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Journal of Development and Agricultural Economics

Full Length Research Paper

Marketing and market integration of cowpea (*Vigna unguiculata* L. Walp) in Uganda

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Despite the importance of cowpea in Uganda as a leading legume, its production and improvement have not received much attention over the last two decades. Data was obtained on prices of grains of cowpeas on a weekly basis from FIT Uganda between 2008 to 2011 in Soroti, Lira and Kampala. Data collected was analyzed using descriptive statistics, particularly, frequencies and the measures of central tendency. Several approaches were used to investigate the degree of cowpea market integration in Uganda: bivariate correlation coefficients, co-integration and Granger-Causality tests were used to account for the complex interactions of prices in different markets. Results from these tests show that cowpea markets as a whole are not integrated. This is not a surprising result since it can be linked to the general lack of market information. Prices in different markets are not equally responsive to changes in the supply of cowpeas. The results obtained will assist in subsequent cowpea variety improvement actions and decisions.

Key words: Market integration, marketing, co-integration, granger-causality, Uganda.

INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp) is a global legume whose cultivation is believed to have begun from Africa more than 5000 years ago (Davies et al., 2005; Jafferson, 2005). At present, it is the second most important grain legume in Africa (NRC, 2006). It is cultivated around the world, particularly in the semi-arid tropics, primarily as a pulse, vegetable (for both grains and the green peas) as well as cover and fodder crop (Faye, 2005). However, the largest part of the world's production comes from Africa. More than 5.4 million tons of dried cowpeas are produced worldwide, with Africa producing nearly 5.2 million. Nigeria, the largest producer and consumer, accounts for 61% of production in Africa and 58% worldwide, while Uganda is among the top 10 producer of cowpea ranked 8th (Ronner and Giller, 2012). As regards trade, Africa exports and imports negligible amounts of cowpeas (IITA, 2013).

In Uganda, cowpea is ranked 4th after beans, groundnuts and soybean (Ronner and Giller, 2012) although it is generally consumed countrywide. The

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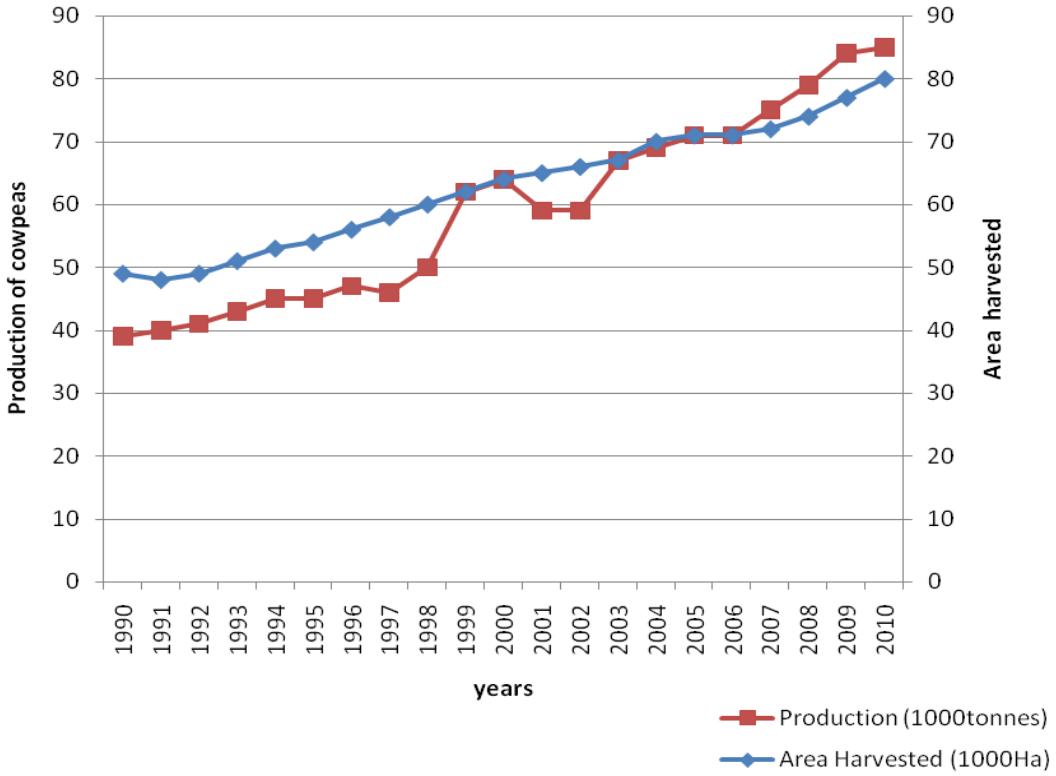

Figure 1. Average cowpea areas and production in Uganda. Source: FAOSTAT 2013 Database; http//www.fao.org

young leaves and immature pods are eaten as vegetables. Relative to other grain legumes and vegetable crops, cowpea possesses multiple advantages to farmers including high yields on poor, sandy soils unsuitable for the production of other crops, high rates of symbiotic nitrogen fixation and lower fertilizer requirements (Carsky et al., 2001; Timko and Singh, 2008). It is thus a valuable component of farming systems in areas where soil fertility is limiting and where it is grown in rotation and/or intercropped with cereals. It is a crop of major importance to the nutrition of poor rural households whose diets tend to heavily rely on starchy foods such as millet, sorghum, maize and cassava. It therefore, has a tremendous potential to contribute to the alleviation of malnutrition.

Cowpea is grown by approximately 2.2 million smallholder farmers in Uganda, mainly in eastern and northern regions, using simple traditional methods. Figure 1 shows the trend of area and production of cowpea for the last two decades (1990-2010). The figure shows relatively similar trend for cultivated area, while production fluctuated throughout the period with several increases and decreases with the highest peak observed in 2000 and a fall in 2002. The reasons for such fluctuations were attributed to weather conditions. Indeed, the country often experiences unpredicted dry periods and floods which might have caused the decreases in addition to insect pests which form a major constraint for increasing cowpea production (Ronner and Giller, 2012) in the harvested areas, while good seasons might have resulted in increases (the ups). Unlike the production, the area trend shows a sustained increase throughout the years independent of the corresponding production fluctuations. This suggests that the production of cowpea is related to increase in the area cultivated. As stated by Coulibaly et al. (2009) the increase in production may also be attributable to the release, adoption and cultivation of improved cowpea varieties at the early stage of cowpea improvement programs.

At the national level, the average yields stand at 0.93 MT/ha. However, the average cowpea yield is estimated at 1.5 to 3 MT/ha on station field trials, while farm level yields are as low as 0.5 MT/ha due to production constraints such as low yielding local varieties, pests and diseases, poor agronomic practices, land shortage, seed scarcity, drought, poor soils and lack of market (Bisikwa et al., 2014).

Minimal value addition of cowpea takes place and involves sorting and grading by type. It is sold as whole grain mostly, although in some cases they sell split grain. Cowpea trade has been limited to the local/domestic market but is slightly picking at regional level, mainly South Sudan and Kenya. Cowpea has therefore been thought of having brought for the smallholder farmers in Uganda an important food and potentially an important cash crop, especially for varieties demanded by the

export market (Adipala et al., 1999). Since the Uganda government policy is to diversify exports and introduce non-traditional cash crops in the economy, cowpea presents a great economic potential.

Due to the demise of cotton as the main cash crop in Northern Uganda and the emergence of important external markets, 50% of farmers in the region now grow cowpea for cash markets (UBOS, 2010). Production of cowpea is in transition where it was traditionally grown almost exclusively as food crop for domestic consumption to cash crop.

In realizing the potential of cowpeas as an alternative cash crop, McKnight Foundation supported a breeding programme engaged in breeding cowpea to improve food security in the region. In the past two decades, no studies have been carried out that focused on market integration. The cowpea programs implemented in Uganda have focused only on the supply side to ensure enhanced productivity. It is not clearly documented whether in the development of improved varieties market integration related information was evaluated. Lack of market information in many African countries as highlighted by Van der Laan (1999) is principally because marketing research has focused on export crops such as cotton, coffee, cocoa and groundnut and to a lesser extent cereals.

Furthermore, the major producing areas have been under political unrest and are recuperating from long-term insurgency for the past two decades resulting into the destruction of infrastructures, government programmes and loss of life. These are among the factors that affect the ways markets for various crops are integrated.

The market reform agenda being practiced in most developing countries has renewed an interest in the working of agricultural markets as a source of income, employment and food security. However, the success of the market reform process in promoting equity and efficiency is constrained by numerous structural deficiencies in local markets. One of the main consequences of these structural deficiencies is poor market integration resulting into difficulty with which information and trade flows among spatially separated markets (Goletti et al., 1995). In order to succeed, among other things, the reform process needs to take into account the extent of agricultural market integration. Little is known about how the agricultural markets, especially for staple foods, are performing in recent years and whether they are integrated or not. Furthermore, research on cowpea varietal improvement and market performance has not received much attention in the last two decades within the two regions.

This study was therefore conducted to gain a better understanding of cowpea market integration which is necessary to enhance production, improve market efficiency and competitiveness which are essential for cowpea market development. It also aims at determining the existence and level of inter-market price dependencies and to examine the causal relationships (how markets drive prices) among spatial locations of cowpea markets.

Marketing and market integration of cowpea in Uganda

The marketing of cowpeas like other crops is mainly confined to local markets and farm gates. This is attributed largely to lack of access to urban markets by farmers partly because of the poor road network and poor modes of transportation. Considerable local trade in cowpea therefore exists. Inter-regional trade in cowpea too exists and it is a profitable crop to produce according to Sabiti (1995) and a lot of the crop finds its way to the Kenyan markets.

Market integration refers to the co-movement of prices and/or flows between markets. More generally, it explains the relationship between two markets that are spatially or temporarily separated. Markets are integrated when their price levels are closely related (Stigler, 1969). Market integration studies attempts to investigate the extent of markets by analyzing the development of prices over time for potential competing products (Asche et al., 2005).

According to Bopape and Christy (2002), there are three forms of market integration: (1) integration across space, (2) integration across product and (3) integration across time. Markets are integrated across space if, when trade takes place between them, price in the importing market equals price in the exporting market plus transportation and other costs of moving the product between the two markets. When integrated across product form, markets are vertically integrated and the price differential between two related commodities should not exceed transportation and processing costs. Markets are said to be integrated across time (inter-temporally integrated) when the expected price differential does not exceed the cost of storage.

The study of market integration can suggest to the producer as to where, when and how much to sell, which in turn will have a bearing on their production strategies and hence resource allocation. Integrated markets are those where prices are determined interdependently (Yogisha, 2006). Fulton et al. (2008) observed that, the examination of the extent of how markets were integrated was an important way of understanding whether sufficient market information was available to the market participants.

Goodwin (2001) had stated that understanding the dynamics and/or the degree to which food markets are spatially efficient has key implications for policy makers. A well-integrated market system is essential to household food security especially in both food deficit regions of the country. In addition, flexible prices are thought to be responsible for efficient resource allocation and price transmission is useful in integrating markets both vertically and spatially. Without spatial integration of

markets, price signals may not be transmitted from urban food deficit to rural food surplus areas thereby leading to increased price volatility. Understanding if markets are integrated is important for policy reforms.

Uganda presents a case where local markets are thought to be fragmented. In fragmented markets, a localized crop scarcity can lead to famine in the area if prices in one local market are not highly responsive to those of another. A well-integrated market system is not only necessary for the efficient allocation of productive resources but also for a reduction in price risks that are likely to impair the wellbeing of economic actors most especially the poor and food insecure households (Ravallion, 1986). This is because the success of market reforms depends to a large extent on the strength of price signals transmitted between different market levels (Moghaddasi, 2009).

