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Full Length Research Paper

Trend, pattern and determinants of crop diversification of small holders in West Bengal: A district-wise panel data analysis

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Crop diversification is one of the most important risk management and income enhancing strategies for farmers. The study investigates the pattern, trend, and factors influencing crop diversification in different districts of West Bengal, based on secondary data. The Simpson index has been used to estimate diversification. The results show that all the districts of West Bengal and the state as a whole have exhibited a higher crop diversification during new millennium than the nineties. Both the supply side and demand side variables have been found to influence crop diversification. These variables include rural literacy rate, the percentage of urban population to total population of the district, relative earning from high-value crops (HVC) than cereals, the market density of a particular region, the percentage of small landholders and area under high yielding varieties (HYV) of food grains. The magnitude of rainfall and extension of crop insurance facility also have a significant impact on crop diversification. The government should come forward with suitable policies to encourage crop diversification. These policies may encompass the development of rural infrastructure, enhancement of rural literacy rate, the extension of crop insurance facilities and above all, the development of suitable price policy in favor of high-value crops.

Key words: Crop diversification, Simpson's index, panel data regression, high-value crop, smallholder.

INTRODUCTION

The agriculture and allied sector continues to be pivotal to the sustainable growth and development of the Indian economy. Not only does it meet the food and nutritional requirements of 1.3 billion Indians, it contributes

significantly to production, employment and demand generation through various backward and forward linkages leading to a multiplier impact on the gross domestic product of the economy. Moreover, the role of

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the agricultural sector in alleviating poverty and in ensuring the sustainable development of the economy is also well established (Government of India, 2017).

The sector is, however, currently facing a dilemma. While it has made large strides in achieving the agricultural development goals of food security, availability and accessibility, it is still being challenged by a formidable agrarian crisis in the form of 'farmer's welfare/ development'. This situation has recently led to fresh thinking on the developmental approach in the agriculture sector. The need for focusing on the welfare and prosperity of farmers has gained prominence (State of Indian Agriculture 2015-16, Government of India, 2015; Ministry of Agriculture and Farmers Welfare, Government of India, 2016a, b).

Indian agriculture is predominantly a small and marginal peasant-based economy with approximately 85% of the operational holdings being below two hectares and at the same time, only 44.58% of the agricultural land is cultivated by them (Agriculture Census 2010-11, Government of India, 2010). Because of small operational holdings, it is indeed very difficult for the small farmers to improve their earnings only by raising the yields of the existing crops, mainly cereals. However, with the availability of modern farm inputs in the current decades, farmers have a ready option to generate higher levels of income by introducing high value crops commonly known as cash crops in their farming units. Thus, the high-value crops being more labour intensive usually provide stable employment and income to a large section of the rural households who face the severe problem of seasonal unemployment and underemployment under the mono-crop economy (De and Chattopadhyay, 2010). Therefore, diversification from low-value crop to high-value crop at farm level can solve many of the problems faced by small and marginal farmers.

In general, diversification is an integral part of the process of structural transformation of an economy (Singh et al., 2006). A deviation from agriculture towards industries and services denotes diversification (across sectors) at the macro level. But there is a lack of clarity when it comes to diversification within a sector itself, and the same holds true also for the agriculture sector. In Indian agriculture, diversification has occurred both between crops and across activities (that is, crop cultivation, livestock raising, forestry, and fishing). Within agriculture, the share of output and employment in the non-crop sectors, i.e. animal husbandry, forestry, and fisheries, has been gradually increasing (Joshi et al., 2004). Thus, significant diversification is taking place in terms of moving away from crop production to other agriculture-allied activities. Simultaneously, similar significant changes are taking place even within the crop sector which is evident from changes in cropping pattern (Singh et al., 2006).

So, to summarize, there are two kinds of diversification

at farm level: horizontal diversification and vertical diversification. Horizontal diversification refers to the cultivation/introduction of different kinds of crops that is, minor crops, fruits, and vegetables along with conventional major crops at farm level by farmers. Vertical diversification occurs when farmers engage themselves in different value-added activities at the farm level or adopt some other enterprises that is, livestock, poultry farming and fish farming along with the growth of crops at farm level (Haque, 1996).

It needs to be noted here that the incidence of crop diversification in India was very uncommon, particularly before the introduction of new agricultural technology in the mid-sixties. With the advent of new agricultural technology particularly, water-seed-fertilizer technology, a significant change in land allocation towards some high-value cash crops such as fruits and vegetables cultivated is evidenced in India, particularly by the small farmers (De and Chattopadhyay, 2010).

Crop diversification as a concept and tool is a strategy to maximize the use of land, water, and other resources and for the overall agricultural development in the country. It provides the farmers with viable options to grow different crops on their land around the year. The diversification in agriculture is also practiced with a view to avoiding risk and uncertainty due to climatic and biological vagaries. It minimizes the adverse effects of the current system of crop specialization and monoculture for better resource use, nutrient recycling, reduction of risks and uncertainty and better soil conditions. It also provides better economic viability with value-added products and improvement of ecology.

Agricultural diversification construed in the sense of change in the cropping pattern towards high-value crops is undoubtedly a major factor contributing towards agricultural development. This is because of two main reasons, first, it has been observed that the impacts of the green revolution in cereals get exhausted after an 'optimum' level is reached that is, agricultural growth becomes stagnant. Secondly, the small and the marginal farmers who dominate the agricultural scenario of most of the Indian states, including West Bengal, can generate higher farm income and employment and mitigate risks by adopting a diversified crop portfolio (Vyas, 1996).

Based on the aforementioned discussion, it may be argued that the small and marginal farmers, depending on a small piece of land and having no alternative sources of employment and income due to the existence of a vast population of surplus labor in the countryside, would always try to produce the maximum output on the given piece of land. They would also try to cultivate as many crops as possible and choose such high-value crops (for example, boro paddy, oilseeds like rapeseed and mustard, potato, jute, fruits and vegetables), which after meeting their consumption needs, would meet their minimum cash requirements for the maintenance of their daily life. Even the medium and large farmers approach

diversification for the improvement of their living standard. Thus the phenomenon of crop diversification in India could be viewed as the survival needs of the farmers, especially of the small and marginal ones. Agricultural diversification is also contributing to employment opportunities in agriculture, increasing incomes and exports.

During the recent decades, the process of diversification has been wide-spread due to the combined effects of water-seed- fertilizer technology as well as some infrastructural development such as market centers, roads, transport etc., in the countryside (Vyas, 1996; Bhalla and Singh, 1997). Agricultural diversification is strongly influenced also by price policy and income of farmers. Rural literacy also has an influence on crop diversification. It has also been observed that rain fed areas have benefited more as a result of agricultural diversification in favour of high-value crops by substituting inferior coarse cereals.

In West Bengal, an interesting observation is that a marked diversification of cropping pattern away from food grains has occurred since economic liberalization. The share of cropped area under non-food grains increased substantially over the past two and a half decades. The percentage of acreage of oilseeds, particularly mustard, was nearly doubled during 1980-2006. The area under potato also increased magnificently during the same period. But the share of cropped area under jute declined over this period, although increased in the 1990s (West Bengal Development Report 2014a; Planning commission, Government of India (GOI), 2007).

In West Bengal, 95.91% of the operating households belong to the marginal and small category and operating about 80.71% of the total land holding (Government of West Bengal, 2014). Like other states of India, the small farmers of West Bengal have got the high priority to high-value crops like summer paddy, mustard, potato, jute and vegetable (De, 2000). Agriculture in West Bengal has been diversifying gradually also towards high-value crops. West Bengal is one of the leading producers of fruits and vegetables contributing nearly 19.62% to the country's total production in 2014-2015 (Government of India, 2016a, b).

Objective

The specific objectives of this paper are:

- (1) To analyze the pattern and trend of horizontal crop diversification
- (2) To find the factors affecting the crop diversification

The study area

The study focuses on 17 major districts of West Bengal during 1990 to 91 to 2013 to 14. These districts differ in

terms of gross cropped area, soil fertility, climatic condition such as rainfall, and availability of agricultural inputs. Due to non-availability of disaggregated data for both South and North Dinajpur from 1990-91 to 1995-96, we have considered Dinajpur as a single district in the name of West Dinajpur. The district of Midnapore has been administratively divided after 2005. However, the agricultural division was done in the 90s. So East Midnapore and West Midnapore are considered separately.

Type and sources of data

The secondary data on an area under different crops and major agricultural inputs at the district level and state level for West Bengal have been collected from different issues of "District Statistical Hand Books". The data on per capita income have been collected from "State Domestic Product and District Domestic Product of West Bengal" published by Bureau of Applied Economics and Statistics, Department of Statistics and Programme Implementation, Government of West Bengal. The post-harvest price data of different crops have been taken from various issues of "Estimates of Area and Production of Principal crops in West Bengal" Evaluation Wing, Directorate of Agriculture, Government of West Bengal.

METHODOLOGY

Determination of crop diversification

There are quite a few methods, which explain either concentration (that is, specialization) or diversification of commodities or activities in a given time and space by a single indicator. Important ones include:

- (1) Index of maximum proportion (IMP = Max P_i), where, P_i = Proportion of acreage under i^{th} crop to total cropped area
- (2) Herfindahl index, mathematically, the index is defined as:

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

Where N = Total number of crops; P_i = Proportion of acreage under i^{th} crop to the total cropped area. This index was first used to measure the regional concentration of industries (Theil, 1967). The value of HI is bounded by 0 (perfect diversification) and 1 (complete specialization)

- (3) Ogive index is computed in order to get an idea about the extent of crop diversification. OI is given by the formula:

$$OI = N \sum_{i=1}^N \left\{ p_i - \left(\frac{1}{N} \right) \right\}^2$$

Where P_i = Proportion of acreage under i^{th} crop to the total cropped area, N = Total number of crops cultivated in the region. OI also takes larger values with increasing diversification and its value decreases with rising specialization. It was first used by Tress (1938) to measure the industrial diversity.

Two other indices are also considered as inverse measures of

concentration. They are entropy index (EI) and modified entropy index (MEI). These two measures are widely used by agricultural economists for analyzing diversification of agriculture (Singh et al., 1985; Shiyani and Pandya, 1998).

(4) The formula for computing entropy index is:

$$EI = \sum_i^N P_i \log_{10} P_i$$

Where, P_i stands for the proportion of an area under i th crop. The index would increase with an increase in diversification and the upper value of index can exceed 'one' when the number of total crops is higher than the value of logarithmic base i.e 10. The value of index approaches Zero when there is complete concentration. When the number of crops is less than the value of logarithmic base, the value of index varies between Zero and One.

(5) In order to get a more accurate measure, MEI is used, which is defined as:

$$MEI = \sum_{i=1}^N (P_i \log_N P_i)$$

MEI incorporates the number of crops as the base of the logarithm. The lower and upper value of MEI is 0 (total concentration) and 1 (perfect diversification) and other one is composite entropy index (CEI).

(6) The formula of CEI is given by:

$$CEI = - \sum_{i=1}^N (P_i \log_N P_i) * \{1 - (1/N)\}$$

The CEI has two components namely distribution and number of crop, or diversity. The value of composite entropy index increases with the decrease in concentration and rises with the number of crops (Pandey and Sharma, 1996; Chand, 1996). The value of CEI ranges between zero and one.

(7) Another one is Simpson's index (SID). Simpson's index, mathematically defined as:

$$SID = 1 - \sum_{i=1}^N P_i^2 \\ = 1 - HI$$

P_i is the proportionate area (or value) of i^{th} crop activity in the gross cropped area (or the total value of output). Each method has some limitation and/or superiority over the other. However, the Simpson's index takes into account both richness (the number of crop species present in a particular area) and evenness (the relative abundance of different crop species) of crops present in a particular area. As crop richness and evenness increase, diversity increases. Thus, the Simpson's index provides a clear dispersion of crops in a particular area. The Simpson's index ranges between 0 and 1. If there exists complete specialisation, the index moves towards zero and away from zero implies diversification. The most widely used method for measuring diversity in recent times is Simpson's index. It is easy to compute and interpret (Joshi et al., 2004). Considering the study objective of assessing the extent of diversity in crop activities, Simpson's index has been used.

Econometric model for determinants of crop diversification

Panel data regression model

To discern the determinants of crop diversification at the district

level, fixed effect model (FEM) with Standard Ordinary Least Squares (OLS) has been used. A balanced panel data set is used which has an equal number of observations for each individual (district). The sample size comprises 408 observations. The regression equation specification has been used to find the association between SID (dependent variable) and technology, infrastructure, relative income, resources - information, demand, and climate (independent variables). The FEM has constant slopes but intercepts differ according to the cross-sectional (district) unit. For i classes, $i-1$ dummy variables are used to designating a particular districts. It allows for heterogeneity or individuality among districts (units) as each district is allowed to have its own intercept value. So, intercepts may differ across districts but they do not differ over time.

Fixed effect models

To take into account the individuality of each district (cross-sectional unit), intercept is varied by using dummy variable for fixed effects. Fixed effect models for panel data (intercept or individual) can be represented by Equation:

$$SID_{it} = \beta_{1i} + \beta_2 TECH_{it} + \beta_3 INFRA_{it} + \beta_4 KNOW_{it} + \beta_5 DEMA_{it} + \beta_6 RAIN_{it} + \beta_7 INCM_{it} + u_{it}$$

Where, $i = 1, 2, 3, \dots, 17$ (cross section (district)), $t = 1, 2, 3, \dots, 24$ (time period (years)),

SID = Simpson index of diversification, TECH = technology, INFR = infrastructure, KNOW = resources and information, DEMA = demand, RAIN = climate, INCM = relative income, u = Stochastic error-term.

To know the factors influencing the shift in cropping pattern, the following variables considered as the explanatory variables (independent variable) were broadly grouped into:

- (1) Technology (TECH) related
- (2) Infrastructure (INFR) related
- (3) Resources and information (KNOW) related
- (4) Demand (DEMA) side
- (5) Climate (RAIN) related, and
- (6) Relative income (INCM) related.

To capture their effect, few proxy variables were used in the model. Technology (TECH) included, proportionate area under high yielding varieties of food grain crops (percent), fertilizer use (kg per ha), proportion of gross irrigated area to gross cultivated area (per cent). For infrastructure (INFR), the proxy variables were market density (number of markets per 1000 ha of gross cropped area), and roads length (square km per 1,000 ha of gross cropped area). Relative revenue of high-value enterprises with cereals and other crops was the proxy for income (INCM) related variables. The average size of landholding (ha) and proportion of small landholder in total holdings used the proxy for available resources and rural literacy (percent) for information (KNOW) related variables. On demand-side (DEMA) variables, urbanization (percentage of urban population) and per capita income (rupees per person) were used in the model. Annual rainfall (mm) was used to define the climate (RAIN) related variable in the model.

RESULTS AND DISCUSSION

Trend and pattern of crop diversification

The district-wise crop diversification indexes of West

Table 1. District-wise crop diversification index in West Bengal during the periods of 1990 to 1991 to 2013 to 2014.

District	Sub period I (TE 1990-93)	Sub period II (TE 2000-03)	Sub period III (TE 2010-13)
	Simpson's index	Simpson's index	Simpson's index
Nadia	0.84	0.86	0.86
Murshidabad	0.81	0.85	0.84
Malda	0.80	0.82	0.82
Jalpaiguri	0.61	0.80	0.82
North 24 Parganas	0.71	0.80	0.80
Darjeeling	0.69	0.80	0.79
Hoogly	0.70	0.78	0.78
West Dinajpur	0.63	0.74	0.76
Coochbihar	0.71	0.72	0.73
Howrah	0.56	0.68	0.68
West Midnapore	0.52	0.65	0.67
Burdwan	0.58	0.68	0.65
East Midnapore	0.53	0.63	0.63
Birbhum	0.45	0.63	0.63
Bankura	0.49	0.58	0.60
South 24 Parganas	0.26	0.52	0.58
Purulia	0.28	0.39	0.35
West Bengal	0.66	0.76	0.77

Source: Various issues of 'district statistical hand books', bureau of applied economics and statistics, and different issues of 'estimates of area and production of principal crops in West Bengal', Directorate of Agriculture, Govt. of W. B. (Government of West Bengal, 2014b).

