach. In this case, a person who does not have decent housing, or / and who does not have access to basic services and / or infrastructure (Rawls poverty) not fully of his human capacities (handicapped) or/and who suffers social exclusions because of his conditions of existence (poverty in the sense of Sen).It was supported by the Rawls School of First Needs and the Sen School of Capabilities (1987).

i) Poverty approach through basic needs

Rawls (1971) identified needs common to all human beings needed to achieve a certain quality of life. These needs are basic need such as education, health, hygiene, sanitation, drinking water, housing, etc. Indeed, according to the author, a person is considered poor when he does not meet his basic needs in relation to a certain standard of living. One of the weaknesses of this analysis is the relativity linked to the notion of basic needs like that of the notion of poverty.

ii) The capacity approach

Since poverty is understood to be a state of deficiency or lack, Sen (1987) admits that the missing "thing" is not necessity or basic needs, but the human abilities or abilities able to attain a certain standard of living. According to him, well-being is not the possession of goods, but it is the fact of being well nourished, well-educated, healthy, and participating in collective life, etc. This set of factors determines the value of life. Sen (1987) states that the value of an individual's life depends on a set of ways of doing and being that it groups together under the term "functioning."

An individual's capacities are determined by his or her potentialities, which correspond to social capital endowments, human capital, physical capital and economic capital (Rousseau, 2001), as well as its opportunities, which are conditional on the environment, specific to the individual and which will determine his possible choices, that is to say the constraints of functioning.

Whether monetary or not, each of the preceding approaches can be declined according to whether one adopts an absolute or relative poverty line.

Absolute poverty and relative poverty

Some measures of poverty define it in absolute terms, that is, the inability to meet basic needs, while other measures define it in relative terms, as an unacceptable deviation from community standards. The approach to relative poverty approaches the concept of inequality in that it focuses on the relative differences between people in the same society. Here, an individual is considered poor compared to another individual in the community, by comparison; which refers to the notion of discrepancy, and hence of inequalities.

Regarding the analysis of absolute poverty, it identifies a number of basic needs that must be met in order to avoid poverty: food, clothing, housing, etc. Thus, people who are deprived of these basic needs, who are the same wherever they are, are considered to be absolutely poor, even if the manner of satisfying them varies from one country to another according to the culture and the economic situation.

The search for the determinants of poverty has greatly fostered the work of authors who have been interested in the analysis of poverty. Aho et al. (1997) formalized the sanitation, drinking water, housing, etc. Indeed, according

determinants of poverty into three categories: factor endowment, individual choice, access to opportunity.

In terms of factor inputs, Andersson et al. (2006) showed that in Vietnam the area of irrigated land, irrigated land area, livestock numbers, education of household members, the technology used in agriculture in the household has a significant effect on household consumption expenditure. The study found that in Vietnam, possession of a large area of irrigated land and livestock and a level of education have a positive effect on household consumption expenditure.

Long before them, Grooteart (1996) was already insisting on the effect of human capital on changing living standards over time. Indeed, through the construction of a household education index, it has shown that in Ivorian urban areas, a household with a high level of education has a high chance of getting out of poverty. Thus, a household whose members have a low level of education is more exposed to negative transitions in poverty. By assimilating the level of general education of the household to that of its head, Gacko et al. (2015) in Mali and Razafindrakoto and Roubaud (2010) in urban Malagasy confirmed the significant effect of education on the level of a household. The results of their work show that a household headed by a chief with a primary level or less has a high probability of experiencing poverty.

Addressing the second cause of poverty, the World Bank (2005) finds that the structure of consumer spending on poverty can justify the poverty situation of households: This position is explained by the fact that it is in terms of the allocation of time between leisure and work, between consumption and savings, or in the choice of consumer goods, between, for example, children or alcohol consumption, people would be responsible for inequalities because they freely choose to allocate their individual resources and suffer the positive or negative consequences as well as their families "(Aho et al., 1997, p16).

This position of the WB was supported by the work of Attanasso (2011), which showed, for example, that households investing in education will be able in the long term to improve their living conditions.

In addition to the structure of household consumption expenditure, the number of hours worked per month may be related to individual choices and may explain household poverty. To this end, Geda et al. (2005) showed that for a household where the number of hours worked per member is low, the likelihood of experiencing poverty is high. They also point out that marital status is a factor explaining poverty in Kenya. Indeed, according to their work, a polygamous household is more prone to poverty than a monogamous family. This can be explained by the fact that the size of the household is greater in polygamy and will therefore put pressure on household resources. It is for this reason that Woolard et al. (2004) consider the size of the household as a shock variable that may explain the level of poverty in South Africa. According to these authors, the variation in the size of a household is a factor explaining the transition from one state to another (transition). Hodonou et al. et al. (2010) agree that an increase in the size of the household reduces the standard of living in Benin. This result will be confirmed by the work of the INSAE (2014), which showed that births increase the share of inactive persons of the dependent age.

Concerning the third cause of poverty, "unequal access to opportunities to escape can be measured by access to essential services (health, basic education, drinking water, electricity), access to economic opportunities such as the market, microcredit or simply non-discriminatory policies towards the poorest groups "(Aho et al. 1997, p17). It is in this context that the World Bank (2005) suggests that indicators of access to electricity and health services should be included in the list of poverty variables in developing countries. This suggestion is well founded, as the work of Andersson et al (2006) has shown that the poor in Vietnam have limited access to basic services. Hodonou et al. et al. (2010) point in the same direction and insist on the economic aspect of inequality by showing that the most notable determinants of poverty besides those related to the demographic characteristics of households are the rate of access to credit, economic accessibility to health and the level of economic accessibility to communication.

In order to better understand the problem of access to the chances of escaping, some authors have considered integrating geographical variables, variables indicating caste membership, an ethnic group, and sex variables.

Concerning geographic variables, Hodonou et al. (2010) and INSAE (2014) have shown that the residence environment (Rural or Urban) favors the occurrence of poverty. INSAE (2014) justifies this situation by the fact that in rural areas populations are more biophysical shocks (flooding, drought) that can cause marked changes in household income.

As for the variables indicating membership of a social caste, Lachaud (1998) showed that belonging to a certain ethnic group of Burkinabe society increases the probability of being poor. A similar result was obtained by Gang et al. (2002) who showed the relationship between caste, ethnicity and poverty in rural India.