The knowledge about the extent to which markets are integrated is important for several reasons. First, by identifying groups of closely integrated markets and by knowing the extent of price transmission across different locations within a country, a government may improve the design of its market liberalization policies. For example, it avoids duplication of interventions and as a result, decreases the fiscal burden on the budget. Second, knowledge of market integration allows monitoring of price moments. For example, the knowledge of the speed of adjustment to shocks (for example, in a country's key commodity sector) arising in different areas of the country is paramount to more efficiently managing a price stabilization policy. Third, integration models can be used to forecast prices in neighbouring markets which facilitates forecasting analysis. Finally, by identifying the structural factors responsible for market integration, investment policy in the marketing infrastructure can be improved, because this allows policy makers to understand which kind of marketing infrastructure is more relevant to the development of agricultural markets in a country (Scott, 1995).

MATERIALS AND METHODS

In carrying out the market integration study, secondary data were obtained from FIT Uganda on weekly wholesale prices of cowpea grains in three districts namely Soroti, Lira and Kampala from 2008 to 2011. Soroti and Lira were considered as the producing zones, while Kampala was considered a purely consumption zone. Wholesale prices were used because they are easily transmitted. These markets were purposively selected based on availability of price data and whether they are located in the production or consumption zone. A total of three (3) markets were sampled. This is shown in Figure 2.

The time series data (prices) was adjusted to two standard deviations from the weakly means as suggested by Goetz and Weber (1986). Missing values were approximated by linearly interpolating the data to account for any missing values between one and three. Where the missing values are more than three, prices from nearby market was used to replace for missing values since it was hypothesized under spatial arbitrage theory that prices of the same commodity in adjacent markets tend to move in unison and that they do not divert much from each other according to Tomek and Robinson (1990). The issues of serial correlation and heteroscedasticity in the error terms of the estimated models were tested for heteroscedasticity using the Breush-Pagan (BP) set up. In order to test for serial correction in the error term of the considered model, the Breush-Godfrey approach was applied using an AR (q) model Greene (2002). The data was analyzed using STATA 9 program, after being set to have time series properties and transformed by two major transformations namely natural log and first difference transformations (STATACORP lp, 2005).

Empirical models

Here, several measures were used to study market integration. Econometric tests were conducted to test the level of cowpea market integration, which include stationarity tests, correlation analysis and the application of new econometric techniques of co-integration analysis using Johansen trace test for bivariate and multivariate models and Granger causality approach (Palaskas and Harriss-White, 1993). On the basis of the fact that only price information was collected by FIT Uganda from private traders in the study markets, this study tests the existence of co-movement and price relationships among markets using co-integration analyses. Co-integration analysis is based on the existence of a stable relation among prices in different localities (Goletti et al., 1995).

Prices move from time to time, and their margins are subject to various shocks. When a long-run linear relation exists among different series, these series are said to be co-integrated. The presence of co-integration between two series was indicative of interdependence; its absence indicates market segmentation. In particular, a segmented link was one were co-integration was rejected in both directions along which the link can be traced. Following Engle and Granger (1987), the co-integration model was composed of two steps: non-stationarity test using the Augmented Dickey Fuller (ADF) test and co-integration analysis. One method was to measure the significance of price relationships between markets in different geographic areas (across space) and to compute bivariate correlation coefficients (r) which are then used as a proxy for the level of market integration. A high (r) implies market integration and vice versa. The theory of price correlation was explicitly formulated by Stigler (1969). Stigler and Sherwin (1985) linked the statistical test for price correlation to market integration when they proposed examining price correlation as a test for market integration.

The use of correlation coefficients to ascertain the degree of market integration is quite common (Bopape and Christy, 2002; Fafchamps and Gavian, 1995; Mbene, 2005). However, the non-stationary nature of agricultural time series price data and some other common factors, such as occurrences of drought and inflationary pressures can influence prices in markets investigated in such a way that the (r) values suggest market integration even if markets are not really integrated. Hence, testing for market integration by only using correlation coefficients could lead to biased results. Five steps were followed during data analysis:

Step 1: Determining the optimum lag length

The dataset was declared time series and a lag-order selection statistic pre-estimated using a combination of the two criterions: the Akaike Information Criterion (AIC), the Hannan-Quinn criterion or the Schwarz criterion to determine the optimal lag length for the cowpea price series. The number of lags included in models was determined using standard information criteria (SBIC) and AIC with priority being given to AIC.

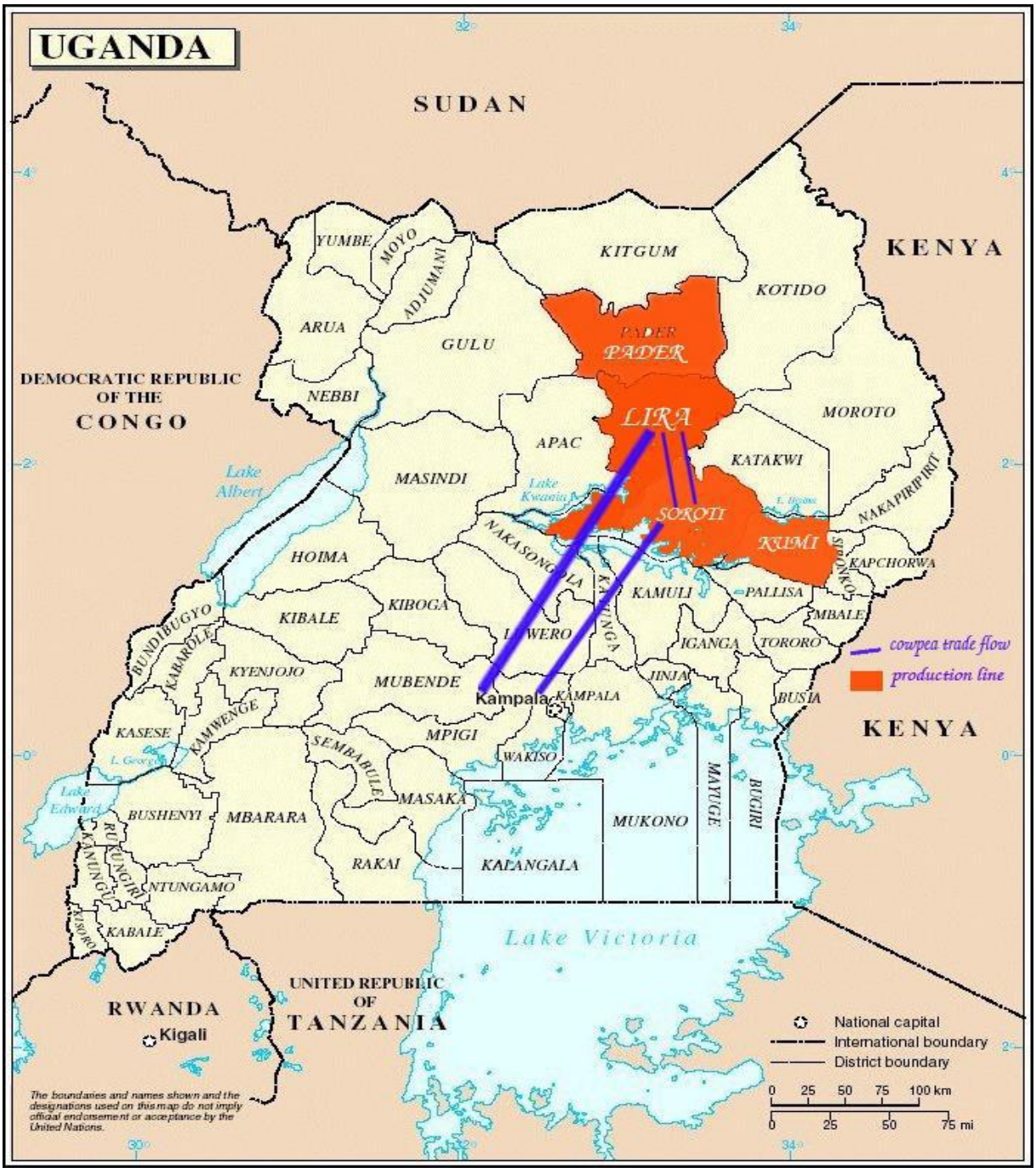

Figure 2. Map of Uganda showing selected study area and location of markets.

Step 2: Test for stationarity

The cowpea price series were tested individually for stationarity using the ADF test (Vinuya, 2007; Uchezuba, 2005; Shahidur, 2002). The ADF test which is also known as the unit root test was used to test the null hypothesis that a given price series P_t is non stationary against the alternative hypothesis that P_t is stationary by calculating a test statistic t for β = 0 in Equation 1 assuming a random walk process.

Following Gujarati (1995), the model is specified as:

$$P_t = \delta + \rho P_{t-1} + \varepsilon_t \quad (1)$$

Where P_t is the cowpea price at time t; P_{t-1} is the lagged cowpea price; δ is a constant drift; ρ is the coefficient of lagged cowpea prices and ε is the error term; t is weekly

The model is transformed into a regression test to determine the slope through application of ordinary least squares (OLS) is what is termed the ADF test. The regression was expressed as in

Equation 2 according to Ghosh (2003) and Myint and Siegfried (2005); the test was based on the statistics obtained from applying the OLS method to the following regression equation:

$$\Delta P_{it} = \alpha + \beta P_{it-1} + \delta T + \sum_{\gamma=1}^{k_i} \varphi_\gamma \Delta P_{it-\gamma} + \varepsilon_t \quad (2)$$

Where: T = time trend; $\Delta P_t = P_t - P_{t-1}$; $\Delta P_{t-\gamma} = P_{t-\gamma} - P_{t-\gamma-1}$; γ = 2, 3, …, n, P_t is the price at time t; α, β, γ and φ_γ are parameters to be estimated and ε_t is the error term. γ = number of lags. The null hypothesis of a unit root is H_0: $\beta = 0$ in Equation 2. The regression was run with a time trend.

According to Bopape and Christy (2002), the trend was only included to rule out the possibility of non stationarity not being due to a deterministic trend. If the observed ADF test statistic is less than the critical values, then the P_t will be stationary and those found to be non-stationary if the critical value is less than the ADF test statistic. For series that were stationary in levels, these were considered to be integrated of order zero that is, I (0).

Step 3: Transforming non-stationary series

The non-stationary series were transformed by differencing to obtain stationary series. If P_t is not stationary at level, it may be stationary at first difference or simply differentiation of this P_t series. The differenced price series was obtained by simply differentiating Equation 1 through manipulation by subtracting P_{t-1} from both sides of Equation 1 gives:

$$P_t - P_{t-1} = \delta + \rho P_{t-1} P_{t-1} + \varepsilon_t$$
$$\Delta P_t = (\beta - 1) P_{t-1} + \varepsilon_t$$
$$\Delta P_t = \alpha P_{t-1} + \varepsilon_t$$

$$\Delta P_t = \alpha P_{t-1} + \varepsilon_t. \quad (3)$$

Where ΔP_t is the price difference ($P_t - P_{t-1}$), and α is equal to (β_1-1)

To test for stationarity in the differenced time series ΔP_t in consideration, the null hypothesis is that α = 0 so that β = 1, in such a case Equation 3 will have a unit root. The series in difference were then tested for stationarity using the ADF test. The alternative hypothesis was accepted for all the series tested meaning that they are integrated of order one that is I(1). The next step therefore was to test for co-integration.