Bengal for different decades are presented in Table 1. The successively increasing value of Simpson's index (SI) indicates an increased level of diversification. The falling value of the index on the other hand, indicates increasing specialization. The calculated Simpson's indices for different districts as well as for the whole state of West Bengal registered higher value for the period starting from 2000 as compared to the previous decade.

Among the different districts of West Bengal considered in this study, the value of Simpson's index is the highest in Nadia followed by Murshidabad in all the sub-periods. This indicates that Nadia showed the highest crop diversification followed by Murshidabad in all the sub-periods under study. Malda is an important district in terms of crop diversification consistently showing high value of Simpson's index. North 24 Parganas, Coochbihar and Hoogly also have a high value of Simpson's index. Burdwan is agriculturally the most developed district in West Bengal, but the speed of crop diversification is not very high in this district. The magnitude of crop diversification indices of Burdwan, Birbhum (except sub-Period I), Howrah, East Midnapore and West Midnapore are more or less the same in all the sub-period under analysis.

The value of Simpson's index in Purulia is always less than 0.40 meaning that there is no tendency of crop diversification. In South 24 Parganas and Bankura, the magnitudes of crop diversification indices are also low. During sub-Period I, South 24 Parganas showed the

lowest value of Simpson's index followed by Purulia. The speed of diversification is quite worth mentioning in Jalpaiguri, Darjeeling and West Dinajpur (Table 1).

In Jalpaiguri, the magnitude of crop diversification index was 0.61 in sub-Period I but the value increased to 0.80 and 0.82 in the following two sub-periods. Darjeeling shows the same pattern of diversifying tendency with the value of diversification index being 0.69, 0.80, and 0.79 during the three sub-periods respectively. In West Dinajpur, the magnitude of diversification index was 0.63 in sub-period I. This value changed into 0.74 and 0.76 respectively in next two sub-periods. The state of West Bengal as a whole indicates diversifying tendency in crop cultivation with the value of Simpson's index being 0.66, 0.76, and 0.77 in three consecutive sub-periods under study.

The result obtained from the study indicates towards a very interesting fact. Out of 17 districts under analysis, 7 districts have always exhibited a higher value of crop diversification index compared to the state as a whole. On the contrary, 10 districts always had crop diversification indices lower than the state figure. While the districts of Nadia, Murshidabad and Malda have always remained within top five. Purulia, Birbhum, Bankura and South 24 Parganas were in the category of bottom five districts in terms of diversification of crops. The district-wise values of other indices like 'Herfindahl, Entropy, and Ogive' also show a similar pattern for all the chosen sub-periods (Appendix Table 1).

Table 2. Categorization of districts according to diversification during 1990 to 91 to 2013 to 14.

Diversification	Value	TE 1990-93	TE 2000-03	TE 2010-13
		Name of the districts	Name of the districts	Name of the districts
Low	$0.25 \geq SI \leq 0.49$	South 24 Parganas, Purulia, Birbhum, Bankura	Purulia	Purulia,
Moderate	$0.50 \geq SI \leq 0.69$	Jalpaiguri, Burdwan, Howrah, East Midnapore, West Midnapore, West Dinajpur, Darjeeling	West Midnapore, Bankura, South 24 Parganas, Howrah, East Midnapore, Birbhum, Burdwan	Burdwan, Bankura, Birbhum, South 24 Parganas, Howrah, East Midnapore, West Midnapore
High	$0.70 \geq SI \leq 0.82$	North 24 Parganas, Hoogly, Coochbihar, Malda, Murshidabad	West Dinajpur, Coochbihar Malda, Jalpaiguri, Hoogly, Darjeeling, North 24Pargans	Malda, Coochbihar, Hoogly, Darjeeling, West Dinajpur North 24 Parganas, Jalpaiguri
Excellent	$0.82 \geq SI \leq 1$	Nadia	Nadia, Murshidabad	Nadia, Murshidabad

On the basis of the magnitude of Simpson index, we categorize the districts in four groups' namely low, moderate, high and excellent which are presented in Table 2. Nadia always belonged to the excellent group in terms of diversification while Purulia remained in a low category throughout the period under study. South 24 Parganas, Bankura and Birbhum remained in the low category in sub-period I but shifted to the moderate group in the subsequent two sub-periods. This implies that Bankura, Birbhum and South 24 Parganas have slowly attempted crop diversification.

Similarly, Murshidabad has shifted from the category of high diversification in sub-period I to the excellent category in the following two sub-periods. Darjeeling, Jalpaiguri, and West Dinajpur are in the moderate category of diversification in sub-period I but interestingly moved up to the high category of diversification in the successive two sub-periods. Districts like Malda, Coochbihar, Hoogly, and North 24 Parganas always fell in the category of high level of diversification. Burdwan, Howrah, East Midnapore and West Midnapore always remained moderately diversified.

Determinants of crop diversification

Crop diversification is influenced by a number of factors both in the supply-side (infrastructure development, technology adoption, relative income, resource endowments) and the demand-side (size of urban population and per capita income) as well as a climatic variable (rainfall). The study has also used dummy¹ variable to analyze the influence of crop insurance on crop diversification. This section examines the factors influencing diversification in favor of high-value crops. Multiple regression analysis has been carried out using

the time series panel data for the period 1990-91 to 2013-14 to identify the important factors affecting crop diversification (Joshi et al., 2004). Both linear and non-linear (log form) multiple regression functions have been attempted in the study. The one, which provided good fit has been considered. The estimated linear equations of Ordinary Least Square are given in Table 3. In the course of analysis, the variables that are statistically insignificant have been dropped step by step.

The technology is defined by the use of fertilizer, the percentage of irrigated area and proportionate area under HYV of food grains. The regression coefficient of these variables showed a negative relationship with crop diversification towards high-value crops in West Bengal. However, out of these three determinants, only the area under HYV for food grains is significant for diversification. This means if there is an increase in availability of HYV for foodgrains then the farmers concentrate on food crops production. This in other words, implies that crop diversification in favor of high-value non-food grain crops declines with the increasing in area under HYV of food crops.

The resource and information related variables are average size of landholding, proportion of small landholder in total holdings and rural literacy rate. There is a positive and significant relationship between crop diversification and the proportion of small holders. This indicates that diversification in favor of high value crops has been practiced mostly by small holders. Such a move of small farm holders in favor of high-value crops is expected to enhance their income. High value crops are mostly labor intensive, which favour small farmers and generate regular flow of income and employment. Rural literacy also yielded a positive and significant influence on crop diversification in favor of high value crop. Education helps the farmers in taking conscientious decisions and enables them in accessing several facilities which are required for crop diversification. If farmers are more educated, their decision for sowing a particular crop

¹Dummy used for the scheme NAIS (National Agricultural Insurance Scheme) has been implementing in the state from the year 2000-01.

Table 3. Determinants of diversification in favor of high-value crops during 1990 to 1991 to 2013 to 2014.

Independent variable	Equation 1		Equation 2		Equation 3		Equation 4	
	Estimate	t-value	Estimate	t-value	Estimate	t-value	Estimate	t-value
Intercept	-3.796e-01	-1.76@	-3.868e-01	-1.934@	-1.474e-01	-0.98	-1.496e-01	-0.996
Percentage of irrigated area	-1.059e-04	-0.46	-	-	-	-	-	-
Area under HYV of food grains	-1.977e-03	-3.2**	-2.003e-03	-3.313**	-2.346e-03	-4.03 ***	2.422e-03	-4.19***
Fertilizer consumption	-4.951e-05	-1.14	-4.924e-05	-1.140	-	-	-	-
Number of markets	1.057e-01	1.42	1.044e-01	1.482	-	-	-	-
Road length	1.188e-04	0.02	-	-	-	-	-	-
Average size of holding	8.716e-02	1.39	8.852e-02	1.432	-	-	-	-
Proportion of small landholder	1.041e-02	5.06***	1.045e-02	5.295***	9.014e-03	4.87 ***	8.906e-03	4.81***
Rural literacy rate	2.361e-03	3.53***	2.362e-03	3.540***	2.352e-03	3.69 ***	2.621e-03	4.47 ***
Percentage of urban population	-5.534e-03	-4.42***	-5.568e-03	-4.470***	-4.804e-03	-4.06 ***	-4.107e-03	-4.15 ***
Per Capita income	4.057e-07	1.68 @	4.106e-07	1.712@	2.472e-07	1.07	-	-
Annual rainfall	-1.302e-05	-2.13*	-1.319e-05	-2.172*	-1.212e-05	-2.01 *	-1.217e-05	-2.02 *
Relative income of HVC to rice	5.589e-03	2.47*	5.533e-03	2.468 *	5.715e-03	2.56 *	5.338 e-03	2.43 *
Relative income of HVC to non-food grains	-8.388e-03	-5.55***	-8.397e-03	-5.64 ***	-8.422e-03	-5.66 ***	-8.155 e-03	-5.56 ***
Dummy for NAIS	3.938e-02	5.93***	3.949e-02	6.007 ***	3.877e-02	5.96 ***	3.982e-03	6.17 ***
District Birbhum	2.330e-03	0.19	2.354e-03	0.191	4.093e-03	0.34	3.152e-03	0.26
District Burdwan	2.110e-01	5.61***	2.137e-01	5.775 ***	2.001e-01	5.66 ***	1.811e-01	5.92 ***
District Coochbihar	9.599e-02	3.84***	1.008e-01	4.598 ***	1.126e-01	6.80 ***	1.113e-01	6.74 ***
District Darjeeling	1.227e-01	2.22*	1.276e-01	2.541*	1.636e-01	3.97 ***	1.465e-01	3.85 ***
District East Midnapore	-9.121e-02	-3.19**	-8.864e-02	-3.166 **	-1.139e-01	-6.07 ***	-1.151e-01	-6.14 ***
District Hoogly	2.331e-01	5.23***	2.348e-01	5.313 ***	2.054e-01	6.03 ***	1.867e-01	6.39 ***
District Howrah	2.627e-01	3.59***	2.684e-01	3.758 ***	1.926e-01	3.43 ***	1.611e-01	3.36 **
District Jalpaiguri	1.336e-01	4.18***	1.381e-01	4.659 ***	1.592e-01	6.24 ***	1.510e-01	6.20 ***
District Malda	2.189e-01	9.02***	2.222e-01	9.561 ***	2.099e-01	10.17 ***	2.130e-01	10.43***
District Murshidabad	2.511e-01	9.04***	2.545e-01	9.630 ***	2.311e-01	10.99 ***	2.289e-01	10.94***
District North 24 Parganas	4.079e-01	6.12***	4.125e-01	6.297 ***	3.647e-01	6.40 ***	3.336e-01	6.801***
District Nadia	2.747e-01	9.10***	2.781e-01	9.530 ***	2.554e-01	9.43 ***	2.445e-01	9.74 ***
District Purulia	-2.211e-01	-11.23***	-2.180e-01	-11.79 ***	-2.301e-01	-14.47 ***	-2.309e-01	-14.58***
District South 24 Pargana	-1.234e-01	-3.87***	-1.183e-01	-3.950 ***	-1.390e-01	-6.49 ***	-1.425e-01	-6.73***
District West Dinajpur	1.582e-01	5.85***	1.623e-01	6.432 ***	1.629e-01	6.71 ***	1.648e-01	6.81***
District West Midnapore	1.723e-03	0.09	2.934e-03	0.153	-8.356e-03	-0.50	-1.259e-02	-0.77
R-Square	0.944	-	0.944	-	0.943	-	0.943	-
Adjusted R-Square	0.940	-	0.940	-	0.943	-	0.939	-
F Statistic	213.5 (30, 377)	-	229.8 (28,379)	-	255 (25,382)	-	265.5 (24,383)	-
Residual SE	0.036	-	0.036	-	0.036	-	0.036	-

Table 3. Contd.

Degrees of freedom	377	379	382	-	383	-
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Significance codes: 0 '****' 0.001 '**' 0.01 '*' 0.05 '@' 0.1.

would be governed by the sound economic estimates of costs and benefits of that crop. The sign of regression coefficient of average size of holding is not statistically significant but positive. This means that the larger the operated area the higher will be the extent of crop diversification. Farmers operating on a bigger piece of land have a wider choice and options for cultivating diversified crops compared to the farmers having a small piece of land.

To capture the effect of infrastructure development on diversification, two important variables, namely, the number of markets and road length has been included in the model. Both the variables yielded positive influence on diversification of high-value crop though they are not statistically significant. Obviously, better markets and road network induce diversification in favor of high-value crop like jute, potato, oilseeds, and vegetables. Improved market and road network means low marketing cost and easy and quick disposal of commodities. It also reduces the risk of post-harvest losses in case of perishable commodities (Joshi et al., 2004).

Similarly, the demand-side factors such as the size of the urban population have shown a negative and significant impact on crop diversification towards HVCs. The crop diversification towards HVCs declines with the increase in urban population. When the process of urbanization begins farmers concentrate towards the production of wheat, rice, and other food crops to fulfill the basic needs of urban peoples. Another demand-side variable namely per-capita income has a positive impact on crop diversification

towards high-value crops. With the rise in per capita income, people spend more on high-value crops like vegetables, potato, oilseeds, and jute etc., in addition to food crops. But this result is not statistically significant.

Rainfall is another variable considered in the model to assess the impact of climate on crop diversification. The variable is highly significant with a negative sign, indicating that the crop diversification is limited in areas with higher rainfall. The farmers in these areas naturally prefer cultivating rice, and it was only in the medium and low rainfall areas that farmers want to diversify to increase their income and minimize risk.

The regression coefficient of relative income of high value crops with respect to rice (dominant crop in West Bengal) is positive and significant. This means that if farmers cultivate any other high-value crop instead of rice in the same piece of land they would earn the higher income. However, the coefficient of relative income of high-value crops with respect to other non-food grains shows the significantly negative effect on crop diversification.

A dummy variable has been used for NAIS (National Agricultural Insurance Scheme) which has a positive and significant effect on crop diversification. The crop insurance can motivate a farmer to cultivate more diversified crops, including high-value crops for which profitability is very high. Crop Insurance mitigates the risk of crop failure to farmers.

Among the coefficients of district dummy, Bankura, Purulia, South 24 Parganas and East

Midnapore have shown significantly negative results. These results exhibit diversification against high-value crops. All the others districts have shown diversification towards high-value crops. However, for Birbhum and West Midnapore these results are statistically insignificant.

CONCLUSION AND POLICY IMPLICATION

The study revealed that the crop sector in the West Bengal, in general, has been diversifying towards high-value crops from the traditional ones. However, there are considerable variations in terms of intensity of the diversification across the districts. Few districts such as Purulia, South 24 Parganas, East Midnapore, Birbhum and West Midnapore show no tendency towards crop diversification. The rest of the state, however, moves strongly towards the cultivation of high value crops. The regression results have brought out the importance of area under HYV of food grains, rural literacy, the proportion of a small landholder, size of the urban population, crop insurance, and relative income of high value crops over rice as the significant determinants of crop diversification, besides the agro-climatic factor like rainfall.

(1) The high-value crops have a significant comparative advantage over staple food crops as they are prone to higher production. With the higher production of HVC the risks – both crop risk and price risk- increase. Therefore, the crop insurance for all farmers should be encouraged to

mitigate the crop risk. The promotion of agribusinesses holds the key for reducing the price risk.

(2) The present day agriculture is much more knowledge-intensive and skill-based. The adequately trained human resources is the need of the hour in agricultural sector. Therefore, the provision of training and skill-formation should be arranged on a larger scale for the agriculturalists.

(3) Infrastructural facilities like the markets and roads play a positive role in promoting diversification in agriculture. It calls for increased public investment in the development of infrastructure to accelerate the pace of diversification.

CONFLICT OF INTERESTS

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Appendix Table 1. Other Indices of crop diversification of different districts in West Bengal during 1990-91 to 2013-2014.