Finally, a flow of studies has shown that the sex of the head of a household can determine the poverty level of a household. However, the meaning of the relationship between the sex of the HOH and poverty is not unanimous. Razafindrakoto and Roubaud (2010) have shown that a woman-headed household is more prone to poverty, while N'Diaye (2005) has proved the opposite in rural Senegal.

In Benin, ATTANASO (2005) used panel data (ELAM 96 and 99) to estimate using a binary logistic regression a model explaining the poverty of women in Benin. The dependent variable is poverty with two modalities: poor (y= 0) and non-poor (y = 1).The same holds for MEDEDJI

(2006) who adopted a multinomial logistic model using panel data from EMICOV 2006 to analyze the transition in poverty and the determinants of household belonging to identified households. These two authors have used such a model because of the qualitative polytomic nature of the variable to be explained. Hodonou et al. (2010) have adopted a Markov model using the transition matrix associated with the Markov chain, reinforced by the use of a logit model (Quelque soit le type de ménage, la variable dépendente est le bien être) to determine the factors explaining the transitions between the different states of well-being distinguished. Thus, qualitative regression models (logit and probit) are generally used to identify the determinants of poverty.

In the light of these different studies on the determinants of poverty, we consider as factors explaining the transition in poverty: geographical factors (household place of residence), socio-economic factors (education, employment, capital physical, accessibility to basic services) and demographic factors (household size, age structure, dependency ratio).

From a theoretical point of view, classical approaches, from contemporary to neo-classical approaches, have explored the different causes of poverty in economic thought.

Poverty and classics

Adam Smith, founder of political economy (1723-1790) began the analysis of the causes of poverty by studying the division of labor. Through his famous work on "the nature and causes of the riches of nations," he relates "general opulence" to the division of labor. According to him, there is no place for poverty or even poverty in the division of labor and therefore the absence of the latter is at the root of poverty. It justifies its position by the fact that the division of labor will lead to economic growth, the fruits of which will be the rise of wages. This will lead to an improvement in the living conditions of the workers. Smith sees in the absence of work the origin of poverty. To this end he asserts that an individual is "rich or poor according to the amount of labor he will be able to command or that he will be able to buy" (Jean, 1999)

Without rejecting Smith's conclusions, Malthus finds that the growth achieved through the division of labor will come up against an important limit: population growth. Indeed, in the statement of the "law of the population," Malthus sees the latter increase spontaneously according to a geometric progression while the means of subsistence grow only according to an arithmetical progression. The growth of the population will end up with a constraint of available means of subsistence. Thus, he sees in the growth of the population the cause of the observed poverty. It should be noted, therefore, that the growth of the population is the responsibility of the individual, and he advocates to the poor to stop growing if they want to keep the means of subsistence available. (Ravallion, 1995; Bertin, 2007)

Inspired by the conclusions of these predecessors, Ricardo bases his analysis on the laws of capitalism. He finds that anything which increases wages necessarily diminishes the profit. Thus, producers and rentiers will seek to reduce wages to a level that will allow them to maximize their profits. When this level is below the natural price of labor, the worker's condition will deteriorate. At Ricardo, poverty is the result of the low wages paid to workers. And it advocates as a means of fighting against poverty the abolition of all laws that would prevent the labor market from regulating itself through the law of supply and demand (Lallement, 2012).

In short, although the analyzes differ, we note that for the classics poverty is rooted in the relationship between man and work. The effort that the individual provides when he works is rewarded by an accumulation of wealth that will enable him to meet his needs. (Bertin, 2007)

Walras and poverty

Walras, author of the neoclassical theory of general equilibrium, is illustrated in the debate on the causes of poverty by developing the theory of justice. It defines justice as the principle that society must organize the initial distribution of wealth among individuals. Through this theory, Walras attempts to explain the poverty of people by the inequality in the initial distribution of wealth. By reducing wealth to land, he finds that the state ownership of land and individual ownership of his work define the just distribution of wealth among individuals. At Walras, the structural cause of poverty is the initial unfair distribution of wealth among individuals. He bases his analysis on the fact that, with a fair initial distribution, inequalities between individuals will have to be considered just because they result from individual choices, to work more or less, to consume or to save. To this end, it advocates that land management should be entrusted to the State which represents the entire population (Lallement, 2012).

Causes of poverty according to some contemporary theories

i) The causes of poverty according to the theory of human capital

Human capital, developed by Schultz (1961) and Becker (1964, 1975), refers to all the skills, abilities and other abilities (know-how, experiences, etc.) possessed by an individual for productive purposes (Veronique, 2003). These capacities, which can be either innate, or acquired during a school or university course, or during a professional experience. It is these skills that he offers in

the labor market in return for salary. Thus, the lower the human capital stock, the higher the income of individuals will be.

ii) The causes of poverty according to life cycle theory

The life-cycle theory is a theory developed by Modigliani (1960) explaining how an economic agent chooses his level of consumption and his savings during his life. According to this theory, age determines both the individual's income and his wealth. Thus the variations in the incomes of individuals are due to their age (Ando and Modigliani, 1963). Life cycle theory suggests an increase in income during periods of intense activity and a decline during the period of retirement.

iii) Food production in relation to the living conditions of the households

EBELA 2017 has shown that the merchant food could contribute to the reduction of poverty in rural households in Cameroon, in the department of MVILA. According to the author, income from the merchantable food remains a source of income because of the dependence on cocoa farming, the decline of rural households around the marketing of food and the lack of modernization of the productive apparatus and commercial food crops. In this context, the fight against poverty through the food market remains one of the solutions to improve the living conditions of households. Similarly, the World Bank 2008 notes that the growth of agriculture is on average twice as effective as that of other sectors in the fight against poverty because it brings together nearly 75% of the world's poor population living in poverty rural area. This reduction is achieved through the creation of employment, the decline of food prices and the increase of farmers' incomes. Poverty reduction is thus directly related to household food production and could be an effective struggle.

METHODOLOGY

This is to present the Data Source, the variables used, the tools and the analysis model.

Data source and study population

This study is based on data from Integrated Modular Surveys on Household Living Conditions (EMICoV) conducted by the National Institute of Statistics and Economic Analysis (INSAE). The survey is designed to provide the Government, policymakers, researchers and development partners with the opportunity to have a large socio-demographic and economic database, including up-to-date indicators for assessing and monitoring development programs and policies, namely indicators on poverty, employment and unemployment, access to micro-finance and participation in savings, food security, land conflicts, human security, governance and democracy. These data have the advantage of providing information on the characteristics of individuals and households and the household consumption expenditure needed to estimate the level of monetary and non-monetary poverty and the factors that influence these levels. This is a repeated survey (4 passages of three months with a month of flapping) by direct interview and covers a national sample of 17982 representative households in the 77 communes of Benin, at the level of the middle residence (urban / rural). It is distributed in 7438 households in urban areas and 10544 in rural areas. The sample is areolar, stratified and drawn at two degrees. In the first stage, 750 enumeration areas (EAs) are drawn proportionally to their size in households enumerated in the 2002 General Population and Housing Census. An enumeration of households in each of these EAs provided a list of households from which 24 households are drawn. The availability of data on the same households in 2006 and 2009 made it possible to build a panel of 6424 households.