Step 4: Co-integration test

If two markets are integrated of order zero I(0), then the series are automatically integrated and hence co-integrated; this implies that there is a longrun relationship between them, say $y_t = \beta_1 x_t + u_t$, where u_t is I(0). The two series are not drifting apart over time. If either or both of the series are nonstationary (that is, integated of order above zero) and of the same order of integration (which implies that the AR and MA processes are nonstationary), then the series may be integrated provided they are cointegrated (that is, there is a linear combination of the series and since only one market (Soroti) was of order (1), no co-integration was run. since

Step 5: Causality test

To achieve objective 4, the Granger-Causality test was used to assess the nature of cowpea price transmission across markets and causal relationships among spatially separated markets. This method was used to determine how price changes in one market could explain price changes in another market. Granger-Causality tests focuses on the presence of at least unidirectional causality linkages as an indication of some extent of integration (Gupta and Mueller, 1982) and it assesses whether price movement follows a well-defined path, that is, if price movement starts around demand or production zones and spreads across other markets.

For the series in level I(0), the Autoregressive Distributed Lag (ADL) model was used to test for causality. The model in level was specified as follows:

$$P_{1t} = \alpha_1 + \delta_1 t + \beta_1 P_{1t-1} + \ldots\ldots + \beta_a P_{1t-a} + \varphi_1 P_{2t-1} + \ldots\ldots + \varphi_q P_{2t-q} + \varepsilon_{1t} \quad (4)$$

$$P_{2t} = \alpha_2 + \delta_2 t + \theta_1 P_{2t-1} + \ldots\ldots + \theta_q P_{2t-q} + \sigma_1 P_{1t-1} + \ldots\ldots + \sigma_a P_{1t-a} + \varepsilon_{2t} \quad (5)$$

Where *a* and *q* are as defined above.

If we take the case of two markets, Kampala and Lira, where P_2 is the price of cowpeas in Kampala, and P_1 is the price of cowpeas in Lira. Causation can occur in two ways: unidirectional- where shocks in one market affect another market but not the reverse - and bidirectional where shocks in one individual market are transmitted both ways.

Therefore, based on Equations 4 and 5, three hypotheses of causality were tested after running a vector auto-regression for each market pair.

1) Unidirectional causality: Kampala prices drives or granger cause Lira prices if any or all the coefficients φ_1 *to* φ_q in Equation 4 are statistically different from zero: Lira prices Granger cause Kampala prices if any or all coefficients σ_1 *to* σ_a in Equation 5 are statistically different from zero

2) Bidirectional causality (both Kampala and Lira Granger cause each other) if any or all coefficients σ_1 *to* σ_a in Equations 4 or 5 and if any or all φ_1 *to* φ_q in Equations 4 and 5 are statistically different from zero.

3) The two markets are independent if all coefficients σ_1 *to* σ_a in Equation 4 or 5 and φ_1 *to*, φ_q in Equations 5 and 4 are not statistically different from zero.

RESULTS AND DISCUSSION

Market integration of cowpea grain

This shows how different cowpea markets in Uganda are interrelated across space. The following discussion is important since data on storage and processing cost were not collected and was not available at the National Statistics Bureau. Weekly wholesale prices for cowpeas collected from 2008 to 2011 by the Fit (U) Ltd were used. Data were collected from Kampala, a major consumption area in Uganda, Soroti and Lira that are primarily production areas. Table 1 summarizes the descriptive statistics computed.

In total, 136 observations on prices were used to test for cowpea market integration. The mean price ranged

Table 1. Average weekly cowpea prices in Shs/kg: 2008-2011.

Market	Mean (n = 136)	Standard deviation	Minimum	Maximum
Kampala	2153.4	368.2	1725.0	3191.7
Lira	1542.9	392.5	866.7	2766.7
Soroti	1171.8	346.8	716.7	2833.3

Source: Fit (U) Ltd (2012).

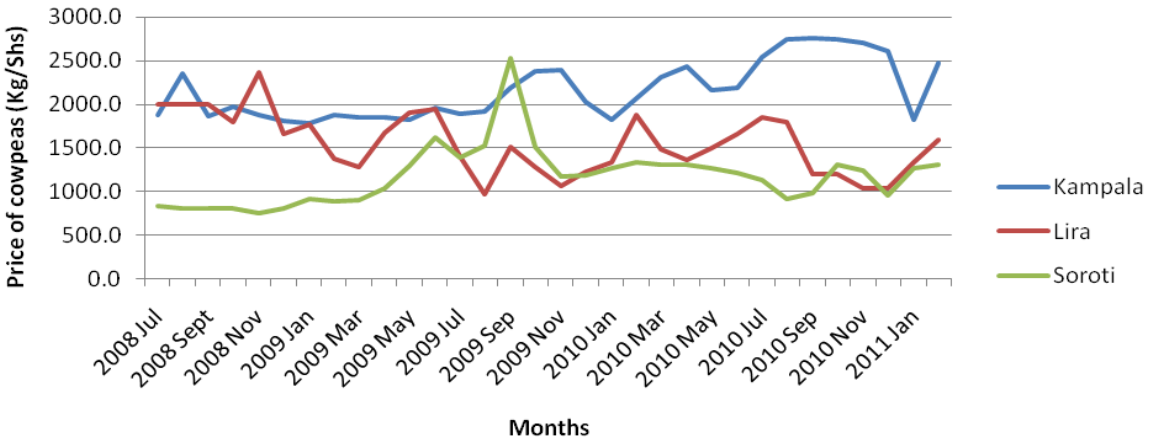

Figure 3. Cowpea price variability. Source: Based on monthly price data collected by FIT Uganda.

from 1171.8 Shs/kg in Soroti to 2153.4 Shs/kg in Kampala. The highest and lowest prices were observed in Kampala and Soroti, respectively. The lowest price in Soroti was primarily due to its being a production zone where most of the farmers grow cowpeas (Emaju, 2000) and therefore the demand for the grain was bound to be low. Furthermore, Soroti is quite a distance from the central market making it a challenge for them to sell directly.

This also means that information flow is likely to be slow and farmers consequently choose to sell at low price than incurring expensive transport costs to Kampala since long distance masks presence of high transaction costs (Uchezuba, 2005). Kampala being the central market had the highest price due to the high demand of cowpeas moreover virtually no grain is produced here.

Cowpea grain prices

Monthly prices of cowpea collected from six urban markets in three districts (Soroti, Lira and Kampala) from July 2008 to April 2011 indicated seasonal variations (Figure 3). As expected, cowpea grains are cheaper during the harvest period and immediately afterwards. There was a clear difference between the prices in different markets. Average cowpea prices ranged from 1250 Shs/kg in December (harvest time) to 2100 Shs/kg in April (lean period). Generally, crop prices set their seasonal low at harvest followed by a post-harvest rally. Post-harvest rallies occur because the supply of the crop is fixed and consumption gradually diminishes that supply, causing prices to rise. Therefore, in terms of the price relationships between Kampala and other markets, Kampala appeared as the dominant market.

It is noted that there are some short run fluctuations for Soroti and Lira markets, while in Kampala market the fluctuations are high and these markets exhibited a non-clear co-movement over time. The lower prices in Soroti and Lira were possibly due to the fact that these areas are production zones and therefore, information flow to these markets is very slow due to long distances and poor infrastructure like feeder roads and lack of storage facilities.

Prices for agricultural products in different markets are largely influenced by seasonality in production, fluctuations in production and the general economic growth within a country. As such price variability becomes a common phenomenon in agricultural outputs due to stochastic nature of the products. The stochastic nature of agricultural outputs is heavily linked to natural factors such as weather and economic factors such as structural transformation in markets, length of different marketing channels, transport and other marketing

Table 2. Price correlation matrix.

Markets	Kampala	Soroti	Lira
Kampala	1.00		
Soroti	0.15	1.00	
Lira	-0.31	-0.29	1.00

Table 3. Stationarity results using ADF.

Market	Levels		First difference			Critical values	
	t-statistic	No. Lags	t-statistic	No. Lags	Order	1%	5%
Lira	-3.78	1			I(0)	-3.15	-3.45
Kampala	-3.50	3			I(0)	-3.15	-3.45
Soroti	-2.32	2	-8.60	1	I(1)	-3.15	-3.45

infrastructure. Demand factors such as consumer habits, substitution between products and per capita income also influence prices (Katengeza, 2009).

The consumers and other market participants can be affected by a host of daily events such as shocks that affect their behaviour and their response to prices. In turn, their reactions have repercussions on other agents and the ensuring dynamic process leads to determination of prices at each point in time. As such it is of particular importance to understand the variability in prices over time and space in order to give an insight of price behaviour within the period of study.

The price correlation matrix

Correlation coefficients are preliminary tests for market integration (Mbene, 2005). The size of the correlation coefficients indicates the strength of the relationship between two markets whereby a large coefficient represents a strong relationship. Table 2 shows the bivariate correlation coefficients, which range between -0.31 and 0.15. The coefficients are very low indicating a weak relationship between Kampala, Lira and Soroti markets hence very weak market integration. The lowest correlation coefficient (-0.31) was observed between Kampala and Lira. For Lira, the low coefficients (-0.31 to -0.29) seem to be consistent with the hypothesis that long distances and poor transportation infrastructures make arbitrage unprofitable and isolate markets (Timmer, 1974). The probable reason would be the lack of information, the social class of people in terms of consumers' preference, substation effect of related commodities like soya peas, beans and groundnuts and the low volume of cowpea consumed and traded.

Correlation coefficients however, are not a proof of market integration but rather are rough indicators of integration and efficiency. There have been criticisms against this approach by several authors such as Barrett (1996) and Negassa et al. (2003) who argued that testing of market integration is based on correlation coefficients of local prices mask presence of other synchronous factors such as general price inflation, seasonality and population growth among others. As such, Golleti et al. (1995) argued that this problem could be conquered by computing correlation coefficients based on price differences since price differences would largely eliminate the technical problems related to spurious correlation arising from presence of common trends.

Stationarity result

The results, presented in Table 3 indicated Step 1 as discussed earlier when using the co-integration test. At 1 and 5% levels of confidence, the t-values for integration were greater than the ADF critical values except for Lira and Kampala which are stationary [I(0)], implying that these markets are integrated. This implies that these markets did not share the common trend with Soroti market.

The market which followed a random walk included Soroti. The null at 1 and 5 % cannot be rejected, while Kampala and Lira have no UNIT ROOTs in their current original form. Thus, the null hypothesis at all levels was rejected and concluded that the series are stationary.

Soroti market was considered to be integrated of order one I(1), while results indicates that Lira and Kampala markets were stationary for cowpea price series at levels implying that there exists a long run equilibrium relationship between these markets and that the markets are integrated and spatially linked. The implication here is that prices of cowpea in these two markets move together for a long period of time.

Market integration amongst these markets could be adduced to proper and efficient use of market information flow from Kampala to Lira since Kampala is an upscale market the flow of information to and from is easy. Furthermore, the integration is due to the flow of cowpeas

Table 4. Causality results for markets.

Number of lags	Market i	Market j	β_i	P_i-value	β_j	P_j-vale	Direction of Causality
	Lira	Kampala					Independent
1.			-0.03	0.804	0. 037	0.349	
2.			-0.10	0.450			
3.			-0.09	0.474			

P-value = 0.05.

from surplus region to the deficit areas hence cowpeas flow from Lira to Kampala. The storability of the cowpeas resulted into integration as stated by Debaniyu (2013) in which he reported that, the possibility of traders being able to store their products, avails them the opportunity of obtaining reliable information about prices and demand between markets thus promoting integration between markets.