Districts	Sub period I			Districts	Sub period II			Districts	Sub period III		
	EI	OI	HI		EI	OI	HI		EI	OI	HI
Nadia	0.82	0.13	0.16	Nadia	0.87	0.15	0.14	Nadia	0.87	0.13	0.14
Murshidabad	0.79	0.55	0.19	Murshidabad	0.87	0.37	0.15	Murshidabad	0.86	0.41	0.16
Malda	0.77	0.44	0.21	Malda	0.82	0.46	0.18	Jalpaiguri	0.83	0.98	0.19
North 24 Pgns	0.67	1.37	0.29	Darjeling	0.76	0.62	0.20	North 24 Pgns	0.81	0.74	0.20
Coochbihar	0.66	1.39	0.29	Jalpaiguri	0.82	1.05	0.21	Malda	0.79	0.58	0.20
Hoogly	0.64	1.09	0.30	North 24 Pgns	0.79	0.82	0.20	Darjeling	0.76	0.63	0.21
Darjeling	0.60	0.88	0.32	Hoogly	0.73	0.76	0.22	Hoogly	0.72	0.80	0.23
West Bengal	0.64	2.05	0.35	West Bengal	0.74	1.49	0.24	West Bengal	0.74	1.47	0.23
West Dinajpur	0.62	2.00	0.37	West Dinajpur	0.73	1.33	0.26	West Dinajpur	0.76	1.20	0.24
Jalpaiguri	0.55	0.55	0.40	Coochbihar	0.72	1.55	0.28	Coochbihar	0.72	1.44	0.27
Burdwan	0.53	1.96	0.42	Howrah	0.61	1.23	0.32	Howrah	0.61	1.23	0.32
Howrah	0.45	1.62	0.44	Burdwan	0.63	1.57	0.32	West Midnapore	0.64	1.93	0.33
East Midnapore	0.47	2.27	0.47	West Midnapore	0.64	2.19	0.35	Burdwan	0.59	1.81	0.35
West Midnapore	0.50	2.88	0.48	Birbhum	0.61	1.91	0.37	East Midnapore	0.57	1.93	0.37
Bankura	0.47	3.17	0.51	East Midnapore	0.56	2.00	0.38	Birbhum	0.61	1.91	0.37
Birbhum	0.44	2.84	0.55	Bankura	0.56	2.81	0.42	Bankura	0.57	2.60	0.40
Purulia	0.28	4.79	0.72	South 24Pgns	0.48	3.31	0.48	South 24Pgns	0.54	2.83	0.43
South 24Pgns	0.25	4.90	0.74	Purulia	0.37	4.50	0.61	Purulia	0.32	4.89	0.65

Source: Various issues of 'district statistical hand books', bureau of applied economics and statistics, and different issues of 'estimates of area and production of principal crops in West Bengal', Directorate of Agriculture, Govt. of W. B.

Full Length Research Paper

Econometric analysis of socioeconomic and demographic determinants of rural households' saving behavior: The case of Sinana district, Ethiopia

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This paper examines the major socioeconomic and demographic determinants of rural households' saving behavior in Sinana district, Ethiopia. A random sample of 267 rural households was selected from four rural kebeles of the district. The study used both descriptive statistics and econometric model for the analysis of primary data. The result of descriptive statistics demonstrates that 47.2% of the sampled households preferred formal saving, 33.3% preferred informal saving and 19.5% preferred both formal and informal saving behaviors, respectively. Econometric result confirms that the probability of preferring informal saving increases with increase in access to credit and distance from formal financial institution, and decreases with increase in square root of annual total income as compared to preferring formal saving behavior. Similarly, the probability of preferring both formal and informal saving behaviors increases with increase in the tropical livestock holding, and decreases with increase in land size as compared to preferring formal saving behavior. Therefore, these variables need special attention in addition to the intervention of concerned authority if the saving behavior of rural households is to be improved.

Key words: Multinomial logistic model, households, saving behavior, Sinana district.

INTRODUCTION

Saving is the portion of disposable income not spent on consumption and it is recognized as an important factor in economic development as it enables the conversion of resources into capital. For economic development of any country, growth is achieved by investment or capital accumulation and saving (Mankiw, 2001). In the developed countries, income is generated at a higher rate

which encourages people to have more savings and push to more investment. But in a developing country like Ethiopia, the income standard is almost uncertain and leads to more consumption rather than saving (World Bank, 2012). The continent of Africa has been identified as having an unsatisfactory growth in saving rates, which slows down capital accumulation. Africa's low saving rate

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influences the ability of banks to lend to small enterprises due to the limited availability of capital. Sub-Saharan countries are also facing low saving rate problem (National Bank of Ethiopia, 2011).

In order to achieve higher rate of growth with relative price stability, the marginal propensity to save should be raised by appropriate incentives and policies. Also, in an era of international financial integration, for macroeconomic stability, higher domestic savings are essential (Degu, 2007). The household saving in Ethiopia has experienced a variety of changes over the past one or two decades due to changes in lifestyles and consumption models (Commercial Bank of Ethiopia, 2011). Saving in rural Ethiopia is mainly done out of the income from agricultural activities and characterized as seasonal and irregular as the cash flow through sale of agricultural product and availability of work is also seasonal (Dejene, 1993).

Several reasons, including low and irregular income and lack of access to financial services, have been contributing to low saving rate in developing countries. In addition, institutional factors, and higher expenditure patterns have found to be associated with lower levels of saving in sub-Saharan Africa (Beck et al., 2008). In Ethiopia, smallholders' income is characterized as seasonal and irregular, in these situations, saving is usually less considered. The unavailability or few formal financial institutions in the rural areas of Ethiopia could be a disincentive for formal saving. The saving mobilization and development of saving habits of a given society will have an impact on capital accumulation and thus on economic growth of a country in general and on the financial well-being of the individuals in particular. In the case of Ethiopia, achieving and sustaining the high growth rates set out in Growth and Transformation Plan requires substantial capital formation and associated resource mobilization. Ethiopia's record in mobilization of saving, access of domestic credit to the private sector as well as the gross capital formation compared unfavorably with the Asian comparators is relatively low (International Monetary Fund, 2014).

In Ethiopia, the saving rate from gross domestic product is lowest when compared with that of China, Bangladesh and South Africa which have better saving rates (Commercial Bank of Ethiopia, 2011). The average share of gross domestic savings of Ethiopia during the year 1980 to 2012 was 12.4% of GDP creating the average resource gap of 6.1% during these years (Ethiopian Investment Agency, 2010) as cited by Girma et al. (2014). Lugauer et al. (2017) argued on the saving behavior of Chinese households and confirmed that households with fewer dependent children have significantly higher saving rates. This result supports the idea that the decline in fertility rate has contributed to the increase in aggregate household saving over time. Study by Curtis et al. (2017) suggests that the decline in the share of dependent children accounts for the majority of

the increased saving rates in China and India. On the other hand, the Japan's saving rate since the mid-1970s is partially driven by the large and growing retirement aged population. Some scholars (Birhanu, 2015; Girma et al., 2014; Dufera et al., 2017; Tsega and Yemane, 2014) tried to explore important factors of household saving behaviors in Ethiopia using different approaches. None of these studies dealt with the preferences of saving behaviors of rural households.

Little effort has been made to study the determinants of saving related to the individual's behavior towards saving within rural sector, specifically in Sinana district (the study area). To achieve higher saving rate in rural areas, both socioeconomic and demographics determinants should be studied. Therefore, the current study intended to fill the mentioned gaps by exploring socioeconomic and demographic determinants of rural households' saving behavior using econometric approach. The result of this study is informative to the responsible organizations that deal with promotion and regulation of rural savings and credit cooperatives, to cooperatives and their members and other beneficiaries.

METHODOLOGY

This study was conducted in Sinana district of Bale zone which is located in the south eastern part of Ethiopia, 430 km from Addis Ababa (capital city of the country). Bale zone is characterized by rural dominancy and agricultural activity. The topography of Sinana district includes moderate, middle steep and plateaus. The altitude extends from 1700 to 3100 m above sea level. The estimated land area of the district is 163,854 hectare and it is known for its high production potential for crops such as wheat, barley, faba beans, emmer wheat, field pea and livestock such as cattle, sheep, goats, horses and donkeys. Crop and livestock productions are the dominant source of income for the communities of this district.

A two stage random sampling technique was used to select a representative sample from the district. At the first stage, four out of twenty rural kebeles of the district were selected by simple random sampling technique. At the second stage, 267 households were selected by systematic random sampling for interview. The sample size was calculated using the following sample size determination formula for proportions (Cochran, 1977):

$$n = \frac{pq(Z_{\alpha/2})^2}{d^2} \quad (1)$$

Where: p is proportion of households who are expected to prefer formal financial saving behavior, Z is the value of standard normal distribution at a chosen level of significance and d is some margin of error in the estimation. The value of p is fixed at 0.50 due to the absence of previous study. Setting $p = 0.50$, $\alpha = 0.05$ and $d = 0.06$, the total sample size obtained was 267 households out of 6010 total households of the selected kebeles. Since the finite population correction is not greater than 5%, it does not need adjustment. Structured questionnaire was used to generate primary data from the selected households.

Both descriptive statistics and econometric model were used for the analysis of the primary data. Descriptive statistics such as mean, standard deviation and percentages were used wherever necessary. An econometric model, multinomial logistic model, was selected to identify the major socioeconomic and demographic determinants of rural households' saving behavior. The multinomial

logistic model is a multi-equation model in which a response variable with K categories will generate K-1 equations. The analytical model is constructed based on the utility maximization theory. Suppose that the utility to a household of alternative j is U_{ij} where $j = 0, 1, \dots, J$. From the decision maker's perspective, the best alternative is simply the one that maximizes net private benefit at the margin. In other words, a household i will prefer saving behavior j if and only if $U_{ij} > V_{ik}, \forall j \neq k$. Based on McFadden (1978), a household utility function from using alternative j can then be expressed as follows:

$$U(\text{Choice of alternative } j \text{ for } i \text{ household}) = U_{ij} = V_{ij} + \varepsilon_{ij} \quad (2)$$

Where, U_{ij} is overall utility, V_{ij} is an indirect utility function and ε_{ij} is a random error term. The probability that household i select alternative j can be specified as:

$$P_{ij} = Pr(V_{ij} + \varepsilon_{ij} > V_{ik} + \varepsilon_{ik}) \quad (3)$$

$$P_{ij} = Pr(\varepsilon_{ik} < \varepsilon_{ij} + V_{ij} - V_{ik}) \text{ for } \forall j \neq k \quad (4)$$

Assuming that the error terms are identically and independently distributed, the probability that household i prefer alternative j was explained by the multinomial logistic model (Greene, 2000).

$$P(y_i = j/x_i) = P_{ij} = \frac{\exp(x_i' \beta_j)}{\sum_{j=0}^3 \exp(x_i' \beta_j)} \quad i = 1, 2, \dots, n, j = 0, 1, \dots, J \quad (5)$$

Where, P_{ij} is the probability representing the i^{th} household preference of category j; x_i are predictors of probabilities; e = natural base of logarithms; n is sample size and β_j are parameters to be estimated. An appropriate normalization that removes indeterminacy in the model is done by setting one of the β_j 's equal to zero. Following the generalized Equation (Equation 5), the multinomial logistic regression fitting to the present study is adopted as:

$$P(y_i = j/x_i) = P_{ij} = \frac{\exp(x_i' \beta_j)}{\sum_{j=1}^3 \exp(x_i' \beta_j)}, (\beta_0 = 0), i = 1, 2, \dots, 267 \quad j = 1, 2, 3 \quad (6)$$

Where, j = 1 for the household who preferred formal saving behavior, j = 2 for the household who preferred informal saving behavior and j = 3 for the household who preferred both formal and informal saving behaviors, x_i are predictors (independent variables) and these include x_1 = sex of household head (SEX), x_2 = educational status of household head (EDUC), x_3 = age of household head (AGE), x_4 = land size (LAND), x_5 = annual total income (SQRTINC), x_6 = annual expenditure (EXPEND) x_7 = access to credit (ACCRDT), x_8 = distance from formal financial institutions (DISTFIN), x_9 = access to extension service (ACCEXT), x_{10} = livestock holding (TLU) and x_{11} = religion of household head (RELIG). An appropriate normalization that removes an indeterminacy in the model is to assume that $\beta_1[\beta_0, \beta_1, \dots, \beta_{11}] = 0$ (coefficients of explanatory variables on the reference category (formal saving)) so that $e^{x_i' \beta_1} = 1$. Here, the probability that a formal saving behavior was preferred can be expressed as:

$$Pr(y_i = 1/x_i) = P_{i1} = \frac{1}{1 + \sum_{j=2}^3 \exp(x_i' \beta_j)} \quad (7)$$

Where, $\beta_2 [\beta_0, \beta_1, \dots, \beta_{11}]$ are coefficients of explanatory variables on the preference of informal saving behavior and $\beta_3 [\beta_0, \beta_1, \dots, \beta_{11}]$ are coefficients of explanatory variables on the preference of both

formal and informal saving behaviors. Due to the fact that all P_{ij} must sum to one, the separate probabilities that the households preferred informal saving behavior, and both formal and informal saving behaviors can be expressed by Equations (8) and (9), respectively:

$$Pr(Y_i = 2/x_i) = P_{i2} = \frac{\exp(x_i' \beta_2)}{1 + \sum_{j=2}^3 \exp(x_i' \beta_j)} \quad (8)$$

$$Pr(Y_i = 3/x_i) = P_{i3} = \frac{\exp(x_i' \beta_3)}{1 + \sum_{j=2}^3 \exp(x_i' \beta_j)} \quad (9)$$

Estimation of the multinomial logistic model

The parameters β are typically estimated by the maximum likelihood technique which is given as:

$$L(\beta) = \prod_{i=1}^n (\sum_{j=0}^J Pr(y_i = j/x_i)^{I(y_i=j)}) \quad (10)$$

Where, $I(\cdot)$ is the indicator function. The log-likelihood of multinomial logistic model will be obtained by taking logarithm of both sides of Equation 10:

$$\ln L(\beta) = \sum_{i=1}^n (\sum_{j=0}^J I\{y_i = j\} \ln Pr(y_i = j/x_i)) = \sum_{i=1}^n \left(\sum_{j=0}^J I\{y_i = j\} \ln \frac{\exp(x_i' \beta_j)}{\sum_{j=0}^J \exp(x_i' \beta_j)} \right) \quad (11)$$

Equation 11 can be rewritten as:

$$\ln L(\beta) = \sum_{i=1}^n \left(\sum_{j=0}^J I\{y_i = j\} (x_i' \beta_j) \ln \left(\sum_{j=0}^J \exp(x_i' \beta_j) \right) \right) \quad (12)$$

The parameter estimates of the multinomial logistic model only provide the direction of the effect of the independent variables on the dependent variables. Thus, the estimates represent neither the actual magnitude of change nor the probabilities. Instead, the marginal effects are used to measure the expected change in the probability of a particular technique being chosen with respect to a unit change in an independent variable from the mean. The marginal effects of the characteristics on the probabilities are specified as:

$$\delta_{ij} = \frac{\partial P_{ij}}{\partial x_i} = P_{ij} [\beta_j - \sum_{j=0}^J P_{ij} \beta_j] = P_{ij} [\beta_j - \bar{\beta}] \quad (13)$$

Where $\bar{\beta} = \sum_{j=0}^J P_{ij} \beta_j$ is a probability weighted average of the β_j .

Test of independence of irrelevant alternatives (IIA)

Independence of irrelevant alternatives refers to the situation where the odds in one outcome do not depend on other outcomes that are available or odds are mutually exclusive. In this sense, these alternative outcomes are "irrelevant." What this means is that adding or deleting outcomes does not affect the odds among the remaining outcomes. This can be tested by the Hausman specification test and the test statistic has the following form:

$$\chi^2 = (\hat{\beta}_r - \hat{\beta}_f)' [\hat{V}_r - \hat{V}_f]^{-1} (\hat{\beta}_r - \hat{\beta}_f) \quad (14)$$

Where r indicates estimators based on the restricted (constrained) subsets; f indicates estimators based on the full set of choices (unconstrained); β_r and β_f are the respective coefficients; V_r and V_f are the respective estimated covariance matrices.

Table 1. General characteristics of sampled households.