Specification of the variables

Dependent variable: transition

It was obtained by comparing the level of poverty in 2009 to that of 2006. The dependent variable in the context of our study is a polytomic variable with three modalities. The different modalities of this variable represent the two transition groups that can be achieved by households: Negative transition (entry or stay in poverty) and positive transitions (never poor or out of poverty) with as a reference modality the "never poor" modality. . So we have the variable "Transition" which is specified as follow:

$$\text{Transition} = \begin{cases} 0 & \text{Never poor} \\ 1 & \text{Entered or persisted in poverty} \\ 2 & \text{Exit from poverty} \end{cases}$$

Independent variables

The specificity of this study is that it takes into account geographical factors different from those identified in the literature to explain the transition into poverty. Here, the focus has been on cash-producing areas and cereal crop production in order to measure the effect of the location of households in these areas on their living conditions. The variable rice zone

The coding of the variable "Rice_zone" was in relation to the potential of the area of residence in rice production. Here, three levels of potential have been selected according to the potentialities of the departments in the lowlands. These include weak potentialities, high and very high potentialities.

The following table presents the different variables used to explain the transition of households as well as the theoretical or empirical bases justifying their choice.

Thus, when the potential in the lowlands is less than 10.000 ha, the department is described as a low potential department, and when the potential is between 10.000 and 50.000 ha, the department is considered a high potential department, while it is designated as a very high potential department when the potential is greater than 55.000.

The variable Cotton_zone

The coding of the variable "Cotton_prod" was done by considering

the cotton producing departments or not. The existing variable named “department” has been recoded as follows: 0 for non-cotton producing departments, and 1 for producing departments.

The national cotton production coming from more than 70% of the large cotton producing departments (borgou and Alibori) (INSAE), only these departments were considered as a cotton producing department, in order to appreciate the influence of the "big producers" of cotton on household transition.

Tools and analysis model

Analysis tools

The study will be based on a descriptive approach coupled with an analysis of the determinants of the transition of households into poverty in order to verify our hypotheses.

The descriptive approach is based initially on the presentation of the structure of the studied population in order to verify the representativeness of our sample then the distribution of the population between the different modalities of the explanatory variables of interest. In a second step, a cross between the dependent variable and the explanatory variables of interest is made in order to verify the meaning of the relationship between them. A previous chi-square test is done to verify the correlation between the explanatory variables and the dependent variable. This analysis is done using tables and graphs obtained using the Excel software.

The explanatory approach is based on an unordered multinomial logistic regression using the STATA software (version 12).

The analysis of the results of this type of econometric model is done by means of the sign of the coefficients, their significance, the odds-ratio calculation and the marginal effects.

The sign of the parameters indicates, in case of significance of the parameter, whether the associated variable influences the dependent variable positively or negatively. The odd-ratio or odds ratio, as its name suggests, is a statistical measure that allows the degree of dependence between the modalities of the explanatory variable and those of the dependent variable to be expressed relatively. Marginal effects give an idea of the sensitivity of the probability of the reference event with respect to unitary explanatory variations.

The significance of the model is appreciated through the LR-test. The decision rule of this test states that when the probability associated with the log likelihood ratio is less than 5%, we accept the hypothesis H1 that the model is globally significant.

Analysis model

The study made estimates using multinomial logit models that are models in which the explained variable is qualitative multinomial; that is, it can take more than two modalities. This choice is justified firstly by the polytomic nature of our dependent variable but also and above all by the simplicity of the calculation of the coefficients and their interpretation. Moreover, this model is widely used in the study of the mobility of households in poverty and according to Bocquier (1996), the use of logistic models is common in the analysis of biographies (events that occur during the life of the individual). However, there are two types of multinomial logit: ordered and unordered. As specified, the dependent variable does not allow us to use an ordered multinomial logit. The use of an unordered multinomial logit is therefore necessary. Formally the multinomial model is written as follows:

$$\ln \frac{\Pr(Transition=m/X)}{\Pr(Transition=j/X)} = X\beta m/j \quad for\ m = 0,1,2 \text{ and } j = 0,1,2\ ;\ j \neq m$$

Where, X represents the matrix formed by the explanatory variables; j represents the reference modality (which makes it possible to compare the groups of individuals) and β denotes the vector of the estimated coefficients.

Thus, the non-ordered multinomial model makes it possible to model the probability of realization of the event m relative to the probability of realization of the event j.

The parameters are estimated by the maximization algorithm of the log likelihood.

More specifically, the analysis model is written:

$$Transition_i = \alpha_0 + \alpha_1 Cotton\_zone_i + \alpha_2 Rice\_zone_i + \alpha_3 Var\_Size_i + \alpha X_i + \varepsilon_i$$

***Transition**$_i$:* refers to the transition made by the household i
***Cotton_zone**$_i$* : refers to the location of the household in relation to cotton production areas
***Rice_zone**$_i$* : refers to the location of the household in relation to areas with potential for rice production
***Var_Size**$_i$* : is the change in household size
a : designates the parameters to estimate
X$_i$: denotes the matrix of the remaining K-4 variables, K> 4
ε$_i$: means the error term that follows a distribution function F (.).

By imposing the logistic law on this distribution function, it becomes:

$$F(X) = \frac{e^X}{1+e^X}$$

PRESENTATION AND ANALYSIS OF THE RESULTS

Descriptive analysis

Descriptive statistic of the sample

The representativeness of the sample is well reflected in Table 2. Indeed, it can be seen that all departments are present and in proportions that corroborate the density of the population in each of them. The most populated departments - the Atlantic, the Borgou, the Ouémé and the Zou - are each more than 8%, while the least populated Donga and Plateau are each represented with at most 6% of the population sample size. We can also see that in the sample, as one would expect, the proportion of households in rural areas (66%) is greater than in urban areas (34%).

As a result, more than three-quarters of households are headed by men. This result reflects that in Benin household heads are often men. Half of households are headed by individuals who are 41 years old, 29.8% are by individuals under 35 years of age versus 44.9% by individuals aged 44 or over.