These results indicate an improvement in spatial cowpea market integration in Uganda in the years following the end of the civil war in the north. However, this improvement cannot be attributed to peace alone as market integration is a function of so many factors. For example, Goletti et al. (1995) observed that marketing infrastructure (e.g. roads and communication), volatility of government intervention, and the degree of self-sufficiency in production are the major determinants of market integration.

Kampala and Lira markets were considered to be integrated at I(0), hence they are confirmed to be co-integrated. It can be concluded from this results that cowpea markets have a co-integrating relationship with markets in the production and consumption regions, indicating that market participants in this market are well informed about price changes and adapt variously to it. Results further show that Kampala is not co-integrated to Soroti. Traders in Soroti engage in trade with the neighbouring countries like Kenya and South Sudan. Also, the lack of co-integration could be attributed to lack of proper and well-functioning infrastructure such as roads. This could have led to difficulty in transferring the commodity from surplus regions to deficit areas. This also masks the presence of high transaction costs which is a key factor in efficient arbitrage conditions (Uchezuba, 2005). In addition, Teravaninthon and Raballand (2009) listed the ways that poor roads increase transport costs: higher fuel consumption, higher maintenance costs, faster depreciation of vehicles, tire replacement costs, and lost time due to lower speeds. Several studies have quantified the effect of road quality on transport costs and market integration.

Granger-Causality

In order to determine whether there are any causal relationships in prices among co-integrated markets, Granger-Causality test was carried out and the results are presented in Table 4.

Results indicate no causality implying independent causation between markets at Kampala and Lira. These markets do not depend on each other, meaning that prices in one market do not react to any deviation or changes of price in the other market from its equilibrium path.

It is concluded that there is no leading market whose price changes influences all other markets as presented in the Granger-Causality results. The result revealed that price changes of cowpea in the markets studied are organized around more than one market. This is similar to the nature of markets in developing countries, where markets are usually more complex than is portrayed by the Ravallion radial configuration of markets.

Co-integration between two variables was proposed by Granger (1986) as indicative of the existence of causality between them. Additionally, if two markets are integrated, the price in one market would be found to have an impact on the price in the other market. The independent causality from the results of Granger-Causality tests are non consistent with such a statement. On the other hand, lack of Granger-Causality may not imply an absence of transmission, as price signals may be transmitted instantaneously under special circumstances, which are expected for a staple food commodity like cowpeas (Abdulai, 2006).

CONCLUSIONS AND POLICY RECOMMENDATIONS

Cowpeas remain an important legume in the three ecological zones of Uganda. However, price fluctuations have constrained farmer's production and productivity of this important legume.

Prices in different markets are not equally responsive to changes in the supply of cowpeas, thus cowpea markets in Uganda as a whole are not fully integrated. This is not a surprising result since it can be linked to the consumer habits, transport costs and general lack of market information.

There is no leading market whose price changes influences all other markets since price changes of cowpea in the markets studied are organized around more than one market. This relates with the nature of markets in developing countries, where markets are

usually more complex than is portrayed by the Ravallion radial configuration of markets.

To realize the potential of cowpea, infrastructure and accessibility to markets have to be improved. There is need to improve on paved road and telephone density so as to ease the flow of goods and information hence improving cowpea market integration.

There is need to improve on provision of market information on price dissemination to all actors. This can be through improving information access through media information, agricultural shows and formation of an efficient information system.

Following the results from this study, two further studies need to be done. Firstly, there is need to empirically test all the hypothesized factors affecting market integration of cowpeas in Uganda. Such a study will need to use annual data that is still difficult to get. Secondly, there is need to analyze the value chain of cowpea in Uganda to map all products, consumption patterns, actors and possible products along the product chain in order to fully understand the flow of cowpea from the domestic to regional markets.

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Full Length Research Paper

Households willingness to pay for improved water services in urban areas: A case study from Nebelet town, Ethiopia

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Cross-sectional data was used that was collected from 181 households in 2011/2012, to estimate households' willingness to pay for improved water service in Nebelet. The probit model was used to identify socio-economic factors that affect the willingness to pay (WTP) of households. Interruption, delay in maintenance, irregular/erratic availability of the public water supply, the price charged per unit, the unequal treatment households face while collecting water at the public supply were found to be the pressing water problem existing in the study area. The descriptive analysis result showed that 96% of the sample households were willing to pay for the provision of improved water service. The Probit model showed that income, distance, water expense, bid, education, level of existing water satisfaction, marital status and sex were associated with households' willingness to pay for the provision of improved water services. Indicating, in designing water project/policy socio-economic factors (such as age, monthly income, educational level) should be considered for successful water project/policy at household level.

Key words: Existing water problem, contingent valuation method, improved water provision.

INTRODUCTION

Development is the integration of economic growth, social, cultural and political conditions (Fissha, 2006; Abebaw et al., 2010). In this regard, most of the sub-Saharan African countries are at a very low stage of development. One of the obvious reasons for the backwardness of those countries is lack of effective and sustainable utilization of the available natural and human resources (Fissha, 2006; Wendimu and Bekele, 2011). Access of clean and safe water which is the integral part of development in general and is one of the basic urban services which highly affects the economic progress of a country and the health of the people in particular is low in developing countries (Baimba, 2003; Delesho, 2006; Abebaw et al., 2010; Lisa, 2009). It is at the heart of the poverty trap especially for women and children, who suffer in terms of illness, drudgery in collection of water and lost opportunities because of the time that water collection consumes (Aloyce et al., 2002; Abebaw et al.,

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2010). Moreover, the mortality and morbidity rates and the number of working days lost that can increase GDP due to lack of clean and safe water are the major problems (Mirajul et al., 2008; Wendimu and Bekele, 2011; Behailu et al., 2012). In Ethiopia the coverage of improved water supply in both urban and rural areas is poor though it is relatively better in urban areas (Bayru, 2004). The provision is low compared to the increasing demand for clean drinking water owing to the increase in the living standard of individuals and the population growth (Baimba, 2003; Kassa, 2006; Behailu et al., 2012). The average access to clean and safe water supply for the fiscal year of 2009/2010 was about 17% of the total population reflecting much worse situations considering the unreliability and unsustainably of the supply of safe water (MoWR, 2010). To reduce the problem, the government has been working by allocating considerable resources. Thus, relatively the provision for improved water services has improved compared to the previous decades. As stated in Abebaw et al. (2010) access to safe drinking water for the year 2011 both urban area and rural areas, 79 and 46.4% respectively, was reached.

However, the intention of the government was on the least cost method of providing potable water. Even the design for new systems to provide clean and safe water has been of general nature and projects were constructed with little understanding of household water demand behavior resulting in failure to achieve the goals set for the number of households to be connected to the water system. Even the amount of water produced and the proportion of costs recovered and the gap between expectations and accomplishments were great in the absence of involving consumers in the project (Guha, 2011). This is a good reflection that it is not necessary to plan, design, and manage water systems without having the involvement of the consumers. It requires eliciting the value society would have for the improved provision of water, to plan, design and manage urban water supply.

Because of the difference in values society would attach to resources according to their socio-economic characteristics, the type of improvement and the reliability of water supply economists may use different approaches (Gaha, 2011). The concept of willingness to pay which is used to determine the amount of money consumers are willing to pay and thereby identify their level of cooperative for the improved provision of the environmental resource is one of the approaches (Lisa, 2009; Molla, 2005).

Such estimated monetary values for ecosystem goods and services which do not normally have prices are important for resource (like water) management decisions (Agudelo, 2001; Pearce, 2002). It helps policy-makers to set standards related to environmental goods and service uses and to design incentives that encourage ecosystem service protection (Anderson et al., 2010). It can be also employed in the assessment and implementation of policies that are used to monitor and manage water resource depletion and degradation (Molla, 2005; Gebreegziabher and Tadesse, 2011). Thus, this study was undertaken in Nebelet town where drinking water service is a serious problem. It is aimed at estimating the economic value of drinking water resource and identifying the factors that determine households' willingness to pay, assessing households' perception of the existing water supply situation and water problems and generating baseline information for policy intervention.

METHODOLOGY

Area description

The study was conducted in Nebelet which is one of the rural towns of Wereda Werie Lekhe. It is located to the east of Edaga-Arbi which is the seat of the Werda administration. Geographically it is located 14° 5' 48" North, 39° 16' 5" East. Moreover, it is located 918 km north of Addis Ababa and 135 km north of Mekelle. The town lies in ragged topography with an altitude ranging from 2150 to 2270 m.a.s.l. The town has an inhabitant of 4750, out of these, 2430 are females and 2320 are males. It has a total area of 154.45 km^2 with population density of 30 per kilometer square. Petty trade, daily labor and urban agriculture such as dairy farming, irrigation, and poultry are the main sources of income for the community in the town. Selling *Tala* which is the locally prepared alcohol equivalent of beer is among the major source of income and is the main means of income for many women to sustain their life and educate their child. It has annual rainfall ranging from 759 to 1500 in mm. It has Kolla agro ecological zone with annual temperature ranging from 12 to 25°C. The source of the water for the town is currently from "Chiemit" which is 7 km away and pumped up to the tankers with the help a generator. To date, the town has three tankers with water holding capacity of 50, 50 and 25 m^3. Water from these tankers is distributed to the residents through eight public taps (standpipes) available at the two kebeles and 61 private connections. From the existing figure, on average, it is calculated that one public tap is a source of water for 594 numbers of people. These public taps on average also are available for customers for seven hours a day, three hours in the morning and four hours in the afternoon.

Data type and sources

A cross sectional primary data were collected in 2011/12. The primary data utilized in the descriptive and empirical analyses of this study were collected using structured questionnaire. The collected data included information on the socio-economic characteristics, existing water supply situation and willingness to pay for improved water service of the sample households. A contingent valuation method (CVM) method was employed to elicit households' WTP for the provision of improved water service. In contingent valuation surveys, there are about four major elicitation methods, namely payment cards, discrete choice (single bounded dichotomous choice), discrete choice contingent valuation with follow-up questions (double-bounded dichotomous choice) and open ended. In this study the double-bounded dichotomous is the choice preferred for correcting the strategic bias and improved statistical efficiency. Firstly, yes-no, no-yes responses for the offered bids make clear bounds on unobservable true WTP; secondly, the yes-yes, no-no response in the double bound dichotomous choice format sharpens the true WTP (Haab and McConnell, 2002) was employed. The study was also

supplemented by secondary data from the Bureau of Water Resources, Nebelet water supply office and from the bureau of water, mining and energy of Tigray region.

Sample design

The town consists of two broad kebeles and both kebeles were included in the study. From the total households (1012) obtained from the 2007 housing census of Ethiopia, 181 sample households were randomly selected from both kebeles for this study. The proportion of number of households in each kebeles to the total number of households in the town was calculated and this proportion was used to determine the number of sample households from each kebeles to be included in the sample. Accordingly, 96 sample households were from kebele one whereas 85 of the sample households were from kebele two. Respondents from each of the kebeles were selected randomly. The choice was made in such a manner that every household had equal probability of being chosen and that neither the researcher nor the data enumerator had an influence as to which household should be selected or excluded from the list of households obtained. In each household, the head of the household or working member of the households was interviewed.

Data analysis

Descriptive statistics such as frequency distribution tables, mean and standard deviation were used to analyze the socioeconomic characteristics of the respondents, the existing status of water service and the perception of households towards the existing situation of water supply. The probit model was used to compute and determine factors affecting households' willingness to pay for improved water supply.