Variables	Item	No. of households	Percent
Sex	Male	170	63.7
	Female	97	36.3
Marital Status	Single	11	4.1
	Married	215	80.5
	Widowed	20	7.5
	Divorced	21	7.9
Education	Literate	155	58.1
	Illiterate	112	41.9
Religion	Muslim	166	62.2
	Christian	101	37.8

Source: Computed from survey (2017).

Table 2. Distribution of sampled households by income and expenditure.

Variables	No. of households	Mean	St. dev.
Annual income (1000 ETB)	267	55.26	49.02
Annual expenditure (1000 ETB)	267	18.09	14.89

Source: Computed from survey (2017).

RESULTS AND DISCUSSION

Descriptive results

The current study was conducted on 267 randomly selected rural households of which 170 (63.7%) were male-headed and the rest, 97 (36.3%) were female-headed households. The distribution of marital status shows that majority of the people in the sampled households were married and account for 216 (80.3%). Regarding the education status, 155 (58.1%) of the sampled households were literate and the rest, 112 (41.9%) were illiterate. The religion categories of the sampled households shows that 166 (62.2%) of the respondents were Muslims and the rest, 101 (37.8%) were Christians (Table 1).

Income and expenditure are among the important variables that highly determine the saving behavior of rural households in any country since the level of household saving is basically reliant on the level of their income. The survey result (Table 2) shows that the average annual total income of the sampled households was 55,260 ETB with standard deviation of 49,020. The annual expenditure of the sampled households was calculated in Ethiopian Birr (ETB) and found to be 18,090 ETB with standard deviation of 14,890 (Table 2). When the income level of the sampled households increased, their expenditure also increased but not as income increased and rural households have a possibility that the

expenditure is utilized on productive activities and this can again lead to an increase in savings. The result obtained implies that the annual income of the households in the study area is somewhat high relative to the result obtained by others in other districts of the region.

The study explored different types of financial saving behaviors preferred by sampled households and accordingly confirms that 126 (47.2%) preferred formal saving, 89 (33.3%) preferred informal saving and 52 (19.5%) preferred both formal and informal saving behaviors, respectively. Basic accesses such as access to credit and access to extension service are among the important variables to increase the awareness of the rural communities towards saving. The result of this study confirms that only 69 (25.8%) had access to credit and the rest significant number, 198 (74.2%), did not have access to credit. Regarding agricultural extension service, 167 (62.5%) of the sampled households had access to extension service and the rest, 100 (37.5%) did not have access to extension service (Table 3). From the result, it is shown that majority of the households in the study district do not have access to credit which they may use to purchase agricultural inputs which in turn helps to diversify their income.

Distance from the nearest market and from formal financial institution is another important demographic characteristic of the households to determine saving behavior. Accordingly, the result shows that the sampled

Table 3. Distribution of households by saving preference and basic accesses.

Variables	Item	No. of households	Percent
Which form of saving do you prefer?	formal saving	126	47.2
	informal saving	89	33.3
	Both formal and informal	52	19.5
Access to credit	Yes	69	25.8
	No	198	74.2
Access to extension service	Yes	167	62.5
	No	100	37.5

Source: Computed from survey (2017).

Table 4. Distribution of household by distance to market and financial institution.

Variables	No. of households	Mean	St. dev.
Distance from the nearest market center (hour)	267	0.70	0.65
Distance from formal financial institutions (hour)	267	1.40	1.23

Source: Computed from survey (2017).

Table 5. Test of independence of irrelevant alternatives (IIA) assumption.

Omitted	Chi ²	d. f	P > Chi ²	Evidence
Informal saving	0.33	11	1.000	for Ho
Both formal and informal saving	2.34	11	0.9969	for Ho

*If Chi² < 0, the estimated model does not meet asymptotic assumption of the test.

Source: Computed from survey (2017).

households are expected to walk 0.70 h on average to arrive the nearest market and the standard deviation was found to be 0.65, whereas the distance from formal financial institution was 1.40 h on average with standard deviation of 1.23 (Table 4). This result suggests that households have to go long distance to access the market and formal financial institutions and this may increase the cost of accessing formal financial institutions to practice formal financial saving options.

Econometric results

The multinomial logistic regression was used to assess factors affecting saving behavior of rural households with three categories of saving preferences: formal saving, informal saving, and both formal and informal savings. Prior to running parameter estimation of multinomial logistic model, the independence of irrelevant alternatives (IIA) assumption was tested by the Hausman specification test. The hypothesis of difference in coefficients not systematic was tested. Under IIA

assumption, no systematic change in the coefficients is expected if one of the outcomes is excluded from the model. Hausman specification test confirms that there is no systematic change in the coefficients when one of the outcomes is excluded. This shows that the assumption is well fitted (Table 5).

Table 6 presents the coefficients and marginal effects from multinomial logistic regression on the existing alternatives of saving behaviors. The sign of the coefficient shows the direction of influence of the variable on the logit. The results of the estimated marginal effects are discussed in terms of the significance and signs on the parameters. The results of the multinomial logistic model and marginal effect as well as their possible discussions are as follows: Square root transformation is applied to annual total income to decrease the variance.

Square root of annual total income (SQRTINC) negatively and significantly influenced the preference of informal saving behavior. The finding of the marginal effect shows that, other things being constant, square root of annual total income decreases the likelihood of preferring the informal saving behavior by 0.09% as

Table 6. Coefficients and marginal effect of multinomial logistic model.

Variables	Coef	Robust S.E	Z	P > Z	dy/dx
Formal saving					
Informal financial saving					
SEX (1 = male)	-0.1824	0.3289	-0.55	0.579	-0.0445
EDUC (1 = literate)	-0.1628	0.3452	-0.47	0.637	-0.0189
AGE	0.0105	0.0116	0.91	0.363	0.0019
LAND	-0.2344	0.1957	-1.20	0.231	-0.0261
SQRTINC	-0.0052	0.0026	-1.95	0.041**	-0.0009
EXPEND	-0.0027	0.0018	-1.50	0.140	-0.0006
ACCRDT (1 = yes)	0.7127	0.3650	1.95	0.041**	0.1420
DISTFIN	0.0096	0.0022	4.35	0.000*	0.0020
TLU	-0.0769	0.0703	1.09	0.274	0.0075
ACCEXT (1 = yes)	-0.0002	0.3289	-0.00	1.000	-0.0140
RELIG (1 = Christian)	-0.1045	0.3371	-0.31	0.757	-0.0193
CONS	0.1163	0.9814	0.12	0.906	
Both formal and informal saving					
SEX (1 = male)	0.0912	0.3578	0.25	0.799	0.0266
EDUC (1 = literate)	-0.2383	0.3715	-0.64	0.521	-0.0296
AGE	0.0051	0.0136	0.38	0.707	0.0002
LAND	-0.3643	0.2016	-1.81	0.071***	-0.0459
SQRTINC	-0.0017	0.0023	-0.76	0.447	0.0004
EXPEND	-0.0011	0.0016	-0.69	0.492	-0.0014
ACCRDT (1 = yes)	0.2229	0.4099	0.54	0.587	-0.0128
DISTFIN	0.0042	0.0027	1.56	0.988	-0.0006
TLU	0.1366	0.0681	2.01	0.045**	0.0179
ACCEXT (1 = yes)	0.2220	0.3648	0.61	0.543	0.0365
RELIG (1 = Christian)	-0.0414	0.3652	-0.11	0.910	-0.0003
CONS	-0.4673	1.0642	-0.44	0.661	

N = 267, LR Chi² (22) = 60.81, Prob > Chi² = 0.000, pseudo R² = 0.1083, Log likelihood = -250.30881. Significance level: 1% (*), 5% (**), and 10% (***).

Source: Computed from survey (2017).

compared to preferring formal saving behavior. The implication of the result is that households with high income are more likely to prefer formal saving behavior than those with low income. The result obtained is in line with theory that high income leads to high formal financial saving. The result obtained is in line with the result of Birhanu (2015) who showed that as annual income increases, the probability of households to save in formal financial forms increases.

Access to credit (ACCRDT) positively and significantly influenced the preference of informal saving behavior. The result of marginal effect shows that access to credit increases the likelihood of preferring informal saving behavior by 14.2% as compared to preferring formal financial saving behavior keeping other variable constant. The household with access to credit may be more likely to prefer informal saving behavior from the credit they accessed in order to pay back the loan. The result

obtained is contradictory to that of Birhanu (2015) who found positive impact of access to credit on the savings of households in formal financial institutions.

Distance from formal financial institution (DISTINF) positively and significantly influenced preference of informal saving behavior. The result of marginal effect shows that, other things being constant, distance from financial institution increases the likelihood of preferring informal saving behavior by 0.2% as compared to preferring formal saving. This implies that if formal financial institutions are far, households are more likely to save their money in local informal institutions such as ekub and edir.

Land size (LAND) negatively and significantly influenced the preference of both formal and informal saving behaviors. The result of marginal effect shows that other things being equal, land size decreases the likelihood of preferring both formal and informal saving by

4.59% as compared to preferring formal saving. The implication is that as the land size of the household increases, the probability to earn more cash increases and this in turn promotes the probability of preferring formal saving behavior.

Livestock holding (TLU) positively and significantly influenced the preference of both formal and informal saving behaviors. The analysis of marginal effect shows that, other things being constant, tropical livestock holding increases the likelihood of preferring both formal and informal saving behaviors by 1.79% as compared to preferring formal saving. The households with large number of livestock have more option to prefer both forms of saving behaviors (formal and informal) than those households with small number of livestock. The result obtained is in line with that of Girma et al. (2014) who found positive impact of livestock holding on the choice both in kind and financial saving forms.

CONCLUSION AND RECOMMENDATIONS

Majority of the sampled households preferred formal financial saving behavior. Basic accesses such as access to credit and access to extension service are not well expanded in the study area. The result of the study further showed that the probability of preferring informal saving behavior increases with increase in access to credit and distance from formal institution, and decreases with increase in square root of annual total income as compared to preferring formal financial saving behavior. Similarly, the probability of preferring both formal and informal saving behaviors increases with increase in the tropical livestock holding and decreases with increase in land size as compared to preferring formal saving behavior. Based on the findings of the study, two recommendations are forwarded: Firstly, development agents should be able to increase the awareness of rural communities on the importance of formal financial saving. Secondly, the interference of government and bank managers is needed to increase the accessibility of formal financial institutions in the rural areas so that the communities can easily have access in their local residence.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Full Length Research Paper

On farm partial budget analysis of pepper (*Capsicum Annum L.*) to the application of NP fertilizer and farmyard manure in Raya Azebo District, Northern Ethiopia

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This research was conducted to assess the economic feasibility of inorganic fertilizer application and farmyard manure on Marako Fana pepper variety in Raya Azebo district, Northern Ethiopia. The combination of 25, 50, 75 and 100% of nationally recommended inorganic fertilizers and 10 t ha⁻¹ farmyard manure as well as four control treatments (unfertilized, 100% farmyard manure, 100% and blended fertilizer/NPS) were used in this study. The experiment was laid out in a randomized complete block design with three replications. The application of half rate recommended inorganic fertilizer in combination with 5 t ha⁻¹ farmyard manure produced significantly, the maximum total and marketable dry fruit yield of 2.495 and 2.375 t ha⁻¹. Moreover, this treatment was also better than other treatments and generated above the minimum acceptable marginal rate of return. Therefore, it could be concluded that this fertilizer rate could be used in the study area for the production of the variety under irrigation. Hence, to obtain optimum economic return from the production of pepper at the study area, it is recommended to apply an integrated fertilizer management approach.

Key words: Blender fertilizer, marginal rate of return, NP, partial budget.

INTRODUCTION

Partial budget analysis (PBA) provides useful information for making decisions. Partial budget analysis can be used for comparing the impact of a technological change on

farm costs and returns (International Potato Center, 1982). The partial budget measures the positive and negative effects of a change in the business. The left side

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of partial budget shows the positive effects on net income including additional income and reduced costs. To counter balance this positive effect, the right side includes reduced income and additional costs or the negative effects of the proposed change (Lessley et al., 1991). New technology can be evaluated in terms of its impact on the productivity, profitability, acceptability and sustainability of farming systems (Herdt, 1987). The profitability of hot pepper production is partly related with the right type of input (fertilizer and improved variety) usage and the cost incurred for these inputs (Amare, 2010).

Partial budget analysis is a simple but effective technique for assessing the profitability of new technology for an existing enterprise. It also provides the foundation for comparing the relative profitability of alternative treatments, evaluating their riskiness, and testing how robust profits are in the event of changing product or input prices. Economic analysis is conducted to assess the feasibility of the treatments using partial budget, dominance and marginal analysis of each treatment. Partial budget analysis is used to organize experimental data and information on the costs and benefits of various alternative treatments. The partial budget included the average yields for each treatment, the adjusted yields, the gross field benefit and the total costs that vary. The total costs which vary are the sum of all cost for alternative treatments. The increased production of the crop due to the application of inputs might or might not be beneficiary to farmers. Therefore, partial budget analysis (CIMMYT, 1988) should be employed to estimate the net benefit and marginal rate of return that could be obtained from various alternative treatments.

Summer chilling is the major problem in Raya Azebo district. Due to this, rain-fed pepper production in the study area is impossible. Once chilling occurs, it affects the pepper plant at any stage of growth. Consequently, both dry and green pod pepper in the area is produced in irrigation season. Not only this, most of the pepper research done in the study area has focused on production issues, but almost none on other pepper economic aspects. Therefore, the purpose of this study was to identify the best pepper production option from different technological package alternatives and recommend those that would meet socio-economic conditions of farmers. It is indeed assumed that some of the pepper technological packages are more profitable than the current farmer pepper production practices. The specific objectives of the study are:

1. To assess the economic feasibility of NP and farmyard manure fertilizers application on *Marako Fana* pepper variety.
2. To identify the profitable hot pepper production package among alternative treatments

MATERIALS AND METHODS

Description of the study area

This study was conducted in Raya Azebo Wereda, northern Ethiopia. The specific site of the research was in lowland area of Raya Azebo Wereda, particularly at Kara Kebele (Figure 1). Raya Azebo Wereda is located in 12°3'-13°7'N latitude and 39°5'-39°8'E longitude. Agro-climatically, the area is characterized as dry semi-arid climate (Araya et al., 2010). The mean annual temperature and mean annual rain fall ranges from 16 to 28°C and from 446 to 830 mm, respectively. Various soil types commonly found in the area include verti soils, nitisoil, combisols and luvisols. Vertisoil (black soil with swelling characteristics) is the dominant soil types, which cover over 70% of the study area (Raya Azebo Wereda ARD Office, 2016).

Treatments and experimental design

The study was executed under irrigation using a pepper variety known as *Marako Fana*. This variety is widely adapted and recommended hot pepper in the study area. The seeds of *Marako Fana* were obtained from Alamata Agricultural Research Center and sown in 15 cm rows in a nursery established on well prepared seed bed. Sufficient numbers of seedlings were raised for the field experiment. The national recommended inorganic fertilizer application rates of 82 kg N ha⁻¹ + 92 kg P₂O₅ ha⁻¹ for the crop and 10 t ha⁻¹ FYM, considered as optimum organic fertilizer rate for vegetables, were the basis for arranging the combined fertilizer treatments. Taking the application of the inorganic and organic fertilizers rates in combination as maximum, the treatments were arranged as 100, 75, 50 and 25% of these rates in all possible combinations. Application of the national recommended inorganic fertilizer rates, 10 t ha⁻¹ FYM, blended fertilizer recently recommended for DAP with recommended urea (200 kg NPS ha⁻¹ + 100 kg urea or 84 kg N ha⁻¹ + 76 kg P₂O₅ ha⁻¹ + 14 kg sulfur ha⁻¹) and no fertilizer application, were considered as control treatments. The blended fertilizer was used as control treatment since Bureau of Agriculture and Rural Development (BoARD) is distributing NPS in place of DAP. In this study, TSP and urea were used as source of P₂O₅ and N, respectively. The field experiment was laid out as randomized complete block design (RCBD) with three replications. A spacing of 30 and 70 cm between intra and inter-row, respectively, was maintained. There were six rows per plot and 15 plants per row with a total of 90 plants per plot in a plot size of 4.5 m × 4.2 m in length and width, respectively. Plants in the two rows at the extreme end of both sides of each plot and the two plants at the end of each row were not considered as experimental plants. This gave the net plot size of 3.9 m × 2.8 m (10.92 m²) with a total of 52 plants per net plot. The spacing between blocks and plots was 1.5 and 1 m, respectively.