In addition, a high proportion of households are headed by individuals who have not received formal education or have only received informal education (61.7%), while only 14.5% have at least one secondary level.

Unified analysis of variables of interest

Distribution of households following the transition

The percentage distribution of households following the

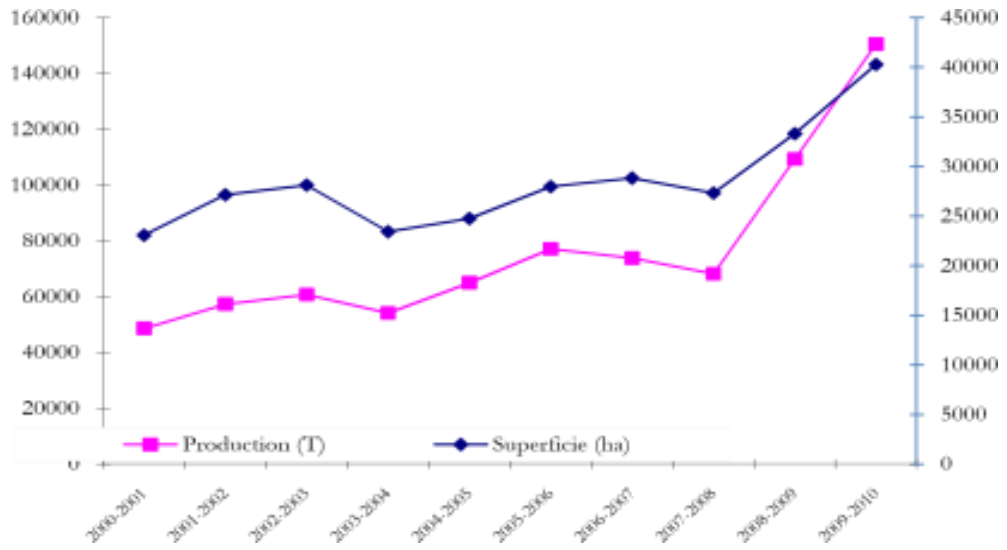

Figure 1. Rice production between 2000-2010.
Source: Authors 2011.

transition is shown in Figure 1.

The analysis in Figure 1 reveals that the proportion of households that have made negative transitions is higher (32%) than that of households that emerged from poverty (19%) between 2006 and 2009.

Distribution of households by geographical location

According to the geographical distribution of households, 17% are located in the cotton production departments (Figure 2).

Graph 1 in appendix shows that households living in departments with high or very high potential for rice production dominate the study population (48% in high potential departments and 34% in highly potential departments). Households living in low potential departments represent only 18% of the study population.

Bi-varied analysis between transition and variables of interest

Cross analysis of transition variables and cotton production zone

The Graph 2 shows the Crossover between Cotton Production Zone and Transition.

As shown in Graph 3, households living in cotton-producing departments made more positive transitions (outflow) than those living in non-producing departments. In fact, 24.1% of households living in the cotton-producing departments came out of poverty compared to 18.7% for households living in non-producing departments. Also, households living in non-producing departments have made more negative transitions (entry or stay) than those living in producing departments (32.7% for non-producer departments versus 26.8% for producing departments).Through this result, it can be guessed that there is a positive relationship between living in a cotton producing department and a positive transition.

Cross between areas with potential for rice production and Transition

The graph 5 shows the crossover between transition and ares with potential for rice production. Rice production could improve the entry and exit of household from poverty. In a zone of high potential for rice production, 21.35% of households emerge more quickly from poverty and return or persist less in poverty 29.55%. On the other hand, in areas with very high potential or low potential for rice production, households are hard-pressed to leave 17.86% and 18.12% and return more easily or persist more in poverty respectively 34.18% and 32.86% than in previous areas. In conclusion, the production route of food crops such as rice in this case by households is a way out of poverty.

Cross analysis of transition variables and size variation

Graph 5 shows the crossover between transition and« var_size»

As depicted in Figure 6, the increase in the size of the household favors entry and keeps it in poverty 42.05% versus 23.8% for the decrease. Similarly, this variable

Table 1 . Summary of the bi-varied analysis.

Parameter		Transition		
		Never poor	Entry or stay	Exit
Cotton_Prod	Non-producing department	48.6	32.7	18.7
	Producing department	49.1	26.8	24.1
HOH_Sector	Formal	67.4	16.5	16.1
	Informal	50.2	30.8	19
HOH_Branch	Other	61.6	20.9	17.5
	Agriculture	45.7	34.9	19.4
Deputy emploi_HOH	No	53.6	27.6	18.8
	Yes	48.8	32.9	18.3
Vul_choc	Did not suffer a shock	54.3	26.4	19.3
	Suffered a shock	51.5	30.2	18.3
Inc_input_price	Did not increase	52.6	29.1	18.3
	Has undergone an increase	48.6	27.4	24
Active_Death	Did not lose an asset	52.5	29.1	18.4
	Lost an asset	48.9	22.6	28.6
Var_Size	Decrease	48.8	23.8	27.4
	Increasing	48.5	40	11.5
HOH_Sex	Man	50.5	30.7	18.8
	Wife	60.2	21.9	17.9
HOH_Education	No level	45.3	32.9	21.8
	Primary level	50.1	32.3	17.6
	Secondary level	58.4	27.8	13.8
	Higher level	84.4	8.9	6.7
HOH_Age	Under 35 years	55.3	30.4	14.4
	35 to 44 years	46.1	34	19.9
	45 to 54 years	51.3	28.3	20.3
	55 years old and over	56.1	22.9	21.1
Household_Credit	Yes	60.8	23.2	16
	No	47.8	32.3	19.9
Household_Size	less 4 people	75.9	15.4	8.7
	4 to 5 people	52.3	29.2	18.5
	6 to 7 people	40.8	36.9	22.3
	8 and over	32	39.4	28.6
Rice_Zone	Low	49	32.9	18.1
	High	49.1	29.5	21.3

Source: Authors' calculations based on EMICoV data 2006-2009.

does not facilitate the exit of household from poverty 11.41% versus 27.36% for the decrease in household sizes. However, the rate of households that have never experienced transition into poverty remains almost equal in both groups (See Annex Table 1).

The bi-varied analysis between the transition variable and the explanatory variables of interest provided a first glimpse of the relationship between them (Table 1). Econometric analysis will provide a clearer and more precise idea of the meaning of the relationship between

Table 2. Estimated result with odds-ratios and marginal effects.