Econometric model specification

The probit model was used for the binary response (0, 1), that is, whether the household is willing to pay or not for the offered bid. Following Cameron and Quiggin (1994), the probit model takes the following form:

$$y_i^* = \beta x_i + \varepsilon_i \quad (1)$$
$$y_i = 1 \text{ if } y_i^* \geq I_i^*$$
$$y_i = 0 \text{ if } y_i^* < I_i^*$$

Where: β' = is vector of unknown parameters of the model; x_i = is vector of explanatory variables

y_i^*= Unobservable households' actual WTP for improved water service. y_i^* is simply a latent variable. y_i = Discrete response of the respondents for the WTP; I_i^*= the offered initial bids assigned arbitrarily to the i^{th} respondent; ε_i = Unobservable random component distributed $\mu \sim (0, 1)$.

The respondents know their own maximum willingness to pay, y_i^*, but to the observer/ researcher it is a random variable with a given cumulative distribution function (cdf) denoted by $G(y_i^*; \theta)$

where θ represents the parameters of this distribution, which are to be estimated based on the responses to the CV survey.

However, before the probit model (Equation 1) was applied to analyze the effect of explanatory variables on WTP, variance inflation factor (VIF) was applied to test the co-linearity between continuous explanatory variables. It is computed as;

$$VIF(X_i) = \frac{1}{1 - R_i^2}. \quad (2)$$

Where, R_i^2 is the coefficient of determination in the regression of one explanatory variable (X) on the other explanatory variables (Xi). If there is no co-linearity between regressors, the value VIF is one (Gujarati, 2004). To see the degree of association between the dummy variables a contingency coefficient was also estimated by using Equation (3):

$$C = \sqrt{\frac{\chi^2}{N + \chi^2}} \quad (3)$$

Where C = coefficient of contingency, χ^2 = Chi-square test and N = total sample size. The data was analyzed using STATA version 9.0 econometric software.

Variables definition and their hypothesized effects

In this study, a number of socioeconomic and demographic characteristics are expected to affect the household's willingness to pay for the provision of improved water service. Some of the factors that are expected to affect the household's willingness to pay in the study area are defined in Table 1.

RESULTS AND DISCUSSION

Socioeconomic background of respondents

181 sample households were taken for the analysis of this study. Of these sample households 59% were women whereas the remaining 41% were males. The age of the surveyed households ranges from the minimum of 19 to a maximum age of 77, with an average age of 37. Survey result also showed that 85% of the surveyed households were male headed and the remaining 15% were female headed. The marital status of the respondents indicated that 80% were married and the remaining 20% were unmarried.

Data about the house condition of households showed that 54% of the sample households live at their own house whereas the remaining 46% households live at rent house from kebele or private peoples. Family size of the sample household from the survey showed that 50% of the respondent's family size was between the ranges of one to three, and 46% had a family size between four and seven and the remaining 4% had a family size greater than seven. Family size of the sample households ranges from the minimum of 1 to the maximum of 9 with an average size 3.6.

Data about the educational attainment of the surveyed household revealed that 46% of the surveyed households

Table 1. Variable name, expected signs and definitions.

Variable name	Expected sign	Definition and coding of variable
Sex		Sex of the respondent, 1 if female, 0 if male
Ager	-	Age of the respondent
Educ	+	Households years of schooling
Inc	+	Income of the household (in birr)
Distan	+	Distance of the household from the source of water (meter)
Hst	-	Average hours, the public fountains are available for customers (hours)
Wexp	+	Household monthly water expense (in birr)
Marsta		Marital status of respondents 1 if married , 0 otherwise
Lesta	-	Level of households satisfaction with the existing water service, 1 if satisfied, 0 otherwise
Hstenure	-	House tenure of respondents, 1 if the house is own house , 0 otherwise

fall under the educational category of primary school and 22% of the respondents fall under the educational categories of high school, another 22% of the households fall to the educational category of illiterate, and the remaining 10% fall under the category of college education. In sum, from the surveyed sample households 82% were educated and the remaining 22% were illiterate indicating large proportions of the households have attained at list a primary school.

Data from the survey indicated that of the total households, 59% were under the category of monthly income from zero up to one thousand birr, 35% were under the category of monthly income from one thousand one hundred up to two thousand birr and another 6% were under the category of monthly income above two thousand one hundred. The average monthly income of the sample households was 1037 birr with a minimum monthly income of birr 200 and maximum monthly income of 4550 birr.

Rank for different services

The total sample households were given seven social services to be ranked in accordance with their priority of need. Survey results showed that 96% rank health service as their first need, 75% of the respondent said water supply is their second need and 60% of the respondent rank school service as their third need. Road, power, toilet, and telephone service are ranked from fourth to seventh respectively. This shows that health and related services such as water supply and sanitation are very essential for the town people and reveal their consistent ranking for the different social services given as options.

Water supply situation and perception of households to the existing water problem

With regard to the existing service households had recognized the improvement of the water service as compared to the past five years. From the focus group discussion most of the households were relied on hand pumps, springs and rivers before the public taps are constructed and they had bad memories on it. Traveling long distance (2-3 km away) to get water service from the hand pumps which were available at the peripheries of the town and unsafe water from the sources were the main problems households remember from the past five water service of the town.

Table 2. Type of change made in the water service.

Mode of change in the water service	Frequency	Percent
Change in quantity	17	9
Change in quality	14	8
Change both in quantity and quality	129	71
No change	21	12
Total	181	100

Source: Own survey, 2012.

Nowadays as indicated by most of the households, their main source of water is the public tap which comes from “Chemit” by the help of a generator. In other words, 96% of the households have got water from these public taps whereas 4% of the households still got water from hand pumps, springs and rivers. 97% of the households who get their water from the public tap used water for cooking and drinking, bathing and washing clothes, and another (3%) used water for watering their livestock and plants in addition to cooking and drinking, bathing and washing their clothes (Table 2).

The average individual water consumption of households from the survey was 65 L with a corresponding average monthly water expenditure of 43 birr ($2.20) which is 4% of their average monthly income of the household, and is less than what is recommended by World Bank which is 5%. This implies that a household living in the study area can spend more if they are provided with improved water supply (get water at

Table 3. Existing level of water service satisfaction.

Level of customers satisfaction with the existing service	Frequency	Percent
Satisfied	24	13.26
fairly satisfied	11	6.08
not satisfied	146	80.66
Total	181	100

Source: own survey, 2012.

Table 4. Affordability of the existing water.

Affordability of the existing water price	Frequency	Percent
Expensive	156	86.19
Reasonable	22	12.15
Cheap	3	1.66
Total	181	100

Source: own survey, 2012.

his/her home). Moreover, 79% of the households were perceived the presence of an improvement on the water service of the town and 71% of them agreed the change is both in quality and quantity whereas, another 17 and 14% agreed with the presence of change in quantity and quality respectively.

Moreover, a discussion with the sample households about the existing situation of water in the survey indicated the presence of radical change in the water service both in quality and quantity as compared to the past five years. This implies that households are aware about the quality and quantity of the water they use and the changes made to the water service they got. Therefore, this is a good indicator that households are cooperative and willing to pay if there is any further improvement in the water delivery system of the town. The higher connection fee required at a time which is minimum of 3800 birr ($195) per household per one kilometer (60%) and the house tenure problem and shortage of water pipes supply from the water office were the main reasons that households revealed for not getting water at their yard (campus). Nevertheless, response on households' willingness on this survey indicated that they would be willing to contribute to the connection fee monthly adding to their monthly bills (charge) if there is any organization, it could be the government, who cover the initial connection fee.

The level of satisfaction of households with water delivery of the town was discussed. In this regard, households in the study town were less satisfied with the existing water service. Only few (13%) households were satisfied with the existing level of water provision from the water office of the town, (6%) were fairly satisfied, whereas the majorities (81%) of the sample households were not satisfied with the existing water service. Interruption of the service without any announcement, delay in maintenance of the public taps when they are broken and the public fountains not being open for customers at the time they like it were some of the reasons for their dissatisfaction (Table 3).

In addition, frequent breaking of the water pipes because of high water pressure, the arbitrary punishment set for those who waste water while filling their containers from the public taps, the high price they pay per jerican in the public water supply were some of the problems household indicated during the survey. Moreover, carrying water for long distance, high population pressure in the water points and killing long time at the water point and the inefficient management of water by the water office were also the other pressing problems they stated for their dissatisfaction with the existing water service.

Affordability of the existing water price in the study area was the other important variable discussed with the sample households. In this regard, households were asked how much do they spent per 20 L (Jerican) in the public tap. According to the water office, guards of the water points and customers as well the price of water per 20 L (Jerican) was 40 cents. Households were asked to state the price they charge as an expensive, reasonable and cheap. Accordingly, 86% of the surveyed households did respond that the water price they charge as expensive. Referencing to the past service they were using and the problems they were facing, 22% of the households stated their payment per 20 L (Jerican) in the public tap as reasonable. Whereas small amount of (3%) the households were stated their payment to the 20 L water from the public tap as cheap. Households were dissatisfied to the payment they made to get a 20 L (Jerican) of water from the public tap. The arbitrary fine placed by the water guards to the customers when they use the public tap to get their water was the problem that households raised during the survey (Table 4).

They further stated that the punishment put to customers by the guards of the water points (public taps) when they spill water is simply arbitrary. There is no reason for the water guards whether the price charge to customers is equivalent to the water they waste when they fill their Jericans (containers). The other problem that households raised in connection to this was also the unequal treatment of customers. As point out by the customers the one who have a good approach with the water guards was going to be charged less even when he/she waste much amount of water. This reflects the preference of households to privately connect to the main water sources and pay based on the water they used. Also this implies household would will to pay for the provision of improved water service.

Another important variable concerns household's attitude towards the responsibility of improved water provision, 25% of the respondents expresses that the

Table 5. Variables affecting WTP.

Variables	Coef.	Std. Err.	z	P>|z|
Ager	-0.1289935	0.061848	-2.09	0.037
Inc	0.0017882	0.0007808	-2.29	0.022
Distan	0.0066932	0.0014184	-4.72	0.000
Hst	0.122897	0.1807567	-0.68	0.497
Wexp	0.0442291	0.0086731	-5.10	0.000
Bid	- 1.125034	0.2236914	5.03	0.000
Educ	0.3276405	0.148649	2.20	0.028
Lasta	-2.996649	1.138507	-2.63	0.008
Mrsta	2.775198	0.8713631	3.18	0.001
Sex	2.26081	1.042497	2.17	0.030
Hsetenure	-1.074124	1.205542	-0.89	0.373
_cons	5.976645	2.624416	2.28	0.023

Source: Author calculation using STATA version 9.0.

government should provide free or subsidized improved water service to the citizens, while the rest 75% said that either the community, private or all should be responsible.

Households willingness to pay for improved water service

Almost all of the surveyed households (96%) were willing to pay for the improved water service (willing to connect privately to the water service) whereas 4% are reported as not willing to pay for the improved water service (did not prefer the private connection). The types of improvement made to the water service described to the customers were of two types. The improvement on the public supply by increasing their number in the town and to privately connect household to the main pipes and create an environment to recover the connection fee by the households adding to their monthly water bill. Accordingly, 89% of the surveyed households were willing to connect privately and choose the private improvement scenario where as 11% of the households were willing the public improvement and agreed to pay to cover the cost of improving the public taps by adding to their monthly water expenses.

Determinants of household's willingness to pay

Family size, age, income, sex, distance from source of water, average time households spent to fetch water, education level, house tenure, daily water expense, hours the public fountains stay open for customers, years a respondent stay in the town, affordability, level of satisfaction, occupation, type of water source, change in water service and initial bid were some of the variables identified to affect households willingness to pay. Before the probit regression is estimated, explanatory variables on households' willingness to pay, before the probit regression is estimated, the explanatory variables were checked for multi-co-linearity using the variance inflation factor and simple pair wise correlation matrix and serious multi-co-linearity problem was detected between the variables water expense and water consumption, years stay and house tenure, average time taken to fetch water and distance. The variables water consumption, years stay, average time was dropped from the regression. Standard errors were rubosted for the presence of heteroskedascity. A test to avoid dummy variable trap was conducted and no dummy variable trap was found. The Shapiro w tests for normal data were conducted for the normal distribution of the explanatory variables and variables were found normally distributed (Table 5).