Experimental procedures

The farmyard manure (FYM) was produced in a trench under shade to avoid evaporation loss of nutrients. The FYM was decomposed for about six months following standard procedures. All available litter and refuse was mixed with dung then placed in the trench. A section of the trench from one end was used for filling with daily collection of three consecutive days. When the section is filled enough, the top of the heap was made into a dome and plastered with dung earth slurry. After two months of decomposition, the FYM was transferred into other well prepared trench early in the morning. Then later, it was left for decomposition for about four extra months.

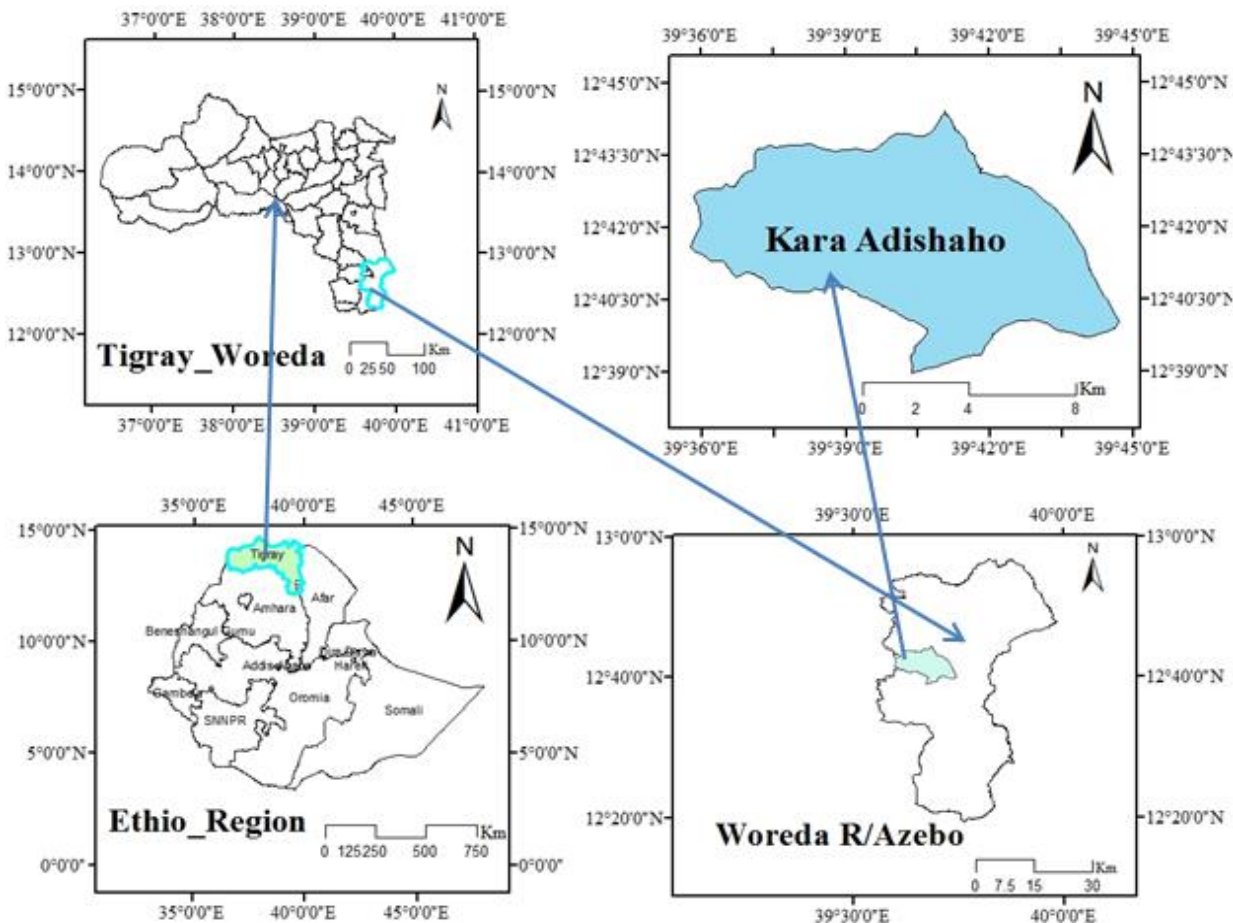


Figure 1. Map of the study area.

Seeds of *Marako Fana* were sown in November 01, 2015 on a seedbed size of 1 m × 10 m. In the nursery, 92 g/bed based P_2O_5 was applied in a bed during sowing time. The beds were then covered with dry grass mulch until emergence and watered using watering cane as needed. After seedlings emergence, the mulch was removed and then beds were covered by raised shade to protect the seedling from strong sunshine until eight days remained for transplanting. During hoeing and thinning of the seedlings, 82 g/bed based urea was applied in order to maintain optimum plant population and to keep seedlings vigorous. Watering was done with a fine watering cane in which the frequency was different depending on the seedling stages and seed bed was hand weeded. Other pertinent agronomic and horticultural practices were applied. The seedlings were transplanted to the field when the seedlings attained 20 to 25 cm height. The layout of experimental units was done before a month (30 days) before seedlings were transplanted in November 15, 2015. Then later, the applications of FYM to experimental units was done on plots that received FYM as sole or in combination of inorganic fertilizers depending on the treatments and randomization made by lottery method. During farmyard manure (FYM) application, they were broadcasted in plots one month (30 days) before seedlings were transplanted. The FYM was mixed with soil by hand hoeing of each experimental unit. Transplanting was done in December 16, 2015. Refilling of dead seedlings in the field was done one week after transplanting on the place where the first seedlings were planted. All rates of P_2O_5 and

half rates of nitrogen of the treatments were applied during transplanting, while half of nitrogen rates were applied after 30 days of transplanting.

Experimental units were irrigated using boarder irrigation method in each plot and row in plots received water from the source without passing any of the experimental plot to prevent mixing of fertilizer given to different plots. Irrigation water application was at field capacity every four days for 15 days after transplanting and every week and 15 days depending on the growth stage of the plants and weather conditions. Other agronomic practices such as weeding, hoeing, etc were applied based on the crop's requirement. Therefore, pods were harvested when they started drying and looked leathery (subjectively) in appearance on the plant. All treatments except unfertilized plot (2.33 times) were harvested three times. After harvesting, pods were further dried in partial shade until delectation.

Methods of partial budget analysis

Three analytical tools were used to identify the technological packages that are not only profitable but also exhibit good margin and remain profitable in different situations of input and output prices, respectively. Partial budget analysis was first carried out and generated the net benefits of the alternatives under study. It was then followed by marginal analysis which compares net benefits

with partial budget by considering the magnitude of corresponding variable costs.

Data collection

Data were collected for the following parameters:

Gross average fruit yield (t/ha) (AvY): An average yield of each treatment converted in hectare base.

Adjusted yield (AjY): Average yield adjusted downward by 10% to reflect the difference between the experimental yield and yield of farmers thus: $jY \text{ (t/ha)} = AvY \times (1-0.1)$.

Gross field benefit (GFB) (ETB/ha): Computed by multiplying field/farm gate price (quintal/ha) by adjusted yield thus: $GFB = AjY \times \text{field/farm gate price for the crop}$.

Total variable cost; cost of fertilizers and FYM preparation used for the experiment. The costs of other inputs and production practices such as labor cost for land preparation, planting, weeding, crop protection, and harvesting was considered to remain the same or will be insignificant among treatments.

Net benefit (NB) (ETB/ha): Calculated by subtracting the total costs from gross field benefits for each treatment thus: $NB = GFB - \text{total cost}$.

Marginal rate of return (MRR %); calculated by dividing change in net benefit by change in cost (CIMMYT, 1988) thus: $MRR = \frac{\Delta NB}{\Delta TVC}$ or

$$MRR (\%) = \frac{\text{Marginal benefit} \times 100}{\text{Marginal cost}}$$

RESULTS AND DISCUSSION

Material costs, farmyard manure preparation costs as well as other input and transportation costs that vary are presented in Table 1. Adjusted yield of the crop is considered for partial budget related things as indicated by CIMMYT (1988) that adjustments between 5 and 30% are appropriate for partial budget analysis. The dry pod yield of pepper was reduced to 10% for agronomic recommendation for farmers.

Partial budget analysis

This economic analysis is based on the average yield of each treatment across all repetitions (Duncan et al., 1990). Therefore, the net benefit estimate for 20 treatments is presented in Table 2. The application of 41 kg N ha⁻¹ + 46 kg P₂O₅ ha⁻¹ in combination with 5 t FYM ha⁻¹ had a total net benefit of 161,547 ETB followed by 82 kg N + 92 kg P₂O₅ ha⁻¹ and 61.5 kg N + 69 kg P₂O₅ ha⁻¹ both in combination with 2.5 t FYM ha⁻¹ which also had a total of 149,505 and 148,805 ETB net benefit, respectively. Furthermore, the later inorganic fertilizers combination with 5 t FYM ha⁻¹ also had higher net benefit of 145,967 ETB. The lowest net benefit was obtained by the application of the highest rates of fertilizers application (82 kg N ha⁻¹ + 92 kg P₂O₅ ha⁻¹ + 10 t FYM ha⁻¹) with a total of 86,180 ETB followed by the net benefit obtained from production of pepper without fertilizer and

by application of 20.5 kg N ha⁻¹ + 23 kg P₂O₅ ha⁻¹ + 7.5 t FYM ha⁻¹ with net benefit of 87,427 and 89,090.6 ETB, respectively. The low net benefit obtained might be due to low yield coupled with high cost prevailing treatment combinations.

The profitability study showed that application of 41 kg N ha⁻¹ + 46 kg P₂O₅ ha⁻¹ in combination with 5 t ha⁻¹ FYM which provided the highest net benefit (161,547 ETB), was the peak to apply fertilizers. This indicated that the total costs increased until a certain level, and the net benefit obtained increased. However, as the total costs that vary increased over the optimum level, the net benefit obtained reduced as a result of higher variable costs associated with lower earnings. Similarly, the result of nitrogen experiment in maize presented by CIMMYT (1988) with application of 40, 80, 120 and 160 kg N ha⁻¹ showed increase of net benefit until increase in the level of investment of up to 80 kg N ha⁻¹ and reduced net benefit after application.

Dominance analysis and net-benefit curve

In most cases, farmers prefer the highest profit (low cost with high income). For this purpose, it is necessary to conduct dominated treatment analysis. A dominated treatment is any treatment that has net benefits that are less than those of a treatment with lower costs that vary (Stephen and Nicky, 2007). The dominance analysis procedure as detailed in CIMMYT (1998) was used to select potentially profitable treatments from the range that was tested and serve to eliminate some of the treatments from further consideration and thereby simplify the analysis. The dominant (undominated) treatments were ranked from lowest to highest costs that vary. The net benefit curve also clarifies the reasoning behind the calculation of marginal rates of return, which compare the increments in costs and benefits between such pairs of treatments. The net benefit curve indicated that as the cost increases from lowest to small increase of 5000 ETB, the net benefit also increased linearly and attained peak at 5178 ETB. Thereafter, the net benefit reduced as the cost increased. The dominant analysis showed that the net benefit of all treatments were dominated except unfertilized plot and application of 20.5 kg N ha⁻¹ + 23 kg P₂O₅ ha⁻¹ + 2.5 t FYM ha⁻¹ and nationally recommended inorganic fertilizers, application of blended fertilizer (84 kg N ha⁻¹ + 76 kg P₂O₅ ha⁻¹ + 14 kg sulfur ha⁻¹), the two higher rates of inorganic fertilizers (82 kg N+92 kg P₂O₅ and 61.5 kg N + 69 kg P₂O₅ ha⁻¹) both combined with low rate of 2.5 t FYM ha⁻¹ and 41 kg N + 46 kg P₂O₅ + 5 t FYM ha⁻¹ (Table 3). This result indicated that the net benefit decreased as the total cost that varies increased beyond undominated fertilizer treatments application. Therefore, no farmer may choose other dominated treatments in comparison with the undominated treatments. This also helps in avoiding the dominated

Table 1. Cost of input fertilizers, FYM production, transportation and materials used.

Treatment	MC	FYMP	N	P ₂ O ₅	S	AP	ITVC	MKTC	TVC
82:92 +10	300	6600	898	1056	0	600	515	25	9994
82:92+2.5	300	1650	898	1056	0	150	140	39	4233
61.5:69+2.5	300	1650	673	792	0	150	136	39	3740
41:46+2.5	300	1650	449	528	0	150	133	26	3236
20.5:23 + 2.5	300	1650	224	264	0	150	129	25	2742
82:92 + 5	300	3300	898	1056	0	300	265	37	6156
61.5:69 + 5	300	3300	673	792	0	300	261	39	5665
41:46 + 5	300	3300	449	528	0	300	258	43	5178
20.5:23 + 5	300	3300	224	264	0	300	254	25	4667
82:92+ 7.5	300	4950	898	1056	0	450	390	33	8077
61.5:69 + 7.5	300	4950	673	792	0	450	386	36	7587
41:46 + 7.5	300	4950	449	528	0	450	383	28	7088
20.5:23 + 7.5	300	4950	224	264	0	450	379	25	6592
61.5:69 + 10	300	6600	673	792	0	600	511	30	9506
41:46 + 10	300	6600	449	528	0	600	508	26	9011
20.5:23 + 10	300	6600	224	264	0	600	504	26	8518
82:92	300	0	898	1056	0	600	15	32	2901
0:00:10	300	6600	0	0	0	600	500	26	8026
Unfertilized	300	0	0	0	0	0	0	23	323
84:76 : 14 S	300	0	920	872	108	600	15	31	2846

Treatment = N + P₂O₅ + FYM); MC = Material variable cost (12 ETB/sack), FYMP = cost of FYM preparation (660 ETB t⁻¹), price of N (10.95 ETB kg⁻¹), P₂O₅ = price of P₂O₅ (11.48 ETB kg⁻¹), S = price of sulfur (7.74 ETB kg⁻¹), Ap = application cost (60 ETB t⁻¹), ITVC = input transportation variable cost (5 ETB qt⁻¹), MKTC = market transportation cost (2 ETB qt⁻¹).

treatment for further estimation of marginal rates of return.

Marginal rate of return

The net benefit-cost ratio showed that as the cost is one birr, the net benefit ranged from 31.2 to 41.6 birr for the dominant treatments. For each pair of ranked treatments, a % marginal rate of return (MRR %) was calculated. The % MRR between any pair of dominant treatments denotes the return per unit of investment in fertilizer expressed as a percentage. This analysis was conducted and presented in Table 4 and Figure 2. As shown in Table 4, the result of analysis of dominant treatments indicated that for each one birr invested in purchase or production of fertilizers, it was possible to recover one birr plus an extra 2.48, 230.53, 58.99, 33.56, 1.42 and 12.74 birr/ha as the fertilizer application changed from unfertilized plot until supplementation of 41 kg N ha⁻¹ + 46 kg P₂O₅ ha⁻¹ + 5 t ha⁻¹ FYM, respectively.

From the time of the first treatment that had the lowest costs to the end of the treatment which had the highest cost, that varies, the marginal rate of return obtained was above the minimum acceptable marginal rate of return. Accordingly, the study revealed that application of 41 kg N ha⁻¹ + 46 kg P₂O₅ ha⁻¹ + 5 t ha⁻¹ FYM was the best

recommendation. The best recommendation for treatments subjected to marginal rate of return is not (necessarily) based on the highest marginal rate of return, rather, based on the minimum acceptable marginal rate of return, and the treatment with the highest net benefit together with an acceptable MRR becomes the tentative recommendation (CIMMYT, 1988).