Model	Variable	Sign of the coefficients	Ratio of relative risk	P-Value	Marginal effects (%)
Model 1	**HOH_education (reference: One level)**				
	Primary	Negative	0.86	0.111*	1
	Secondary and more	Negative	0.75	0.024	2
	HOH_Branch (référence: secteur secondaire ou tertiaire)				
	Primary sector	Positive	1.81	0.00	11
	Credibility_access (reference: no)				
	Yes	Negative	0.54	0.00	9
	Cotton_Zone (reference: non-producing department)				
	producer department	Negative	0.55	0.00	10
	Rice_zone (reference: weak potentiality)				
	strong potentiality	Negative	0.58	0.00	9
	very strong potentiality	Negative	0.59	0.00	7
	Var_Size (reference: decrease)				
	Increase	Positive	3.77	0.00	27
Model 2	**HOH_education (reference: No level)**				
	Primary	Negative	0.89	0.323*	3
	Secondary and more	Negative	0.66	0.017	8
	HOH_Branch (reference: secondary or tertiary sector)				
	Primary sector	Negative	0.56	0.00	3
	Access_Credit (reference: no)				
	Yes	Positive	1.28	0.227*	2
	Cotton_zone (reference: non-producing department)				
	producer department	Positive	1.76	0.00	3
	Rice_zone (reference: weak potentiality)				
	strong potentiality	Positive	1.34	0.037	0.20
	very strong potentiality	Positive	1.08	0.576*	3
	growth	Negative	0.2	0.00	12

* not significant
Source: Authors from EMICoV data (2006, 2009).

these variables.

Econometric analysis

Presentation and interpretations of results

In the context of econometric analysis, two types of estimations were made, by variation of the reference category, based on an unordered multinomial logistic regression. The results of these estimates are recorded in Table 3.

As the model statistics show, the likelihood of the log likelihood of chi-square being less than 5%, the model is statistically validated. Thus the model has at least one variable explaining the transition into poverty. We can therefore switch to interpretations of the results.

Effect of variables of interest on negative transitions

The significance at the 1% threshold of the coefficient associated with the variable "Cotton_zone" and its sign show us that the probability of entering or remaining poor is lower for a household living in a cotton-producing department compared to that of a household living in a non-producing department. Indeed, all things beingequal, there is 0.55 times less risk for a household living in a cotton producing department to make a negative transition than for a household living in a non-cotton producing department. In addition, when one moves from a household living in a non-cotton producing department to a household living in a cotton producing department, the risk of making negative transitions decreases by 10%. This result seems to confirm the results of the descriptive analysis, but does not yet allow us to accept the first

Table 3. Estimate with all variables.

Transition	Coef	Std.Err.	Z	P IZI	95%Conf	Interval
Never poor			**Base outcome**			
Entered or persisted in poverty						
Sex CM	-0.09526	0.111441	0.85		-0.31368	
Instruction_CM	-0.15376	0.060517	-2.54	0.393	-0.27237	
branch_cm	-0.58798	0.088496	6.64	0.011	0.414531	0.123156
acredit	-0.62314	0.160473	-3.88	0	-0.93766	0.035151
Vul_choc	-0.10805	0.082255	-1.31	0	-0.26927	0.761427
Household_under_employement	-0.3627	0.078235	4.64	0.189	0.209357	-0.30862
Actif_death	-0.41026	0.298509	1.37	0	-0.99533	0.053164
Incr_price	-0.25139	0.170487	-1.47	0.169	-0.58554	0.516034
Household_size	-0.80311	0.043527	18.45	0.14	0.717803	0.174805
Var_size	1.322048	0.093446	14.15	0	1.138897	0.08276
Sector_CM	1.253731	0.2309	5.43	0	0.801176	0.888424
Prod_cotton	-0.80409	0.113472	-7.09	0	-1.02649	1.505199
Prod_rice	2087356	0.056736	-3.68	0	-0.31994	1.706286
Age_CM	-0.14562	0.036534	-3.99	0	-0.21723	-0.58168
_cons	-.3.265418	0.271321	-12.04	0	-3.7972	-0.09753
				0		-0.07402
						-2.73364
Exit from poverty or persisted						
Sex CM	0.02919	1208738	0.24	0.809	-0.20772	0.266099
nstruction_CM	-0.30654	0.07145	-4.29	0	-0.44658	0.633455
Branch_cm	0.015807	0.097472	0.16	0.871	-0.17524	-0.1665
acredit	-0.35731	0.179687	-1.99	0.047	-0.70949	0.206849
Vul_choc	-0.03878	0.093646	-0.41	0.679	-0.22233	-0.00513
Household_under_employment	0.143664	0.089361	1.61	0.108	-0.03148	0.14476
Actif_death	0.104131	0.270068	-0.39	0.7	-0.42519	0.318808
Incr_price	0.310799	0.171305	1.81	0.07	-0.02495	0.633455
Household_size	0.618641	0.047373	13.06	0	0.525792	0.646551
Var_size	-0.28012	0.105563	-2.65	0.008	-0.48702	0.711489
Sector_CM	0.885319	0.235222	3.76	0	0.424292	-0.07322
Prod_cotton	-0.05894	0.117669	-0.5	0.616	-0.28957	1.346345
Prod_rice	-0.22267	0.064696	-3.44	0.001	-0.34947	0.171687
Age_CM	-0.07436	0.04098	-1.81	0.07	-0.15468	-0.09587
_cons	-2.12122	0.281751	-7.53	0	-2.67344	0.005958
						-1.569

hypothesis associated with the variable "Cotton_zone".

As for the variable "Rice_zone", the significance at the 1% threshold of both modalities and their negative signs show that the risk of making negative transitions decreases when the household lives in a department with high or very high potential rice production. Indeed, all other things being equal, households living in these types of departments are respectively 0.58 and 0.59 times less likely to make negative transitions than households in low-potential departments; this allows us to accept our hypothesis 2, according to which "The probability of a household to make a negative transition (entry or stay) increases when it lives in a department whose potential for rice production is low".

Finally, the 1% significance of the coefficient associated with the variable "Var_Size" and its sign indicate that the increase in household size has a positive effect on the probability of entering or remaining in poverty. In fact, a household whose size has increased is 3.77 times more likely to make a negative transition than a household whose size has decreased. As well, when moving from a smaller household to a larger household, the risk of negative transitions increases by 27% (see Graph 4 in the Appendix). Those results confirm the outcomes of the descriptive analysis and allow us to accept hypothesis H3 according to which "the increase of the size of a household increases the probability for this last one to make negative transitions".