Variation in willingness to pay for the provision of improved water service was observed on households. Old aged households were less likely to pay for the provision of the improved water service. This is highly related to income and to the concept that old peoples fear to invest on projects which their return is expected after long term. This agrees with Fujita et al. (2005), who recognizes the younger the age of the respondent, the higher is the monthly income and the higher is willing to pay for the improved water service.

A significant difference was observed during the survey between households in willing to pay for the provision of improved water service. The variable household income was significant at 5% significance level. The sign of the variable household income is as expected and affects willingness to pay positively. This tells us the realities that as the income of households increase their demand to improved services increased. This is in line with the studies done by Fujita et al. (2005), Hensher et al. (2005), and Fanta (2007), who found that

when income increases the probability of the household saying yes to contribute for the improved service increases.

The sign for the sex variable was positive. A significant difference was recorded between male and female in willing to pay for the improved water service. Female headed households were more willing to pay for the improved provision of water service than their male counterparts. This may be females are responsible to collect water and are directly influenced by water related problems. This is similar to the research done on affordability and willingness to pay of water supply in Nazrath town, Ethiopia, Bayru (2004) who observed a difference on willingness to pay between male and female headed households.

The distance variable shows the distance the households have to travel before getting water from the public tap. Significant difference was observed among the households' in willing to pay for the provision of improved water service. The further the household from the nearest public taps, the higher the disutility to the household involved. The variable has a priori positive sign, indicating that households far away from the source of water would be willing to pay more. This could be because households located near the source would take shorter time to fetch water and minimizes cost of transport. This is in line with the studies, Olajuyigbe and Fasakin (2010), Coster and Otufale (2014), who recognized a positive relationship between households' willingness to pay and distance of source of water.

The level of education attained by the household heads has the expected positive sign, which indicates that households whose heads have higher education indicated a higher willingness to pay than the less educated ones. Higher education shifts the demand for water services to the right, implying a higher level of welfare. A household with higher level of literacy has better chances of maximizing the utility and welfare from consuming and having access to clean and potable water. The result is not unusual; the enlightened population has great impact on the demand for welfare facilities like water, health, education, sanitary conditions, etc. Education is significant at 90 and 95% levels. Similar studies were found by Ogujiuba (2013), Herath and Masayuki (2014) in their study on estimating the Willingness to Pay for Water Services.

Water expense affects households' willingness to pay positively and was statistically significant at 10% level of significance. Households showed a significance difference on willingness to pay for provision of improved water service. Households with higher monthly expenditure of water were more likely willing to pay for the provision of improved water service. This may be in line to the reality that if households incur higher cost, they would be willing to pay more if provided with improved water service. This was similar to the research result found by Bayru (2004), Herath and Masayuki (2014) on their research done on the households' willingness to pay for improved water.

The coefficient for the variable level of households' satisfaction with the existing water service had the expected sign and statistically significant at 5% level of significance. Households had showed a significance difference on willing to pay to the provision of improved water service. Individuals who satisfied with the existing water supply were less likely to pay for provision of improved water service over those unsatisfied. One possible reason could be those households who were unsatisfied with the current water service due to poor quality, less quantity, unreliability and absence of own private pipe are likely to pay for improved water services than those households who were satisfied with the existing services. The fact that, it is significant showed that the variable level of households' satisfaction with the existing water services was a major determinant of the willingness to pay the amount for the proposed water supply services. This agrees with Gebreegziabher and Berhanu (2007) who recognized a negative relationship between willingness to pay and households' level of satisfaction.

The regression result analysis showed that marital status was found statistically significant. This indicates that married respondents were more likely willing to pay for the provision of improved water as compared to their unmarried counter parts. This is because married people are more cautious of the health and other risk involved in poor water supply service due to family responsibility in the future than their single counterparts. This is similar to the study done by Coster and Otufale (2014). The coefficient for the variable bid was negative and was significant at 5% level of significance. As the bid offered to the respondent increases the probability of the household willingness to pay for the improved water service decreases. This was in line to the studies done on improved water service in Harar town; Bekele (1999) and Coster and Otufale (2014) who recognized a negative relationship between willingness to pay and initial bid.

CONCLUSION AND RECOMMENDATIONS

181 households were analyzed in this study and their socioeconomic and demographic characters such as marital status, sex, age and income were discussed. Regarding the existing water service in the study area, households' were not satisfied and they stated that interruption, delay in maintenance, high population pressure on the water points and high water pressure are the vital problems in the water service of the study area. Most of the households (89%) prefer to connect privately to the main water pipe and were willing to pay for the connection fee adding to their monthly bill. Factors affecting households' willingness to pay for the provision

of improved water service in the study area was analyzed using the probit model. The coefficients of Income, distance, water expense, bid, education, affordability, marital status and sex were significant whereas the coefficients for the variables house tenure and hours the public tap is open to customers was not significant. However, the variable house tenure affects willingness to pay negatively.

If the government or any organization covers the connection fee initially in the study area, they would recover the cost before the five years project. The policy implication of the study is that the inhabitants of Nebelet town are willing to pay for improved water supply service if it is provided for an affordable price. In addition, policymakers need to be aware that socio-economic characteristics and water use practices of households influence the willingness to pay for better water services.

Conflict of Interest

The authors have not declared any conflict of interest.

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Determining factors of the strategies for diversifying sources of income for rural households in Burkina Faso

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This article has used a multinomial logit model to analyze the determinants of diversification strategies of rural households' income sources in Burkina Faso. The main results have enabled the identification of three strategies of the income-source diversification, all carried out around agriculture. They are low, average, high diversification strategies. The outcomes reveal that the age of the household head, household size, dependency ratio, acreage, membership of a producer group, amount of credit, agricultural potential of the area, morbidity, distance to a main road, access to a radio, total income and technical assistance were the key factors in determining the level of income diversification. They indicate that the diversification of income sources is both a strategy for managing risk of fluctuations in agricultural income and a means to take advantage of opportunities in the production environment, given the constraints of rural households.

Key words: Multinomial logit model, diversification strategy, source of income, rural households.

INTRODUCTION

In most African countries, rural areas are increasingly marked by the diversification of income sources. Literature points out that these mutations can be explained by the willingness of rural households to respond to the opportunities of liberalizing agricultural markets (Delgado and Siamwalla, 1997) or face the risk of subsistence (Losch et al., 2011; Winters et al., 2010). These changes have important effects on the well-being and poverty reduction in rural households (Blocks and Webb, 2001).

Since the liberalization of the agricultural sector in Burkina Faso in 1992, rural households increasingly pursue the diversification of their income sources. Beyond the desire to take advantage of new market opportunities, the diversification of income sources can limit the fluctuations of income related to the volatility of agricultural prices and climate risk. However, agriculture remains the main source of income for most households. Savadogo et al. (2011) have found that farm income accounted for approximately 64% of the total rural household income.

The poverty profile shows that most of Burkinabe rural households live below poverty line. They draw the most essential of their subsistence from farming activities and represent almost 80% of the population (Ministère de l'Économie et des Finances, 2010). In this context, the ability of rural households to develop efficient diversification strategies of their income sources is an

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indispensable condition to improve the well-being and reduce poverty in rural areas (Dercon, 2005). The constraints on the choice of the business portfolios are crucial in explaining the persistence of rural poverty.

Despite the importance of the issue, there is virtually no work on the determinants of the choice of strategies to diversify the sources of income for rural households in Burkina Faso. Since there are no credit and insurance markets, the diversification of household activities plays an important role in risk management, the stabilization of income, and the smoothing of consumption (Ellis, 2000; Bardhan and Udry, 1999). Escobal (2001) stresses that access to credit can also significantly increase the probability of implementing an independent activity, whether agricultural or non-agricultural.

Reardon et al. (1992) have found that income diversification in Burkina Faso was encouraged by the need for households to cope with income fluctuations linked with poor harvests. In a more detailed analysis, Zahonogo (2011) indicates that in areas with low agricultural potential, the aim of involvement in non-agricultural activities is to fill the gap in agricultural income; whereas in the high-agricultural potential areas, the objective is to maximize the agricultural profit.

Reardon et al. (1993) have identified low yields, lack of irrigation, the short duration of the farming season, the underdevelopment of the credit market, and land constraints as the main factors of income diversification in Burkina Faso, Niger, and Senegal. Their results indicate that poor households adopt low levels of diversification, while rich households adopt high levels of diversification.

Feirrera and Lanjouw (2001) have found that being a man increases the probability of practicing non agricultural activities with a high productivity. However, Escobal's (2001) results indicate that gender does not influence the probability to participate in various forms of activities. Likewise, he shows that age has no influence on the form of activity. While Barrett et al. (2001) have found that age reduces the probability of participating in a non-agricultural activity; Ferreira and Lanjouw (2001) have shown that it has a positive effect on this probability.

Barrett et al. (2001) have shown that the size of a household has no significant effect on the participation in a non-agricultural wage-earning activity together with agricultural activities. However, it increases the likelihood that household members work as agricultural workers, besides the activities of the family's farm. The results of Abdulaï and CroleRess (2001) have also indicated that the size of the household increases the probability of participating in a non-agricultural activity.

The results of Evans and Ngau (1991) establish that a high level of education promotes participation in non-agricultural activities and reduces the probability of participation in agricultural activities. However, Yunez-Naude and Taylor (2001) show that a low level of education is positively associated with a non-farm work. A more detailed analysis of Feirrera and Lanjouw (2001) indicates that a high level of study has a positive effect on the participation in a qualified non-agricultural employment, while a low level of education positively influences participation in an unskilled non-agricultural employment.

The importance of social capital in the diversification and sustainability of livelihoods has been demonstrated by Smith et al. (2001). The works of Abdulaï and CroleRess (2001) have highlighted the positive effect of the acreage of the operations on the participation in non-agricultural activities. However, Reardon et al. (2000) note that inequalities of access to a land can be converted into inequalities of access to non-agricultural activities. Lay et al. (2008) find that declining farm sizes and related to declines in soil fertility force land poor households to diversify into nonfarm activities to ensure survival.

Socioeconomic opportunities play an important role in the explanation of the forms of household activities. Debalen et al. (2004) note that if there is no local market, the probability of developing non-agricultural activities in addition to the farm decreases, while the quality of the roads increases. In the same way, the results of certain researchers have found that the distance to the city or the market reduces the probability of participation in a non-agricultural activity (Winters et al., 2009).

Generally, these various studies resort to two main directions of modeling the diversification of activities. The first one, which objective is to model the participation in various activities, uses as many regressions as there are diversification activities.

Thus, the logit binimial model is the most used one (Yunez-Naude and Taylor, 2001; Debalen et al., 2004). However, Escobal (2001) has used a double censorship of a Tobit model of the share of the various activities in the household income.

The second orientation modeling diversification of activities most often uses a qualitative choice model multinomial logit (Abdulai and CroleRess, 2001; Barret et al., 2001) to model a portfolio. This approach, in addition to considering the nature of rural households multiple activities, identifies the determinants of the choice of strategy to diversify sources of income. The present study uses a multinomial logit model to analyze the factors explaining the choice of strategy of diversification of income sources from data collected in 2011 on 540 rural households in Burkina Faso.