The process of calculating the marginal rates of return of alternative treatments, proceeds in steps from the least costly treatment to the most costly, and resolves if they are acceptable to farmers, which is called marginal analysis (CIMMYT, 1988). One way of assessing this change is to divide the difference in net benefits by the difference in costs that vary (CIMMYT, 1988). Marginal rate of return is marginal net benefit (Stephen and Nicky, 2007). In this study, 100% was considered as minimum acceptable rate of return for farmers' recommendation. It is important to note that the acceptable minimum rate of return for farmers' recommendation is 50 to 100% (CIMMYT, 1988).

Conclusion

Pepper (*Capsicum annum* L.) is the world's most important vegetable after tomato. Both sweet and hot peppers are processed into many types of sauces,

Table 2. Net benefit estimate of the combined application of FYM and NP fertilizers on pepper Marako Fana variety in Raya Azebo district during 2015/16.

Treatment	AY (Q/ha)	ADY (Q/ha)	FP/Q (00 ETB)	GFB (ETB/ha)	TVC (ETB/ha)	NB (ETB/ha)
82:92 +10	13.7	12.3	78	96174	9994	86180
82:92+2.5	21.9	19.7	78	153738	4233	149505
61.5:69+2.5	21.73	19.6	78	152544.6	3740	148804.6
41:46+2.5	14.3	12.9	78	100386	3236	97150
20.5:23 + 2.5	13.7	12.3	78	96174	2742	93432
82:92 + 5	20.4	18.4	78	143208	6156	137052
61.5:69 + 5	21.6	19.4	78	151632	5665	145967
41:46 + 5	23.75	21.4	78	166725	5178	161547
20.5:23 + 5	14.16	12.7	78	99403.2	4667	94736.2
82:92+ 7.5	18.1	16.3	78	127062	8077	118985
61.5:69 + 7.5	20.1	18.1	78	141102	7587	133515
41:46 + 7.5	15.7	14.1	78	110214	7088	103126
20.5:23 + 7.5	13.63	12.3	78	95682.6	6592	89090.6
61.5:69 + 10	16.7	15	78	117234	9506	107728
41:46 + 10	14.37	12.9	78	100877.4	9011	91866.4
20.5:23 + 10	14.43	13	78	101298.6	8518	92780.6
82 : 92	17.6	15.8	78	123552	2901	120651
0:00:10	14.43	13	78	101298.6	8026	93272.6
Unfertilized	12.5	11.3	78	87750	323	87427
84:76:14 sulfur	17.13	15.4	78	120252.6	2846	117406.6

Treatment = N:P kg ha⁻¹ + FYM t ha⁻¹; AY = average yield, ADY = adjusted yield, FP = field price, GFB = gross field benefit, TVC = total variable cost, Q = quintal and NB = net benefit.

Table 3. Dominance analysis of FYM by NP combination application in Raya Azebo district during 2015/16.

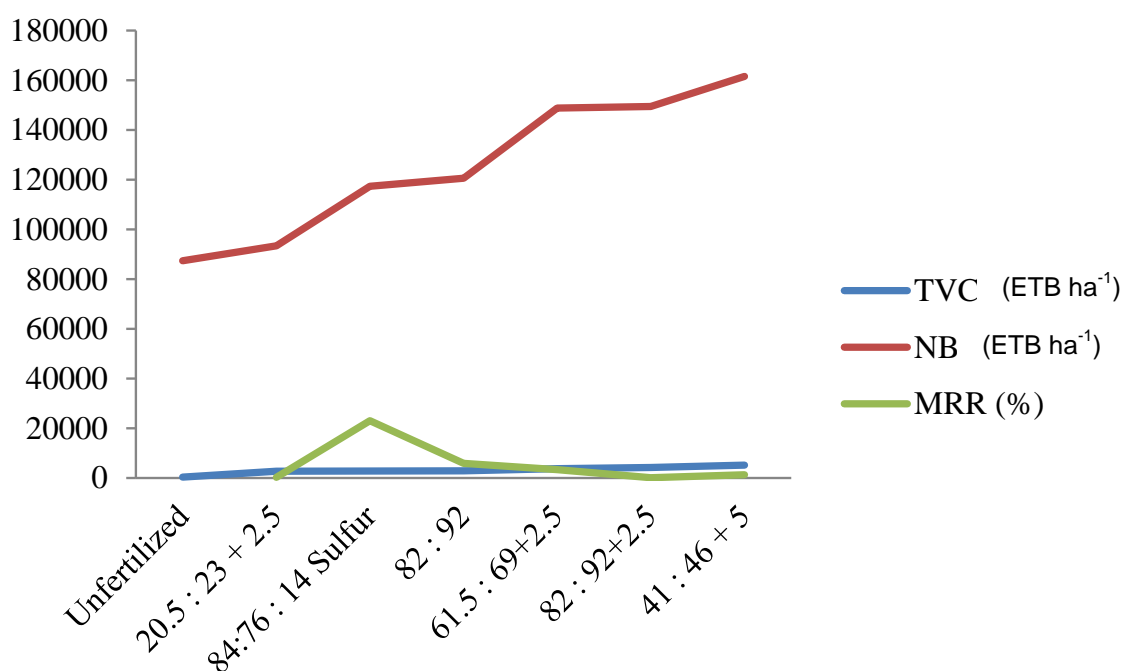
Treatment	TVC (ETB/ha)	NB (ETB/ha)	B:C ratio
Unfertilized	323	87427	
20.5:23 + 2.5	2742	93432	34.0744
84:76:14 Sulfur	2846	117406.6	41.25
82:92	2901	120651	41.58945
41:46+2.5	3236	97150D	30.02163
61.5:69+2.5	3740	148804.6	39.78733
82:92+2.5	4233	149505	35.31892
20.5:23 + 5	4667	94736.2D	20.29916
41:46 + 5	5178	161547	31.19873
61.5:69 + 5	5665	145967D	25.76646
82:92 + 5	6156	137052D	22.26316
20.5:23 + 7.5	6592	89090.6D	13.51496
41:46 + 7.5	7088	103126D	14.54938
61.5:69 + 7.5	7587	133515D	17.59786
0:00:10	8026	93272.6D	11.62131
82:92+ 7.5	8077	118985D	14.73134
20.5:23 + 10	8518	92780.6D	10.8923
41:46 + 10	9011	91866.4D	10.19492
61.5:69 + 10	9506	107728D	11.33263
82:92 +10	9994	86180D	8.623174

Treatment = N:P kg ha⁻¹ + FYM t ha⁻¹; D = Dominated treatments, TVC = total variable cost, NB = net benefit, B : C ratio = benefit cost ratio.

Table 4. Marginal rate of return of FYM and NP fertilizers application in combination for dry fruit production of Marako Fana pepper variety in Raya Azebo district during 2015/16.

Treatment	TVC (ETB ha ⁻¹)	MC (ETB ha ⁻¹)	NB (ETB ha ⁻¹)	MB (ETB ha ⁻¹)	MRR (%)
Unfertilized	323		87427		
20.5:23 + 2.5	2742	2419	93432	6005	248
84:76:14 Sulfur	2846	104	117406.6	23974.6	23053
82:92	2901	55	120651	3244.4	5899
61.5:69+2.5	3740	839	148805	28154	3356
82:92+2.5	4233	493	149505	700	142
41:46 + 5	5178	945	161547	12042	1274

Treatment = N:P kg ha⁻¹+FYM t ha⁻¹; TVC=Total variable cost, MC = marginal cost, NB = net benefit, MRR = marginal rate of return.

**Figure 2.** Net benefit curve of dominant organic and inorganic fertilizers application.

pickles, relishes and canned products. This study was conducted in Raya Azebo Wereda of Northern Ethiopia; specifically, Kara Kebele in 2015/16. It was executed under irrigation to assess the economic feasibility of NP and farmyard manure fertilizers application on *Marako Fana* pepper variety. The experiment was laid out as a randomized complete block design with three replications and treatments consisting of the combined application of four levels each for nitrogen, phosphorus and FYM. In this study, no fertilizer application, application of nationally recommended nitrogen and phosphorus rates, 10 t ha⁻¹ FYM as well as NPS fertilizers were considered as control.

The highest total dry fruit yield t ha⁻¹ was obtained from plots that received inorganic and organic fertilizers

combination. Similarly, the highest marketable yield (2.375 t ha⁻¹) of *Marako Fana* was obtained on combined application of FYM which consisted of 50% of the blanket recommendation of inorganic fertilizers and 5 t ha⁻¹ FYM. The application of this treatment showed that about 1.125 t ha⁻¹ more marketable yield than unfertilized plot. Most of the treatment combinations of inorganic and organic fertilizers produced almost the same amount of unmarketable dry fruit yield except the highest and the lowest unmarketable dry fruit yield obtained from blended fertilizer and 41 kg N + 46 kg P₂O₅ + 2.5 t FYM ha⁻¹ applications, respectively.

In this study, partial budget analysis was also employed by considering total variable cost and net benefit, dominated and dominant treatments using dominance

analysis, cost-benefit curve and marginal rate of return. The result indicated that the net benefit of all treatments except in the unfertilized plot. The combined application of half the nationally recommended rates of nitrogen, phosphorus and 5 t ha⁻¹ FYM fertilizers was economically acceptable as compared to the other dominant treatments, although the marginal rate of return obtained from all dominant treatments was above the minimum acceptable marginal rate of return. Hence, to obtain optimum economic return from pepper production in the study area, it is recommended that 5 t ha⁻¹ of FYM with half the rate of nationally recommended nitrogen and phosphorus fertilizers be applied. This recommendation is made based on varying total costs and marginal rate of return for alternative treatments.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ABBREVIATIONS

FYM, Farmyard manure; **RNPR**, recommended nitrogen and P₂O₅ rate; **NP**, recommended NPS rate; **RCBD**, randomized complete block design.

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Full Length Research Paper

Sustaining the economic growth for agriculture sector in Benin[#]: How do agricultural technologies influence the growth rate?

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This paper examined the influence of agricultural technologies on the growth of agricultural value-added based on time series data (1990-2016) and Cobb-Douglas production function. The results indicated that there are significant and certain benefits to draw economically from the utilization of a system of technological innovations including mechanization, renewed capital stocks, as well as temporary annual cropping and permanent cropping practices. Farming practices involving crop rotation, multi-cropping, and agroforestry are recommended for sustaining agricultural sustainability since they seem to be economically viable and environmentally friendly. It is found that technological innovations pertaining to both soil irrigation system and chemical fertilizers might be beneficial to agricultural production growth when they are managed in accordance with soil characteristics and in a balanced way, respectively. The results also showed that the labor force, the forest area, the amount of credits to agriculture, and the amount of energy consumed to power irrigation are likely to be insignificant to boost directly the growth of agricultural value-added. Thus, the various issues raised in the process of using all agricultural technologies must be addressed either by policy or by appropriating the knowledge relating to their good management so as to make them more profitable to agricultural economic growth.

Key words: Sustainable economic growth, agricultural technology, Cobb-Douglas production function.

INTRODUCTION

A key challenge the world is facing today is how to grow food sustainably, meeting the demands of a growing population without degrading our natural resources base,

so as to secure our common future. Responding to this interrogation, the United Nations advocate the adoption of resource-conserving technologies and sustainable

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production practices in agricultural field¹.

In recent years, agricultural production increasingly depends on science and technology advances, farm infrastructures, fertilizers use, pesticides use, planting structures for crops, water management and policy for agriculture development. Different input factors have different influences on agricultural production. For instance, while the Integrated Pest Management (IPM) seeks to use pesticides when other options are ineffective (Hassanali et al., 2008; Bale et al., 2008), the Integrated Nutrients Management (INM) recommends balancing both organic and inorganic fertilizers (Goulding et al., 2008; Ahmad et al., 2011, Ramasamy et al., 2013) for green production. Actually, owing to some serious concerns, sustaining the agricultural production growth and yields requires nowadays the application of Fertilizer Best Management Practice (Roberts, 2007) as a key technological innovation. Several classifications of technological innovations have been made to differentiate policies or modeling. For example, a categorization distinguishes between technologies that are embodied (such as machines, fertilizers, and seeds) and those that are disembodied (e.g., integrated pest management schemes, a set of new practices) (David and David, 2000). The technological progress function developed by Kaldor (1957) measures technological progress as the rate of growth of labor productivity. So, a technological change may cause the production-possibility frontier to shift outward, allowing economic growth. In this context, Lin et al. (2015), Yu and Ju (2011) and Wang and Zhou (2006), after measuring the contribution rate of scientific and technological (S&T) progress, suggested that the Chinese industry sector, in particular the coal and construction industries, should rely on technological progress so as to improve the international competitiveness and realize the sustainable development goal. Except for S&T, a number of researches turned attention of government and practitioners towards agricultural technologies and practices concerns, and then, diverse statistical methods or mathematical models such as Cobb-Douglas production function, and Solow remaining value model, have been used to measure their contribution to agricultural production in the short and long terms (Suman et al., 2016; Venkatesan et al., 2004). Regarding chemical technologies, Kumar and Yadav (2001) found that the yield response of grains (rice and wheat intercropped) to a direct Nitrogen (N) fertilizer supply would decline over a long period, and in contrast, the application of Phosphorus (P) and Potassium (K) would increase the grains yields. Moreover, their findings revealed that a balanced dose of N-P-K is required to maintain durable soil fertility and raise grains yields.

[#]A country located in Western Africa, Benin is a tropical nation, highly dependent on agriculture, with substantial employment and income arising from subsistence farming.

¹ UN sustainable Development Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture.

Obviously, the increase on crop yields also related to many other factors. Some researchers basically drew attention upon the impact of human capital investments and fixed capital stock investments on agricultural gross domestic product, and some, investigated on the impact of irrigated land (Chao and Sun, 2013). In addition to the common factors of production (capital stock, labor force, land area), the range of agricultural technologies² considered in this article includes, mechanization, chemical technology, management practices and policies relating to cropping, as well as other agricultural infrastructures.

The main question raised in this research is how are agricultural technologies linked to the agricultural production growth? And what association of agricultural technologies should we deploy to sustaining the growth of agricultural gross domestic product? The research leans on the econometric analysis model based on Cobb-Douglas (C-D) production function so as to determine the influence of agricultural technologies on the increase in agricultural value-added in the country of Benin over the period 1990-2016. Moreover, the analysis is made on the system of technologies and practices that might foster a steady and sustainable growth of agricultural value-added (OECD, 2016; Sasmal, 2016). The corresponding suggestions according to the findings are put forward.

MODELING AND DATA DESCRIPTION

Theoretical modeling

The mathematical equation estimated in this study, based on Cobb-Douglas (C-D) production function, may be written as:

$$Y = A_0 \exp(\delta t) \prod_{i=1}^p X_i^{\alpha_i} \quad (1)$$

where Y is the potential output or income value, A_0 is the level of the output at base period, \exp represents the exponential function, δ is the parameter of technological progress, t indicates the time variable expressing the influence of technological progress, p is the number of factors of production, X is a matrix of factors of production and α_i is the parameter of i th factor of production.

It may be demonstrated that the α_i are the output or income elasticity coefficients. Thus, seeking the partial derivative on X in Equation 1, we can get:

$$\frac{\partial Y}{\partial X_i} = \alpha_i \frac{Y}{X_i} \quad (2)$$

Hence,

$$\alpha_i = \frac{\partial Y}{\partial X_i} \times \frac{X_i}{Y} \quad (3)$$

X_i is the i th factor of production. The values of the α_i are obtained by applying the logarithm on both sides of Equation 1. Thus, the basic specification is given as follows:

² According to the World Intellectual Property Organization (WIPO), a technology is knowledge of a system to produce a product or provide a service. This knowledge may be a product or process invention, a form design, a practice, may also be a design management and other specialized skills.

$$\ln(Y) = \ln(A_0) + \delta t + \sum_{i=1}^p \alpha_i \ln(X_i) \quad (4)$$

where $\ln(Y)$ is the logarithm of the dependent variable. Moreover, the contribution rate in percentage of a factor of production to the growth of output or income may be calculated by the following equation.

$$E_{X_i} = \alpha_i \frac{g_{X_i}}{g_Y} \times 100 \quad (5)$$

where E_{X_i} and g_{X_i} , are respectively, the contribution rate and the average annual growth rate of the i th factor of production; and g_Y is the average annual growth rate of the output or income.