Effect of variables of interest on positive transitions

Significance at the 1% level and its sign show that the probability of making positive transitions for a household living in a cotton producing department is higher than the probability for a household living in a non-cotton producing department. Indeed, all things being equal, this probability is 1.76 times higher than for a household living in a non-producing department. This also confirms the results of the descriptive analysis, and allows us to validate hypothesis H1 according to which "The probability of a household to make positive transitions (exit) increases when living in a cotton producing department"

Moreover, the significance at the 5% threshold of the "high potential" modality of the variable and its sign allow us to affirm that a household living in a high potential department is more likely to emerge from poverty than a household living in a low potential department.

Finally, the significance of the variable "Var_Size" at the 1% threshold, and its negative sign show that a household whose size has increased is less likely to emerge from poverty than a household whose size has decreased. Indeed, this chance is 0.20 times lower in a household whose size has increased, all things being equal.

The effects of the other variables on the transition will be observed in the tables in the appendix (Appendix Tables 2 to 4). However, the variables "HOH sex", "Death of an active member", "vulnerability to biophysical shocks", "Increase in input prices" do not have a significant effect on the nature of the household transition (annex) and were not taken into account in the final estimates.

Results interpretation

In this paragraph, the results previously presented will be clarified and evidences capable to justify them in the Beninese context will be pointed out.

As a first step, it is important to summarize the verification or not of research hypotheses. Thus, with regard to the effect of the geographic location of households on the nature of the transition made by them, as expected to live in a cotton producing department increases the probability of making positive transitions (H1). Similarly living in a department with high or very high potential in rice production decreases the probability of carrying out negative transitions (H2) on the other hand, making negative transitions, is positively affected by the increase in the size of the household (H3). So all our hypotheses are validated and are not rejected.

In light of the results of the econometric analysis, it is noted that the location of households in cotton production areas has a positive effect on outputs. This situation can be explained by the increased income of cotton producers1 between 2006 and 2009 following a good cotton season (INSAE, 2014). Indeed, if it is assumed that households in these areas are almost all seed cotton producers, then the positive effect of this location on the outings can be interpreted as the result of a good cotton season on the level of household life.

Regarding the location in potential areas (high or very high) in rice production, the negative effect of this location on negative transitions can be explained by the upward trend that began to take rice production in the past. Benin in 2008 (see Figure 1 in the appendix). This increase would have the effect of improving the incomes of the households that live from this production and thus to keep them above the line of poverty considered.

Finally, the positive effect of the increase in household size on negative transitions is easily explained by the Malthusian theory that population growth is a source of significant pressure on the resources of the population. In the case of Benin, new births would constitute a new burden for households that do not already have a fairly stable living standard.

Conclusion

The objective of this study was to determine the explanatory factors of household transitions in Benin's poverty, the households that come out of them and to highlight the variables related to those who remain poor or enter poverty. At the end of this work, the various descriptive analysis and the multinomial logistic regression, tools of verification of the hypotheses, made it possible to validate the various hypotheses. The results show that the probability of making positive transitions (outflow) increases when the household lives in a cotton producing department. At the same time, the probability of making negative transitions decreases when the household lives in a department with a potential (strong or very strong) in rice production while it increases when the household increases in size.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interest.

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Appendix

Table 1. Potentiality in lowlands estimated by department.

Department	Estimated potentialitie (ha)
Atacora-Donga	56,000
Borgou-Alibori	33,000
Zou-Collines	65,000
Mono-Couffo	17,000
Ouémé-Plateau	19,000
Atlantique	15,000

Source: Author, 2017.

Table 2. Variable description.

S/N	Variable		Description	Source	Expected effect
1	Cotton_Prod	0 for non-producing department * 1 for production department	Indicates if the household lives in a cotton producing department	Recoded variable	-
2	HoH_Sector	0 for formal * 1 for informal	Indicates HOH business sector	INSAE (2014)	-
3	HoH_Branch	0 for others * 1 for agriculture	Indicates the industry of HOH	INSAE (2014) and Hodonou et al. et al. (2010)	-
4	Under employment_HoH	0 for no * 1 for yes	Indicates the quality of HOH employment	David Ricardo	-
5	Vul_choc	0 for absence of shock * 1 for shock	Indicates the household's status in the face of biophysical shocks	INSAE (2014) and Hodonou et al. (2010)	-
6	Input-price-increase	0 for no increase * 1 for increase	Indicates if the household has experienced an increase in input prices	INSAE (2014)	-
7	Active_Death	0 for no death of an active member * 1 for death of an active member	Indicates if the household experienced a death of an active member	Walras	-
8	Var_Size	0 to decrease the size * 1 to increase the size	Indicates the status of the household in relation to its size	Thomas Malthus	-
9	HOH_Sexe	0 for men * 1 for women	Indicates the sex of HOH	INSAE (2014) and Hodonou et al. (2010)	+
10	HOH_Degree	0 for no degree * 1 for primary level 2 for secondary level 3 for higher level	Indicates HOH's degree of education	Human Capital Theory and Sen's Approach	- +
11	HOH_Age	0 for less than 35 years *	Indicates the age of HOH	Life cycle theory	+

Table 2. Contd.

		1 for 35 to 44 years			+
		2 for 45 to 54 years			-
		3 for 55 and over			-
12	Household_credit	Yes* No	Indicates whether the household has access to credit		
13	Household _Size	less than 4 people * 4 to 5 people 6 to 7 people 8 and above	Indicates the initial size of the household	Malthusian theory and INSAE (2014)	+ - -
14	Zone_Riz	Weak* High Very high	Indicates the potential of the area of residence of the household in the lowlands	Recoded variable	+ +

* Reference modality.
Source: Authors (2017).

Table 3. Characteristics of the sample.