The rest of the article is structured in four parts; the first part presents the modeling choice of strategy to diversify income sources and the method of data collection. The second part presents the typology and characteristics of strategies to diversify sources of income adopted by households. The third part analyzes the factors explaining the choice of strategies to diversify sources of income. Finally, the fourth section draws conclusions and implications of the study in terms of economic policies.

MODELING THE CHOICE OF THE STRATEGY OF INCOME DIVERSIFICATION

The theoretical model of the strategy choice to diversify sources of income, the variables selected for the analysis and method of data collection for the study are presented here.

Specification of the multinomial logit model

The choice of the strategy to diversify the sources of the household-income source is based on expected utility. The household adopts a given strategy only if its expected utility is higher than the rest of the strategies. The expected utility (U_{ij}) by household i by choosing strategy *j* among the *j+1* possible strategies is an unobserved underlying variable that depends on characteristics related to the households (X_{ij}). The choice model of the strategy to diversify the sources of household income is defined by:

$U_{ij}^{*} = X_{ij}'\beta + \varepsilon_{ij}$, $i = 1, \ldots, N$ and $j = 0, \ldots, J$

$y_i = j$ if $U_{ij}^{*} = \max(U_{i0}, U_{i1}, \ldots, U_{iM})$, adoption of the strategy j,

Where y_i represents the adopted strategy, β is a vector of unknown parameters and ε_{ij} a random error

The multinomial logit model assumes that error terms are independent random variables with one another and identically distributed according to Gumbell's law. In this case, the probability that i household will adopt j strategy is defined by:

$$P(y_i = j) = \frac{e^{\beta_j' x_i}}{\sum_{k=0}^{J} e^{\beta_k' x_i}}, \; j = 0, \ldots, J$$

By dividing the probability by $e^{\beta_0' x_i}$, it can be re-written as follows:

$$P(y_i = j) = \frac{e^{(\beta_{j-} \beta_0)' x_i}}{1 + \sum_{k=1}^{J} e^{(\beta_{k-} \beta_0)' x_i}}, \; j = 0, \ldots, J$$

By definition, the sum of the probabilities is equal to 1. Therefore, any change in the probability associated with a strategy of income diversification must be offset in the opposite direction by the probability of one or several strategies. To identify the parameters of the multinomial model, it is necessary to impose a constraint of normalization of type $\beta_0 = 0$. The parameters are then interpreted as gaps in the vector of β_0 parameters. The probability associated with the reference 0 strategy is defined by:

$$P(y_i = 0) = \frac{1}{1 + \sum_{k=1}^{J} e^{(\beta_k)' x_i}}$$

The probabilities of adopting other strategies to diversify income sources are calculated in relation to the benchmark strategy. Thus, the sign of the variables' coefficients shows the direction of change of the probability of transition of the reference strategy for a given strategy. Odds ratio enables estimating the chances of going from the reference strategy to the other strategies. Odds ratio between a given diversification strategy *j*, and diversification strategy of reference $0, j = 0, \ldots, J$ and $k = 0, \ldots, J$ and is defined by:

$$\frac{P_j}{P_0} = \frac{P(y_i = j)}{P(y_i = 0)} = \frac{e^{\beta_j' x_i}}{e^{\beta_0' x_i}} = e^{(\beta_{j-} \beta_0')x_i}$$

Under the standardization hypothesis $\beta_0 = 0$, $\frac{P_j}{P_0} = e^{\beta_j' x_i}$

If, $\frac{P_j}{P_0} > 1$, following the variation of an explanatory variable, the probability that the household will adopt a given diversification strategy varies from $\frac{P_j}{P_0}$ time in relation to the reference strategy and vice versa.

The parameters of the multinomial logit model presented can be estimated by the maximum likelihood method from household data.

Definition of the model's variables

The theoretical model and the empirical literature have enabled the identification of the variables that are likely to explain the choice of the strategy to diversify the rural households' sources of income. The dependent variable consists of three strategies for diversifying the sources of household income: (i) the low diversification of income sources; (ii) the average diversification of income sources; and (iii) the strong diversification of income sources. The strategy of the low diversification of income sources, due to its closeness with the specialization, has been chosen as the reference strategy. This helps to properly highlight the factors that influence the choice of the strategies for diversifying the sources of income.

Factors that can explain the choice of strategies to diversify the sources of household income can be grouped into three categories: (i) demographic characteristics of households that include the age of the head of the household (years), the size of the household (workforce) and the dependency ratio (number of household members supported by worker); (ii) capital endowments which consist of planted area (ha), possession of animal traction, the number of years of education of household head, membership in an association of producers and the amount of total credit received; and (iii) the socio-economic, technical and environmental opportunities that consider the agricultural potential of the area, the morbidity (probability of falling ill), distance from the residence of the household to a main road, access to a radio, total income, social assistance measured by agricultural subsidies and technical assistance received.

Method of data collection

The study data have been gathered by the Laboratoire d'Analyse Quantitative Appliqué au Développement – Sahel (LAQAD-S) as part of a collaborative research project with the International Food Policy Research Institute (IFPRI). The objective of the project called "Convergence» was to make a research on the increasing effect of the social service costs on the productivity of agricultural operations and incomes in African countries.

In order to consider all national differences, the entire rural area of Burkina Faso has been divided into six strata based on the quality of social characteristics (health, education, nutrition, access

to drinking water) of the populations and the concentration of non-governmental organizations in the community. Within these strata, 8 of the 45 provinces of Burkina Faso have been selected on the basis of their agricultural potential and the weight of each stratum.

In each province, two departments have been chosen randomly and in each department 4 or 5 villages have been randomly selected. Thus, the survey has covered 36 villages and in each village, 15 households were selected randomly. In all, 540 households have been surveyed. The collected data have been obtained from the working members of farm households, in a single wave, from January to February 2011.

The survey has been conducted through questionnaires on a declarative basis of farm households, generally on a recall covering the last 12 months before the passage. The collected data have focused on the socio-economic, demographic, and institutional characteristics. Detailed data have been collected on the activities and the various sources of income of the rural households.

STRATEGIES OF DIVERSICATION OF HOUSEHOLDS' INCOME SOURCES

This section provides a typology of strategies to diversify the sources of income adopted by the Burkinabe rural households. It also highlights the characteristics of households according to their income diversification strategies.

Sources of household income

The economic organization of rural households in Burkina Faso is based on the multiple activities around agriculture. Diversification of income sources meets a need of households to take advantage of market opportunities, stabilize their incomes facing climate risks and price fluctuations of agricultural products. Households are likely to share a higher income against lower incomes, but less risky. Therefore, they combine various sources of income according to market opportunities in order to protect themselves against income fluctuations.

Table 1 shows that rural households choose their diversification strategies among four potential sources of income: (i) agricultural income including any income from agricultural activities; (ii) income from breeding composed of poultry breeding, livestock breeding, and closely related products; (iii) income from off-farm employment, which consists of income from labor in non-agricultural sectors; (iv) and other sources of income from the remuneration of the factors and migration of household members.

The results indicate that all the households derive, at least, a portion of their incomes from agricultural activities. However, very few rural households devote themselves exclusively to agricultural activities (6.1%). The form of diversification of the most common income that combines agriculture, livestock, off-farm employment and other sources of income is practiced by 30% of rural households. The combination of agriculture, with animal husbandry and off-farm employment, is the second most common form of diversification in terms of the occupation of households (21.8%). The other forms of combinations of income source that have been observed are practiced by less than 10% of rural households.

Typology of strategies to diversify sources of income

The number of agricultural-related income sources has been used to set up a typology of strategies for income diversification of rural households. Various portfolios of income diversification reflect the reality of the organization of the production system of rural households of Burkina Faso. Table 2 shows 3 types of strategies of diversification of income sources; they all depend on agriculture, but are characterized by degrees of agricultural specialization and different forms of diversification. The strategy of low diversification of income sources consists in practicing agricultural activities exclusively or to resort at most to one other source of income besides agriculture. This diversification strategy is characterized by the high dependence of the rural households that practice it in farm income. The agricultural income portion represents approximately 81.3% of the total income of these households. The strategy of low diversification of income sources is practiced by 30.9% of rural households.

The strategy of diversifying sources of average income is to develop around agricultural activities two other sources of income. Rural households that adopt this strategy derive about half of their income from agricultural activities (54.4%). Reducing the contribution of agriculture compared to the low diversification strategy is for the benefit of livestock (17.4%) and off-farm employment (23.4%) which becomes important sources of income for households. This diversification strategy is most adopted by rural households (39.1%).

The strategy of strong diversification of income sources is to derive its revenue from three additional sources of diversification in the margins of income from agricultural activities. Rural households that adopt this strategy take a little less than half of their income from agricultural activities (47.4%), but agriculture remains dominant relative to other sources of income. The declining share of agriculture in relation to the low diversification strategy is primarily for the benefit of livestock (16.9%) and off-farm employment (26.8%), but also for other sources income (8.9%). This diversification strategy is practiced by 30% of rural households.

Characterization of households according to their income diversification strategies

The choice of strategy to diversify sources of household income depends on their demographic characteristics, their capital endowments and socio-economic, technical and environmental opportunities. Table 3 indicates that

Table 1. Distribution of households by income sources.

Combination of revenue sources	Number ofhouseholds	Proportion(%)
Agriculture	33	6.1
Agriculture - livestock	52	9.6
Agriculture – employment	45	8.3
Agriculture - other sources	37	6.9
Agriculture - livestock - employment	118	21.8
Agriculture - livestock - other sources	43	8.0
Agriculture - employment - other sources	50	9.3
Agriculture - livestock - employment - other sources	162	30.0
Total	**540**	**100.0**

Source: Calculated from data of the project "Convergence" / Burkina Faso, 2011.

Table 2. Distribution of household incomes by diversification strategies (%).

Diversification strategies	Share of agriculture	Share of breeding	Share of employment	Share of other sources	Proportion of households
Low income diversification	81.2	6.7	8.3	3.8	30.9
Average income diversification	54.4	17.4	23.4	4.8	39.1
Strong income diversification	47.4	16.9	26.8	8.9	30.0

Source: Calculated from data of the project "Convergence" / Burkina Faso, 2011.

Table 3. Characterization of households according to their income diversification strategies.

Diversification strategies	Low diversification		Average diversification		High diversification	
	Average	Difference	Average	Difference	Average	Difference
Demographic characteristics of households						
Age of household head	44.7	-	45.4	-0.7	44.8	-0.2
Household size	8.1	-	8	0.2	8.2	-0.1
Dependency ratio	1.2	-	1.3	-0.1 *	1.3	-0.1 **
Capital endowment						
Area	3.7	-	3.7	0	3.2	0.5 **
Animal traction (1=yes)	0.5	-	0.5	0	0.5	0
Education of household head	0.5	-	0.5	0	0.9	-0.4 **
Member of a group (1=yes)	0.4	-	0.5	-0.1	0.4	0
Total credit	49358	-	34543	15143 *	22774	17466 *
Socio-economic, technical and environmental opportunities						
Agricultural potential (1=high)	0.4	-	0.2	0.2 ***	0.1	0.3 ***
Morbidity	0.2	-	0.3	0.0 *	0.3	-0.1 ***
Distance to a main road	6.8	-	9.6	-2.9 ***	6.6	0.2
Access to a radio (1=yes)	0.6	-	0.6	0	0.7	-0.2 ***
Total income	550921	-	686441	-133502 *	694414	-142014 **
Social assistance (1=yes)	0.4	-	0.2	0.2 ***	0.2	0.2 ***
Technical assistance (1=yes)	0.2	-	0.2	0	0.3	-0.1 ***

Source: Calculated from data of the project "Convergence" / Burkina Faso, 2011. Low-diversification strategy has been considered as the reference strategy in the calculation of difference tests. *** Significant at 1%, ** Significant at 5%, * Significant at 10%.

the head of a household is in average 45 years old and responsible of about 8 people. The dependence ratio

shows that each working member of a household has to take care of at least one non-working member of the household. The difference test indicates that rural households with the highest dependency ratios have degrees of diversification of income sources that are more significantly greater.