Availability of data and materials

The dataset supporting the conclusions of this article is included within the article and its additional files. The modeling adopted is based on annual time series data of 27 observations (1990-2016) obtained from different sources, including the Food and Agriculture Organization of the United Nations (FAO), and the United Nations Conference on Trade and Development (UNCTAD). Table 1 provides variable definitions and data sources.

Figure 1 describes the trend of annual growth rate of variables and it indicates that the evolution of variables has not been steady over the period of study. The trends depict serious fluctuations of the growth rate of agricultural technologies and as a result, an unstable growth rate of agricultural value-added. In 2005 and 2010 (Figure 1a), the growth of agricultural value-added was negative, showing a certain drop in the value-added with a slight severity in 2010. These years in Benin represent the end of a political mandate, and the years before the beginning of new management policies. The highest growth rate is about 16.5% (2003) and attained by *IRRIG* whereas the lowest growth rate is about -6% (2006) and attained by *ALAND*.

Figure 1b presents information specific to the growth rate trend of chemical fertilizers uptake of which the peak is attained at 1942%. This evolution raises some questions pertaining to the effect of chemical technologies on crop yields. Evidences have suggested that applying chemicals in a balanced ratio would be the best way to draw profit from these land-saving technologies (Roberts, 2007).

Figure 2 describes the linear relation between agricultural technologies and agricultural value-added. It indicates that the number of machines used, the number of hectares equipped for irrigation, and the number of hectares for arable land and permanent crops, are greatly related to the growth of agricultural value-added. Therefore, a linear model might explain correctly the relationship between the underlying variables. Thus, it is suggested to boost the growth of agricultural production in association with these underlying technologies. In contrast, the agricultural gross domestic product is likely to be inexplicable by the amount of chemical fertilizers in terms of linear relation in this study. However, owing to the role of this land-conserving technology, it is suggested to apply chemicals in a balanced ratio.

EMPIRICAL RESULTS

Unit-root test on variables

The Augmented Dickey-Fuller (ADF) tests (Table 2) showed that the null hypothesis that each variable (in logarithmic value)³ does have a unit-root at level cannot be rejected. Then, variables were converted into first

difference or second difference (*LIRRIG*).

Estimation of parameters α_i

Based on Equation 4, the growth of agricultural value-added is estimated (Table 3) by running the relevant econometric model containing an autoregressive component. Moreover, some *dummy* variables (*Dum1*, *Dum2*) are introduced in order to capture respectively the impact of sectorial development policy and strategy, and natural phenomena (e.g. flooding, precipitations). These variables influenced the growth of agricultural value-added since the null hypothesis that their coefficients are equal to zero cannot be accepted.

The regression model performs well, predicting 99% of the specified equation correctly. The causality between the growth of agricultural value-added and its determinant factors is established through F-statistic. All the diagnostic tests on residuals coming from the long-run model estimation (serial correlation, heteroscedasticity, normality) are desirable.

Prediction of the growth of agricultural value-added

Here, the study aims to analyze the gap between the forecasted value (*LAGRIVAF*) and the value of *LAGRIVA* estimated earlier named Actual value. The objective is to conclude on the goodness of the estimated regression model. Figure 3a pertaining to forecasted value indicates that the Root Mean Squared Error is set to only 1.146% and the curve of *LAGRIVAF* is passing through 95% confidence interval. The Theil Inequality Coefficient shows a perfect fit as well. As a result, we may conclude that forecasted and actual *LAGRIVA* are moving closely, and then, the predictive power of the estimated regression model is quite satisfactory. This can be observed in Figure 3b where both *LAGRIVA* and *LAGRIVAF* are plotted together.

DISCUSSION

The results indicated that the growth of agricultural value-added (*AGRIVA*) is influenced by the technological progress, the net capital stocks value, the number of machines used, the number of hectares for arable land and permanent crops, the number of hectares equipped for irrigation, and the amount of chemical fertilizers consumed. The technological progress appeared at nearly 99% to be a major determinant of boosting the potential productivity of limited input factors, notably land factor (Shenggen, 1991). Thus, as time increases, technological changes occur, affecting positively the economic growth. In other words, when new farming devices and practices (e.g. multi-cropping, agroforestry, new varieties of seeds, new resources management) are

³ *LAGRIVA*= Logarithm (*AGRIVA*)

Table 1. Variable definitions and data sources.

Variable	Definition	Sources
AGRIVA	Agricultural value-added (million local currency, value price 2005)	FAO (2017)
NETK	Net capital stocks value (million local currency, value price 2005)	FAO (2017)
MACHI	Number of machines (tractors, harvesters, threshers) used	FAO (2017)
CREDI	Amount of credits to agriculture (million local currency, value price 2005)	FAO (2017)
ENERG	Amount of energy used to power irrigation, in terajoule	FAO (2017)
LABOR	Number of workers in agriculture sector	UNCTAD (2017)
ALAND ⁴	Number of hectares for arable land and permanent crops	FAO (2017)
FORES	Number of hectares for planted and naturally regenerated forest	FAO (2017)
IRRIG	Number of hectares equipped for irrigation	FAO (2017)
FERTIL	Number of tons for chemical fertilizers (nitrogen, phosphorus and potassium) consumed	FAO (2017)

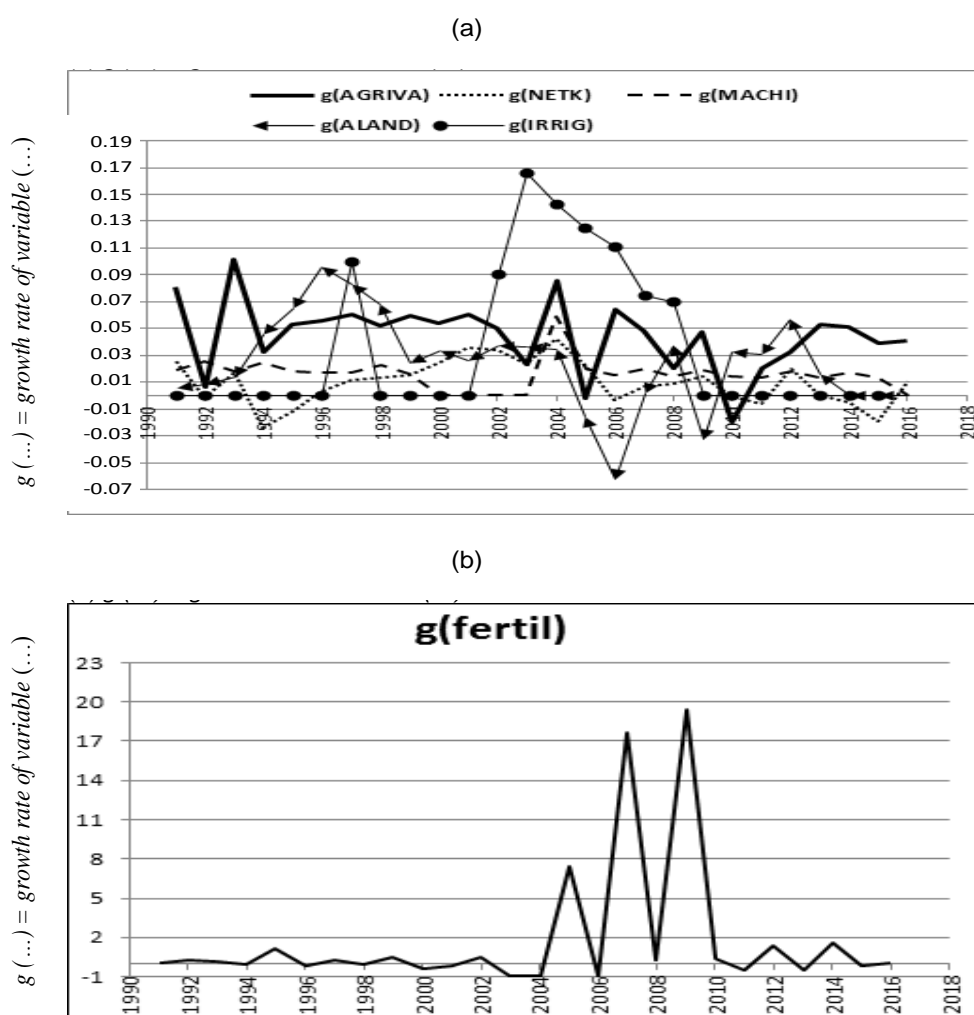


Figure 1. (a) Trends of annual growth rates of agricultural value-added, net capital stocks, machinery, arable land & permanent crops, and area equipped for irrigation (1990-2016). (b) Trend of annual growth rate of chemical fertilizers (1990-2016).

⁴According to the FAO, “Arable land” refers to land producing crops requiring annual replanting or fallow land or pasture used for such crops within any five-year period” (multiple-cropped areas are counted only once). A briefer definition appearing in the Eurostat glossary similarly refers to actual, rather than potential use: land worked (ploughed or tilled) regularly, generally under a system of crop rotation.

“Permanent cropland”, meanwhile, refers to land producing crops which do not require annual replanting. It includes forested plantations used to harvest coffee, rubber, or fruit but not tree farms or proper forests used for wood or timber.

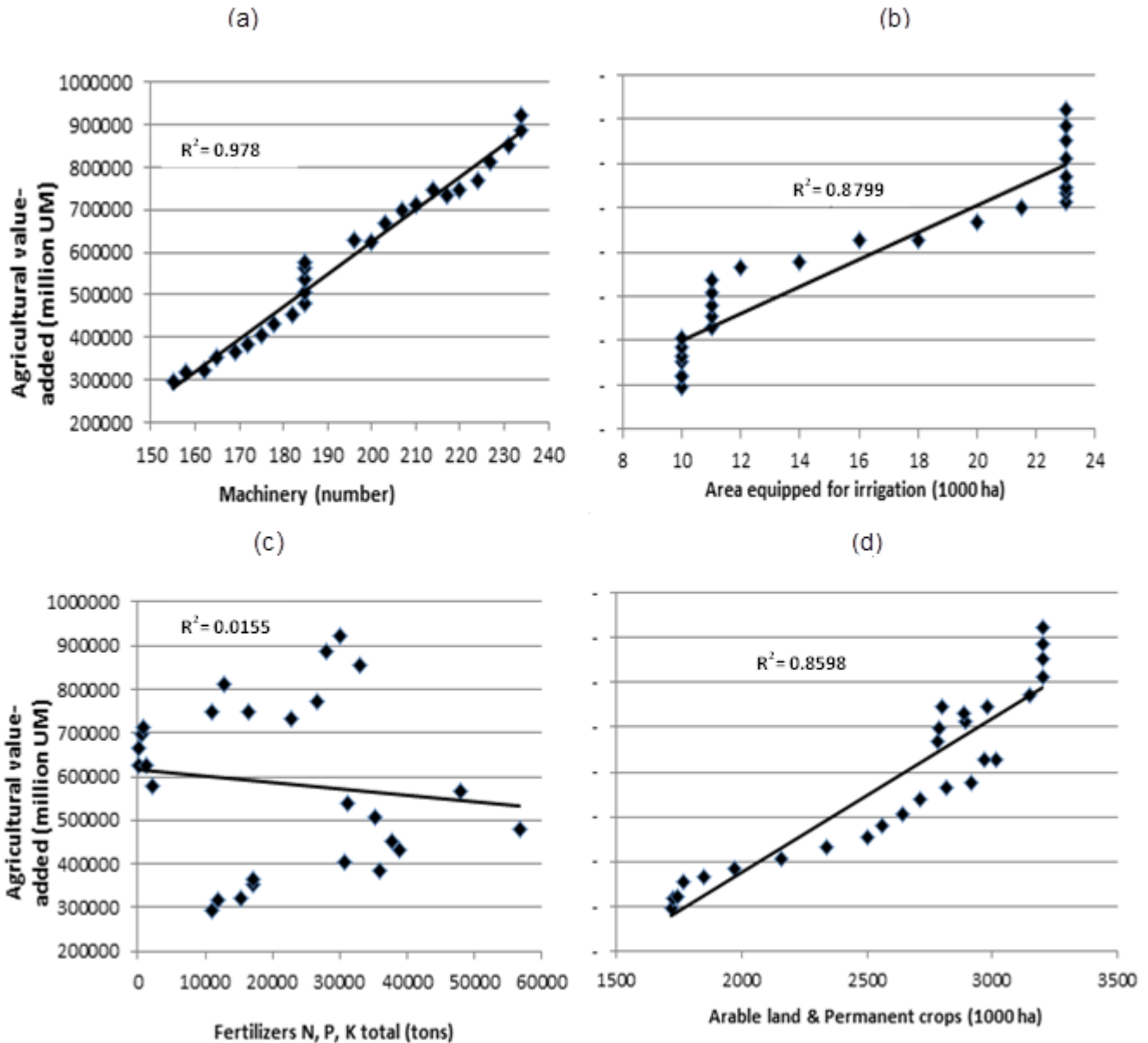


Figure 2. (a) Relationship between machinery and agricultural value-added (1990-2016) (b) Relationship between area equipped for irrigation and agricultural value-added (1990-2016) (c) Relationship between chemical fertilizers and agricultural value-added (1990-2016) (d) Relationship between arable land and permanent crops area and agricultural value-added (1990-2016).

adopted and introduced into the production process over the years, it might help to increase the total factor productivity. Currently the main driving factors of the economic growth in China are S&T progress and capital investment and the role of S&T progress is becoming increasingly important (Zhao, 2011; Qiguo and Jikun, 2011).

Indeed, the results showed that the amount of net capital stocks (*NETK*) does affect positively and significantly the agricultural gross domestic product. It is found that when farmers increase the capital stocks by

1%, the agricultural value-added would increase by about 0.59%. However, the presence of supporting infrastructure such as roads is fundamental (Dorward et al., 2004) and was a major factor in Asia's successful Green Revolution. The contribution of the factor *NETK* is established approximately to 13% in the present study. Wang and Yu (2011), state that China should make a large scale investment in agricultural capital as this factor appears to be greatly related to the growth of agricultural production value. This statement was put forward further to their findings regarding the Anhui province case study,

Table 2. ADF unit-root test on variables.

Variables	Unit-root test in	ADF test statistic	Test critical values	Integration order
<i>LAGRIVA</i>	First difference, including intercept	-6.926025	-3.724070***	I(1)
<i>LNETK</i>	First difference, without intercept nor trend	-2.730906	-2.660720***	I(1)
<i>LMACHI</i>	First difference, including intercept	-4.067870	-3.724070***	I(1)
<i>LCREDI</i>	First difference, without intercept nor trend	-11.40214	-2.664853***	I(1)
<i>LENERG</i>	First difference, without intercept nor trend	-4.898979	-2.660720**	I(1)
<i>LLABOR</i>	First difference, including intercept and trend	-3.924902	-3.673616**	I(1)
<i>LALAND</i>	First difference, without intercept nor trend	-2.077273	-1.955020**	I(1)
<i>LFORES</i>	First difference, including intercept	-3.674498	-2.986225**	I(1)
<i>LIRRIG</i>	Second difference, without intercept nor trend	-5.234235	-2.664853***	I(2)
<i>LFERTIL</i>	First difference, without intercept nor trend	-6.700149	-2.660720***	I(1)

***, ** Indicates significance at the 1 and 5% levels, respectively.

Table 3. Estimation of the growth of agricultural value-added [Sample: 1990-2016 (N = 27)].

Variable	Coefficient	S.E.
<i>Constant</i>	-103.5374**	34.48855
<i>YEAR</i>	0.041686***	0.011901
<i>LNETK</i>	0.586066**	0.203309
<i>LMACHI</i>	0.886031**	0.352736
<i>LCREDI</i>	0.003155	0.004138
<i>LENERG</i>	0.958764	1.200274
<i>LLABOR</i>	-0.029977	0.488572
<i>LALAND</i>	0.383954***	0.094556
<i>LFORES</i>	1.766482	1.259222
<i>LIRRIG</i>	-0.268012***	0.082152
<i>LFERTIL</i>	-0.004634*	0.002418
<i>Dum1</i>	0.079432***	0.015338
<i>Dum2</i>	-0.045332**	0.016504
<i>AR(3)</i>	-0.688183**	0.275643
<i>Adjusted R²</i>	0.997	
<i>F-statistic</i>	800.48***	
<i>Durbin-Watson stat (DW)</i>	2.358	

***, **, * Indicates significance at the 1, 5 and 10% levels, respectively.

where the capital investment contribution rate is found to be about 92.59% over the period 1995-2006.