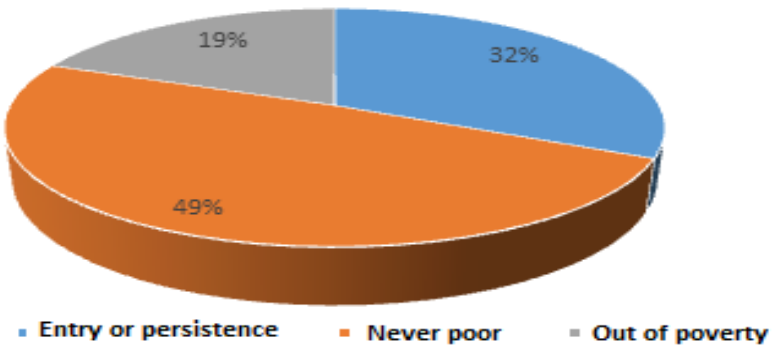
Variable	Categories	Percentage/age
Sexe of HOH	Man	80.20%
	Woman	19.80%
Living zone	Urban	34%
	Rural	66%
Age	Mean	44 years old
	Median	41 years old
	Maximum	96 years old
	Less than 35 years old	29.80%
	35-44 years old	25.20%
	45-54 years old	19.20%
	55 years old and more	25.70%
Department	Alibori	6.70%
	Atacora	9.70%
	Atlantique	13.30%
	Borgou	8.60%
	Collines	7.80%
	Couffo	8.60%
	Donga	4.00%
	Littoral	6.30%
	Mono	7.50%
	Ouémé	9.20%
	Plateau	5.50%
	Zou	12.90%
Education	No level	61.70%
	Primary level	23.80%
	Secondary level and more	14.50%

Source: Authors (2017).

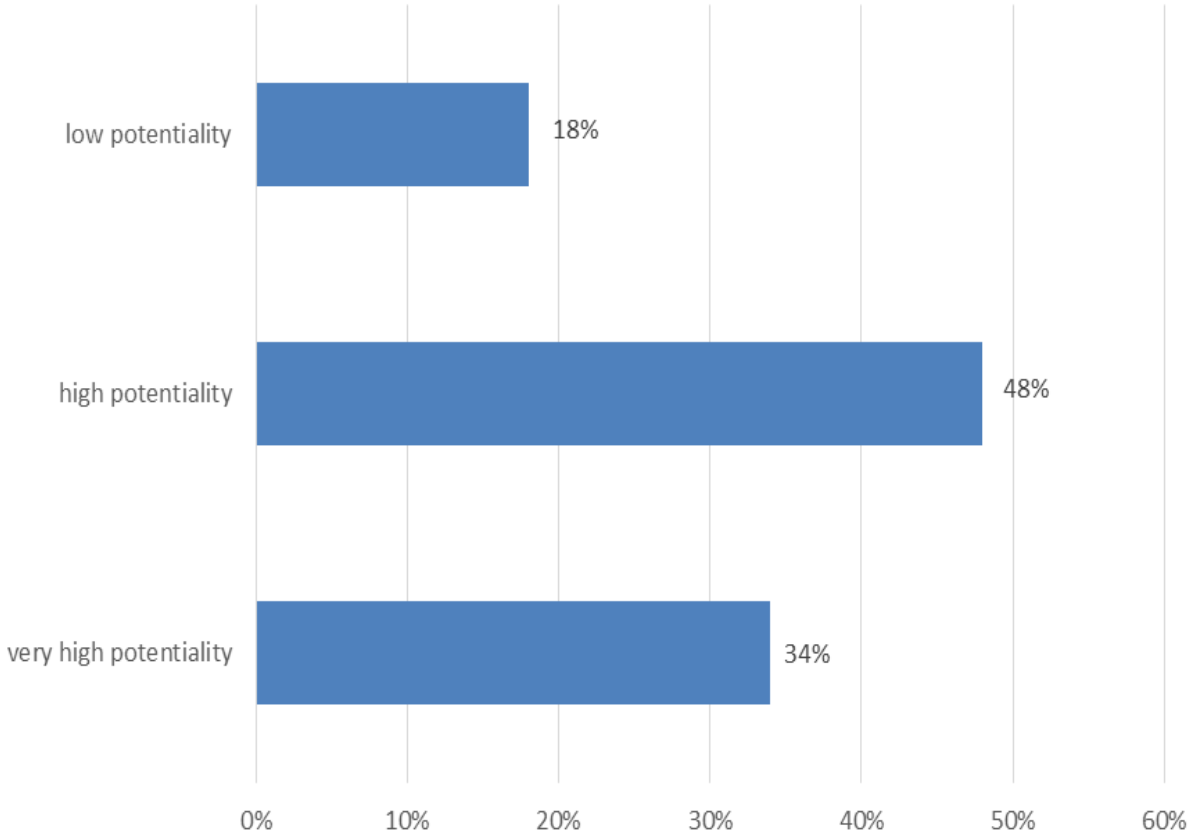
Table 4. Econometric analysis.

Parameter	Model 1: Transition (base: never poor)		Model 2: Transition (base: entry or stay)	
	Entry or stay	Exist	Never poor	Exist
	Coef		Coef	
Instruction_HOH				
Primary (1)	-0.15	-0.26**	0.15	-0.11
Secondary and more (2)	-0.29**	-0.7***	0.29**	-0.41**
Branch_HOH				
Primary (1)	0.59***	0.02	-0.59***	-0.57***
Credit_Acess				
yes(1)	-0.62***	-0.37**	0.62***	0.25
Household_underemployment				
yes(1)	0.35***	0.15	-0.35***	-0.21**
Household size				
4 to 5 (1)	0.94***	1.02**	-0.94***	0.08
6 to 7 (2)	1.75***	1.44**	-1.75***	-0.3*
8 and more (3)	2.42***	1.97**	-2.42***	-0.45***
Size variation				
Increase (1)	1.33***	-0.28**	-1.33***	-1.61***
HOH_Sector				
Informal	1.27***	0.84**	-1.27***	0.43
Cotton_Zone				
production department (1)	-0.59***	-0.03	0.59***	0.57***
Rice_Zone				
high (1)	-0.55***	0.25*	0.55***	0.29**
very high (2)	-0.53***	0.45**	0.53***	0.08
Age_HOH				
35 to 44 years old (1)	-0.11	0.11	0.11	0.22
45 to 54 years old (2)	-0.36***	-0.13	0.36***	0.23
55 years old and more	-0.41***	-0.13	0.41***	0.28
Constant	-3.27***	-2.33*	3.27***	0.94
Number of valid observations	4378			4378
LR chi2(32)			996.42	
Prob > chi2	0.00***			0.00***
Maximum likelihood log	-4028.58			-4028.58
Nickname R2	0.1101			0.1101

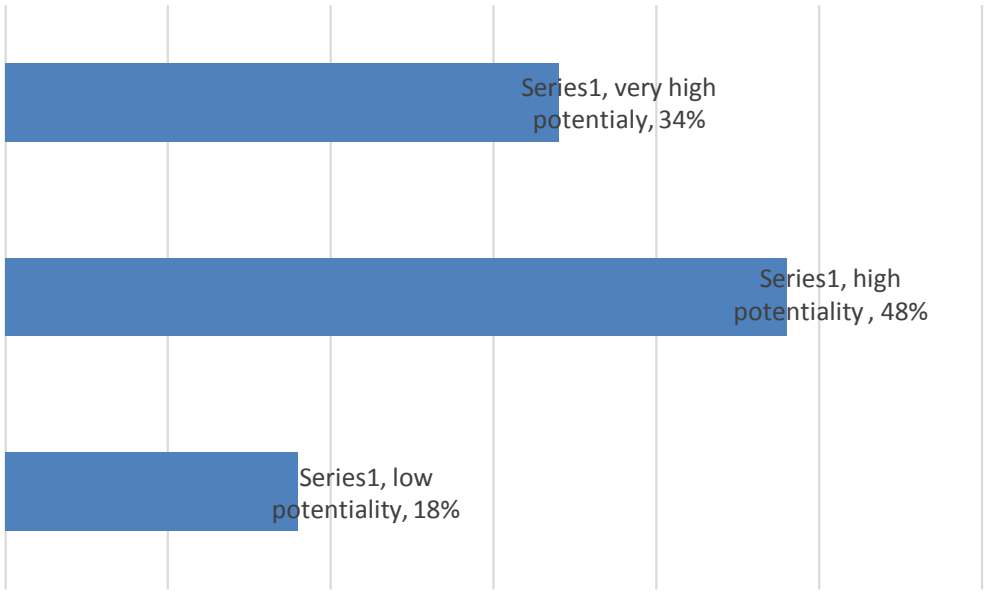
*Significant at the 10% threshold; ** significant at the 5% level; *** significant at the 1% level.
Source: Authors from EMICoV data (2006, 2009).



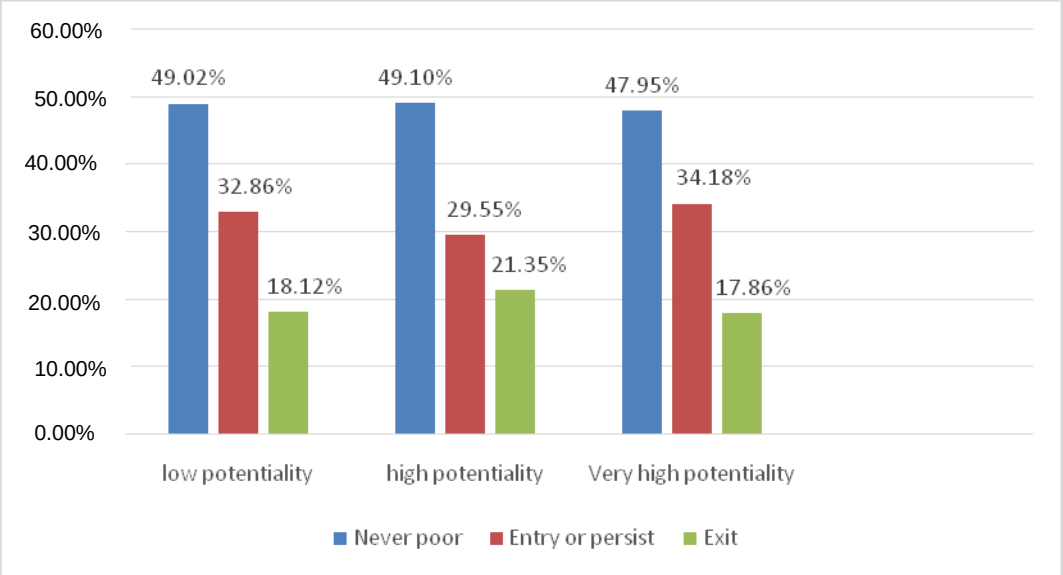
Graph 1. Household distribution (in percentage) according to the transition.
Source: EMICoV (2006,2009).



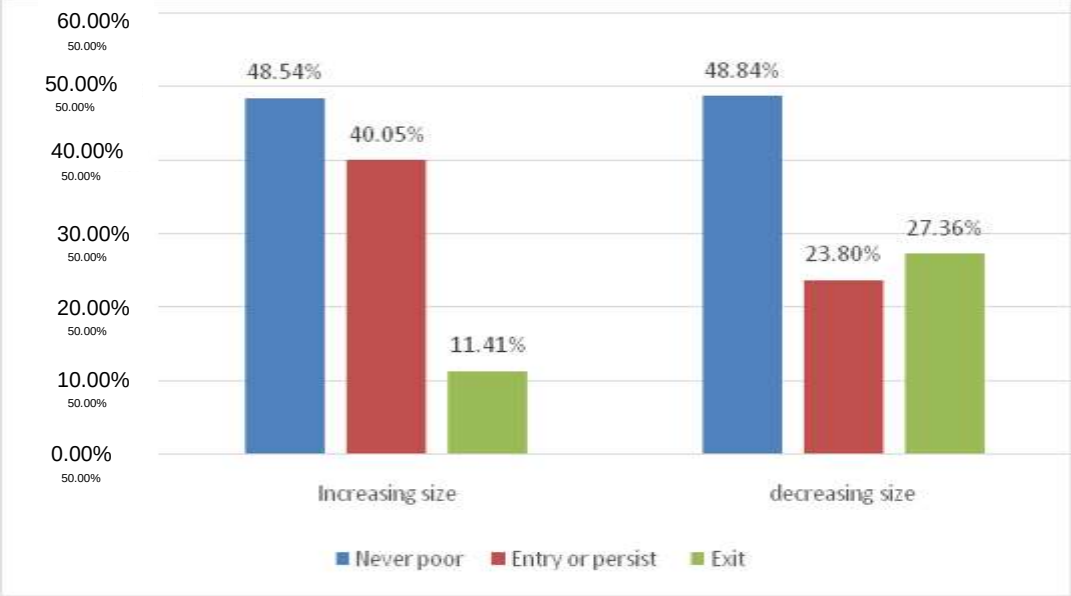
Graph 2. Household distribution according to department potentiality in rive production.
Source: authors 2017 from Emicov data base (2006, 2009)



Graph 3. Crossover between cotton production area and transition
Source: EMICoV Data base (2006, 2009).



Graph 4. Crossover between zone of coton production and transition.
Source: EMICoV data base (2006, 2009).



Graph 5. Crossing between transition and rice's potentiability zone.
Source: EMICoV Data base (2006,2009).

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