The number of machines is destined to capture the importance of agricultural mechanization (labor-saving technology). It is found that as the number of agricultural machines (*MACHI*) increases, so does the agricultural value-added. Thus, when agricultural production is mechanized, it might foster the drop of some production inputs (labor for example) and the saving of work time, and then, the increase in production value. The contribution of the factor *MACHI* is approximately established to 32% in the present study. This result is very close to that of Zhu and Cui (2011) in the case of

China.

The number of hectares arranged for arable land and permanent crops (*ALAND*) was significant and did influence positively the growth of agricultural gross domestic product. This result is similar to that obtained by Luo and Huang (2013). Since this variable includes sustainable farming practices like multi-cropping, crop rotation and agroforestry, the probability that it is positively related to the sustainable agricultural growth is revealed as obvious and approximately 99% in this study. The practice of agroforestry on a farmland might be quite beneficial to a green agricultural revolution with some staple crops namely rice, corn and wheat. Permanent

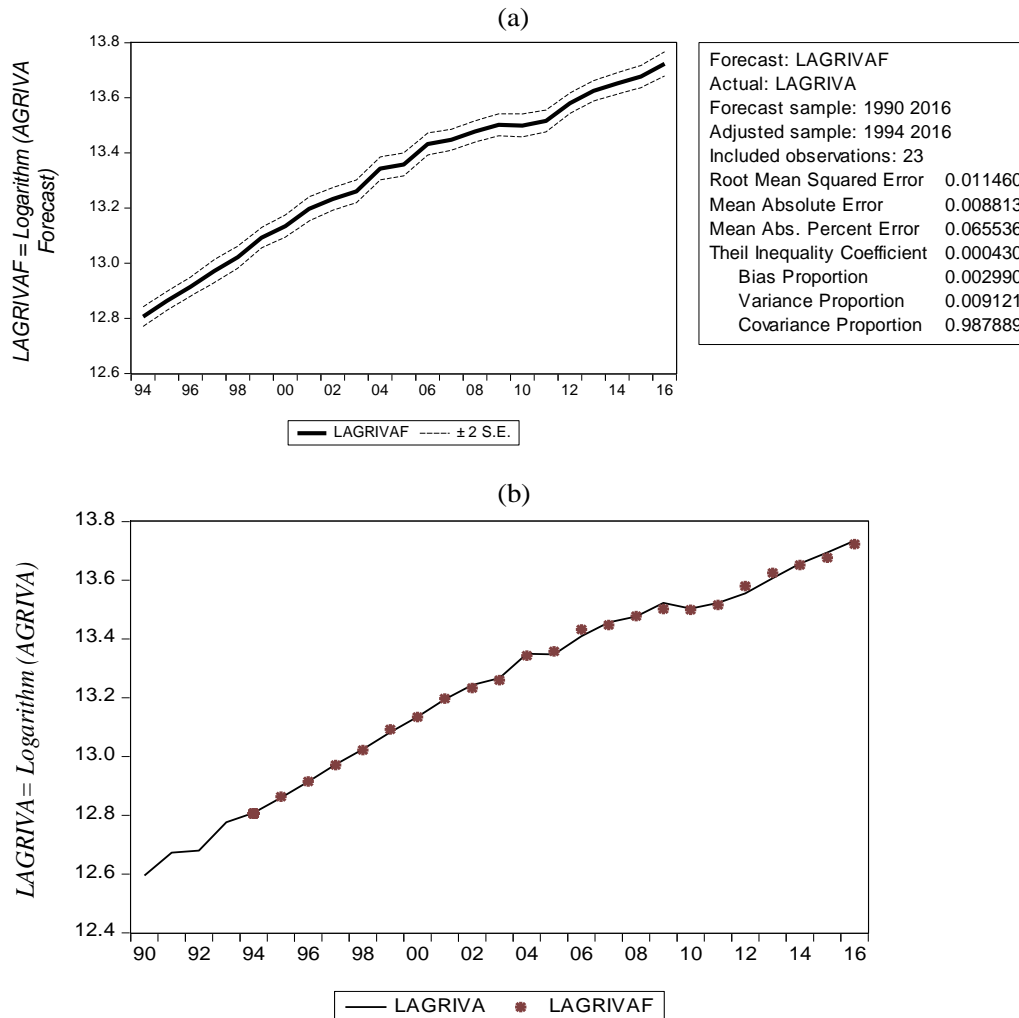


Figure 3. (a) Trend of forecasted growth of agricultural value-added (1990-2016). (b) Gap between actual and forecasted growth of agricultural value-added (1990-2016).

cropping may be encouraged and recommended as it seems to be an agricultural sustainability practice due to the fact that it may avoid ploughing more land, degrading soil, and so, may be playing an ecological role. In the country of Benin, the permanent cropping is carried out and derived products such as cashew nuts, mangoes, and palm oil are among the main commodities for exportation. The contribution of the factor *ALAND* is established approximately to 21% in the present study.

In addition, both the number of hectares equipped for irrigation (*IRRIG*) and the amount of chemical fertilizers (*FERTIL*) appeared to be negatively related to the growth of agricultural value-added. These results contradict those of Chao and Sun (2013), who found both of these technologies to have a certain and positive contribution to the agricultural economic growth. Many aspects must be considered in analyzing this outcome given that sometimes, the positive effects generated by applying land-conserving technologies may not globally

compensate their negative externalities. Currently, the pursuit of the agricultural sustainable development goal in the country of Benin not only relies on chemical fertilizers, but also considers their mixture with organic manure. For all that and in relation with FAO (2015), it is recommended to use the underlying technologies in accordance with soil characteristics and in a balanced way. In this context, a further study may be interesting on how chemical and organic fertilizers should be managed in accordance with soil characteristics in order to sustain crop yields over time.

None of variables *LABOR*, *FORES*, *CREDI*, and *ENERG* were found to be significant determinants of agricultural value-added growth. In other words, the underlying variables are not likely to foster increasing directly the agricultural value-added. In the context of sustainable development, the labor force has to be strengthened with new knowledge and modern practices, otherwise, its impact on agricultural production growth in

Table 4. Impulse response of agricultural value-added (1-10 years).

Period	<i>LAGRIVA</i>	<i>LNETK</i>	<i>LMACHI</i>	<i>LALAND</i>	<i>LIRRIG</i>	<i>LFERTIL</i>
1	0.016548	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.000938	0.001880	0.004575	0.003364	0.003025	-0.006375
3	0.009523	0.000622	0.008313	0.003506	-0.001925	-3.58E-06
4	0.005766	0.001267	0.011745	0.010891	-0.001772	-0.002663
5	0.000604	0.003451	0.007465	0.016807	-0.000977	0.003770
6	0.003461	0.005264	0.008238	0.018609	-0.005930	0.002293
7	0.000132	0.003888	0.005086	0.016867	-0.004091	0.001389
8	0.002821	0.002423	0.004726	0.012513	-0.004422	0.001753
9	0.004001	-5.71E-05	0.006643	0.009692	-0.003263	-0.000406
10	0.003092	-0.001353	0.006889	0.009398	-0.000784	0.001047

the long-term might be negligible in the presence of labor-saving technologies. Wang and Yu (2011) find that the insignificant impact of labor force in the province of Anhui in China is the fact of a huge number of rural labor force. Hence, the authors do propose measures to accelerate the transfer of the rural labor surplus, such as developing labor-intensive industries with deep-degree and fine processing of agricultural products, and so that, to promote a rapid development of the tertiary industry. Meanwhile, the contribution of the sub-sector of forest seems to be negligible. However, out of their economic role, forests recognize an environmental role like carbon dioxide sinks (positive externalities). In addition, it appeared that the credits received by farmers for the purpose of agricultural activity do not impact the growth of the agricultural value-added. An explanation may be the fact that the amount of credits received per farmer for investing is too insignificant to generate increasing returns to scale. Another explanation may be the fact that the provided loans required that farmers obtain reimbursement at a high interest rate or the credits may vanish due to an imperfect management. Lastly, it seems that the amount of energy used would only be affecting the functioning of irrigation equipment, and then, the contribution of the variable *ENERG* would be perceived through the impact of the variable *IRRIG*. For all that, it is suggested that a new method of management be implemented for labor force, forested area, agricultural credits, and energy used for irrigation, so as to render them more contributive to sustaining gross domestic production. A further study may investigate how rural demographic dividend can help a country solve the issue of food security.

IMPULSE RESPONSE OF AGRICULTURAL PRODUCTION GROWTH

Here, information on how agricultural value-added will be reacting within the short and long terms further to a positive innovation or shock to an agricultural technology

is provided. The impulse response to Cholesky (d.f. Adjusted) One S.D. Innovations is thus presented in Table 4.

It is found that today's innovation to machinery and arable land and permanent crops area (Figure 4c, d) may be affecting positively and steadily the growth of agricultural value-added within 10 years (long term). Therefore, the goal of sustainable agriculture should rely on mechanized technologies and farming practices involving multi-cropping and agroforestry.

The growth of agricultural value-added may be responding positively to a net capital stocks impulsion (Figure 4b) in the short and medium terms (1-8 years), but it may be declining and turning into negative effect after 8 years (long term). Accordingly, it is advised that capital investments be reinforced or renewed at opportune moment so as to keep steady the positive trend of the agricultural economic growth over the years.

Figure 4e shows that the growth of agricultural value-added may be responding negatively within 10 years further to a shock to irrigation technologies. However, this negative response may be reversed after 10 years, indicating that once farmers do appropriate soil characteristics and other sub-factors relating to irrigation technologies management, these might later impact positively the production growth. Meanwhile, the positive response of *AGRIVA* to *FERTIL*'s impulsion (Figure 4f) is likely to dominate the negative effect in the long term (after 4 years). However, the impulse response is plainly negative in the short term. For sustainable agricultural goal, it is suggested that these chemical technologies be applied in a balanced ratio.

Furthermore, it is found that the output growth may be reacting successfully within 10 years system when a shock is directly put to the overall production system (Figure 4a).

Conclusions

This research examined the influence of agricultural technologies on the growth of agricultural value-added

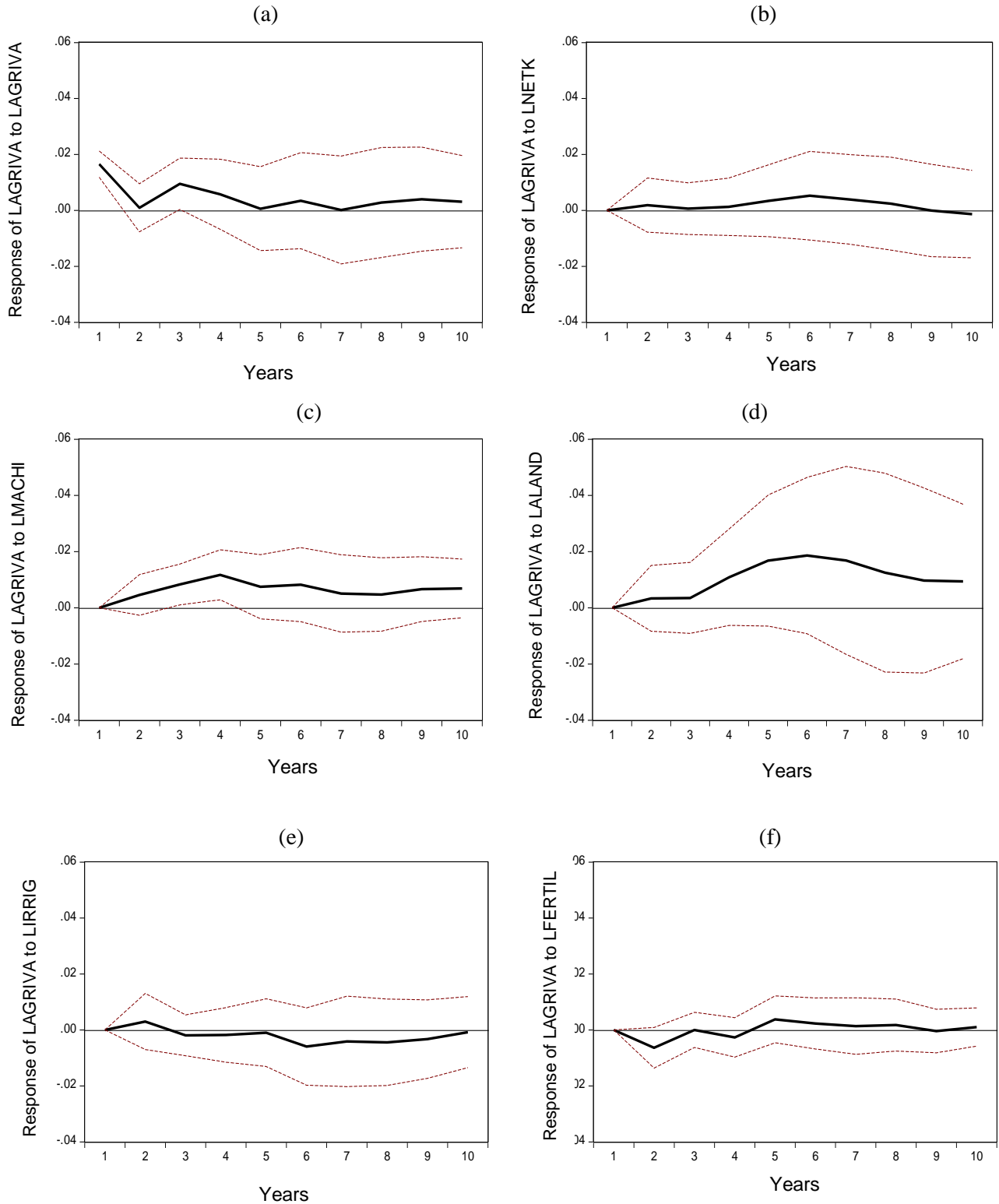


Figure 4. Projected growth rate of agricultural value-added in response to technological innovations (1-10 years).

based on time series data (1990-2016) and C-D production function. It determines that there is a positive link between the growth of agricultural value-added and

the technological progress, the amount of net capital stocks, the number of agricultural machines used, and the number of hectares for arable land and permanent

crops. Thus, there are significant and certain benefits to draw economically from the utilization of a system of technological innovations including mechanization, renewed capital stocks, and sustainable farming practices involving temporary cropping and permanent cropping. For the latter, farming practices like agroforestry and multi-cropping are largely revealed as satisfactory in number of country, and then, recommended for the sake of ecological concern. In contradiction to Chao and Sun (2013), it is found that both the number of hectares equipped for irrigation and the amount of chemical fertilizers are negatively related to the growth of agricultural value-added. However, technological shocks pertaining to irrigation and chemicals, as well as other agricultural technologies, might be beneficial for agricultural production growth in the long-term when they are perfectly managed. As a result, the adoption and diffusion of those technological innovations may impact positively farmers' welfare (Berihun et al., 2014; Khan et al., 2014; Mamudu et al., 2012; Solomon et al., 2012). Then, it is suggested that these technologies be used in accordance with soil characteristics and in a balanced way.

The results also indicate that the labor force, the forest area, the amount of credits to agriculture, and the amount of energy consumed to power irrigation are likely to be insignificant to boost directly the growth of agricultural value-added in the long-term. However, the different issues raised by the utilization of these factors must be addressed either by policy or by appropriating the knowledge relating to their good management so as to make them more profitable to agricultural production (MENG, 2012). In addition, sectorial development policies and strategies as well as natural phenomena are also significant determinants of agricultural production growth. Actually, the role of the central government is very crucial for a successful green agriculture (Dorward et al., 2004). In the light of all the forgoing, it is recommended that the goal of sustainable agriculture should be to consider a systematic approach associating technologies and practices that impulse positively the growth rate of agricultural value-added in the long term.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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