The results show that the farm area by rural household is around 3.5 ha; households practicing strong diversification strategies have significantly smaller agricultural areas. The data also show a low level of education of household heads. It is estimated at less than one school year. Households that adopt the strategy of strong income diversification are those where the heads of households have significantly higher education levels. However, the results indicate it is the rural households that have less access to credits that are more likely to diversify their sources of income.

The data indicate that households residing in areas with high agricultural potential are less likely to diversify their sources of income. Among the households that have adopted the strategy of low diversification, 40% come from areas with high agricultural potential. For those who have chosen the strategy of average diversification, 20% are from areas of high agricultural potential, and only 10% of households that adopted strategy of strong diversification live in areas with high agricultural potential. These results show that households in areas with low agricultural potential are significantly more likely to diversify their sources of income. Similarly, the morbidity indicates that the degree of diversification of income sources is significantly higher when the probability of falling ill increases.

Access to radio and technical assistance received help stimulate the diversification of income sources. However, rural households that receive social assistance are less willing to diversify their sources of income. The results also indicate that rural households with the highest incomes realize degrees of diversification significantly higher sources of income. We also note that the distance from the residence of the household to a main road plays an important role in the diversification of income sources.

FACTORS EXPLAINING THE CHOICE OF THE STRATEGY TO DIVERSIFY SOURCES OF INCOME

The results of econometric estimation of multinomial logit model for the choice of strategy to diversify sources of income are presented in Table 4. The likelihood ratio test indicates that the estimated model is globally significant at 1% threshold. Individual significance tests indicate that most of the model's variables significantly influence the choice of strategy to diversify income at a threshold less than or equal to 10%. The model is well estimated and its results can be used for interpretation and analysis of economic policy.

The results indicate that demographic characteristics of households are crucial in the choice of their strategies for revenue diversification. The probability of adopting a strategy of strong diversification of income sources compared to the low diversification strategy significantly reduces at the threshold of 5% with the age of the household head. However, from 50.2 years this probability increases with the age of the household head. The odds ratio shows that the chances that this transition takes place decreases about 0.99 times when the age of the household head increases by one year.

The more the size of a rural household increases, the more the probability of choosing an average diversification decreases significantly at the threshold of 10%. The chances of achieving this transition decreases approximately 0.94 times when there is an additional member in the household. However, increasing the responsibility each working person raises significantly at the threshold of 10% the probability to practice a strong income-source diversification. The Odds ratio indicates that the chances of achieving this transition increases by 1.35 times when the dependency rate grows by one point.

The results have also highlighted the role of household capital endowments in the choice of strategy to diversify their income sources. The planted area increases significantly at the threshold of 10% the probability of moving from a low diversification strategy to a strategy of broad diversification. The chances for this passage to take place increase about 1.28 times when the area increases by one hectare. The fact of belonging to a group of producers significantly improves at 10% threshold the probability of choosing an average diversification related to the low diversification with an Odds ratio of 1.40 times.

The amount of credit received significantly decreases the probability of moving from a low diversification strategy to strategies of average or high diversification respectively at the threshold of 5 and 1%. The chances of achieving these passages decrease of approximately 0.99 times when the credit amount received increases a thousand CFA Francs. These results imply that rural households that can easily get credit to protect themselves against agricultural shocks are less likely to diversify their sources of income.

The results in Table 4 also show that socio-economic, technical and environmental opportunities play an important role in the choice of strategy to diversify sources of income. The probability that a household that resides in a high-agricultural-potential zone will go from a low- diversification strategy to average - or - high diversification strategies decreases very significantly at 1% threshold. Odds ratios indicate that the chances of achieving these transitions decrease respectively by about 0.24 times and 0.2 times, when this takes place in an area of high agricultural potential. These results indicate that rural households that are in areas with low agricultural potential mostly practice diversification of

Table 4. Determinants of the choice of strategy to diversify income.

	Average diversification		Strong diversification	
	Coefficient	**Odds ratio**	**Coefficient**	**Odds ratio**
Constant	0.4543	1.5751	1.2262	3.4084
Demographic characteristics of households				
Age of household head	-0.0130	0.9871	-0.1004 **	0.9045
Age of household head ²	0.0002	1.0002	0.0010 **	1.0010
Household size	-0.0643 *	0.9377	-0.0287	0.9717
Dependency ratio	0.1983	1.2193	0.3027 *	1.3535
Capital endowments				
Area	0.0338	1.0343	0.2453 *	1.2780
Area ²	0.0073	1.0073	-0.0144	0.9857
Animal traction (1=yes)	0.0436	1.0446	-0.1192	0.8876
Education of household head	-0.0608	0.9410	0.0001	1.0001
Education of household head ²	0.0059	1.0059	0.0074	1.0075
Member of a group (1 = Yes)	0.3371 *	1.4009	0.1660	1.1806
Total credit	-0.0028 **	0.9972	-0.0045 ***	0.9955
Socio-economic. technical and environmental opportunities				
Agricultural potential (1 = high)	-1.4439 ***	0.2360	-1.6207 ***	0.1978
Morbidity	0.4540	1.5746	1.0655 *	2.9024
Distance to a main road	-0.0694 **	0.9329	-0.1098 ***	0.8961
Distance to a main road ²	0.0033 ***	1.0033	0.0037 ***	1.0037
Access to a radio (1 = yes)	0.1763	1.1928	0.7715 ***	2.1631
Total income	0.0004 *	1.0004	0.0005 *	1.0005
Social assistance (1 = yes)	-0.2072	0.8128	-0.4665	0.6272
Technical assistance (1 = yes)	0.4245	1.5288	1.0148 ***	2.7588
Number of observations 540		Prob>Chi^2	0.0000	
LR Chi^2 (38) 125.74		Pseudo R²	0.11	
Log likelihood - 523.35				

Source: Calculated from data of the project "Convergence" / Burkina Faso, 2011. *** Significant at 1%, ** Significant at 5%, * Significant at 10%.

income source.

The probability of moving from a low diversification strategy to an average or strong diversification strategies increases significantly at the threshold of 10% with the income of rural households. The chances of achieving these transitions increase 1 times when the total income increases by a thousand CFA francs. These results suggest that rural households with substantial incomes are more capable of taking advantage of market opportunities and investing in an income-source diversification.

Access to radio and technical assistance contribute very significantly to increase at the threshold of 1% the probability that rural households will develop different forms of activities. The Odds ratios show that the chances of moving from low diversification strategy to strong diversification strategy increase more than 2 times when a household has access to a radio or receives technical assistance. These results show that the access of rural households to information and technical training on the practice of new activities encourages the income-source diversification.

The probability that a rural household will adopt an average or strong diversification, with respect to the strategy of low diversification of income sources, significantly reduces at the thresholds respective of 5 and 1% with the distance from his residence to the main road. The Odds ratios indicate that the chances of achieving these transitions decrease by approximately 0.93 and 0.90 times when the distance of the residence of the rural household to the main road increases by 1 km. These results suggest that the market access facility encourages the diversification of income sources.

However, from 10.5 km for the average diversification and 14.8 for strong diversification, the probability that a rural household adopts a strategy of diversifying its sources of income increases significantly at the threshold of 1%. The Odds ratios show that the chances of

realizing these changes increase about 1 times with the distance adding 1 km more from these thresholds. These results indicate that beyond these distance thresholds, the market access facility is no more decisive in explaining the diversification of income sources of rural households.

The data indicate that the probability of adopting a strategy of strong diversification versus specialization increases significantly at 10% threshold with the probability that a household member contracts a disease. The odds ratio shows that the chances that this transition takes place increases by nearly 3 times when the morbidity increases by one point. These results indicate that the households most vulnerable to disease are more willing to diversify their sources of income.

CONCLUSION AND POLICY IMPLICATIONS

The study used a multinomial logit model to analyze the determinants of the choice of strategy to diversify sources of income for rural households in Burkina Faso. The econometric results indicate that the model is well specified and most of the estimated coefficients are significant at a threshold less than or equal to 10%. The results highlight three main strategies for diversifying income sources: low diversification strategy, average diversification strategy and strong diversification strategy. For all these strategies, agriculture remains the main source of income around which revolve the other sources of income of rural households.

The outcomes reveal that the age of the household head, household size, dependency ratio, acreage, membership of a producer group, amount of credit, agricultural potential of the area, morbidity, distance to a main road, access to a radio, total income and technical assistance have different significant effects on the probability that a rural household diversifies its income sources. Diversification of income sources seems to respond to both a logical survival through the management of agricultural income fluctuation risks and the desire to take advantage of opportunities in the production environment in view of the constraints of rural households.

These results allow us to draw several implications for public policy that are likely to improve the well-being of rural households. Policy makers should, in short-term, focus on the development of a system of social protection in rural areas to enable the households that are the most vulnerable in climate risks to choose the most profitable activities.

Thus, the network of the existing community institutions can serve as a springboard for the implementation of this policy. In the average-and long-terms, it would be necessary to develop markets for credit and insurance to enable the households to cope with agricultural risks in rural areas.

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Analysis of access to apiculture supporting services by smallholder farmers in northern Ethiopia

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This study was conducted to analyze factors affecting access to apiculture supporting services by smallholder beekeepers in Ahferom district of Tigray region, Ethiopia. Primary data were collected by interviewing 130 randomly selected smallholder beekeepers during March to April 2011. The data were analyzed using descriptive statistics and econometric (probit) model. Probit model results of farmers' access to extension service revealed that number of productive members, beekeeping experience, age, farm size, distance to Farmers Training Center (FTC), number of bee colonies and ownership of Radio, TV and/or mobile phone were significant factors. Likewise, other off/non-farm activity, distance to FTC and number of bee colonies significantly affected farmers' access to credit service. Similarly, sex, other off/non-farm activity, distance to FTC and district town, beekeeping experience, ownership of radio, TV and/or mobile phone were significantly associated with farmers' access to input supply service. Therefore, these significant factors in accessing apiculture supporting services should be considered by policy-makers and planners of governmental and NGOs in setting their policies and strategies of institutional services development and apiculture production improvement interventions in Ahferom district and in areas with similar settings.

Key words: Extension service, input supply service, credit service, probit model, apiculture.

INTRODUCTION

Agriculture is the backbone of Ethiopian economy therefore the country is in the process of transforming its agricultural sector from subsistence to market orientation (MoARD-IPMS, 2006). Apiculture is a promising off-farm enterprise, which directly and indirectly contributes to smallholder's income in particular and nation's economy in general. It has significant role in generating and diversifying the income of subsistence Ethiopian smallholder farmers mainly the small land holders and landless (EARO, 2000; Gezahegn, 2001). In Ethiopia traditional, transitional and improved beehives were recognized for honey production with total of 5.15 million beehives (of 93% traditional) and the farm households keeping bees were 1.4 million. Endowing with diverse agro-climatic zones, the total honey and beeswax production estimates about 39,700 and 3,800 tons per year. Such an amount puts the country 10th in honey and 4th in beeswax production worldwide. Moreover, Ethiopia has the potential to produce up to 500,000 tons of honey and 50,000 tons of beeswax per year (GDS, 2009).

The current Ethiopian government has increased its attention to develop the apiculture sub-sector as one of

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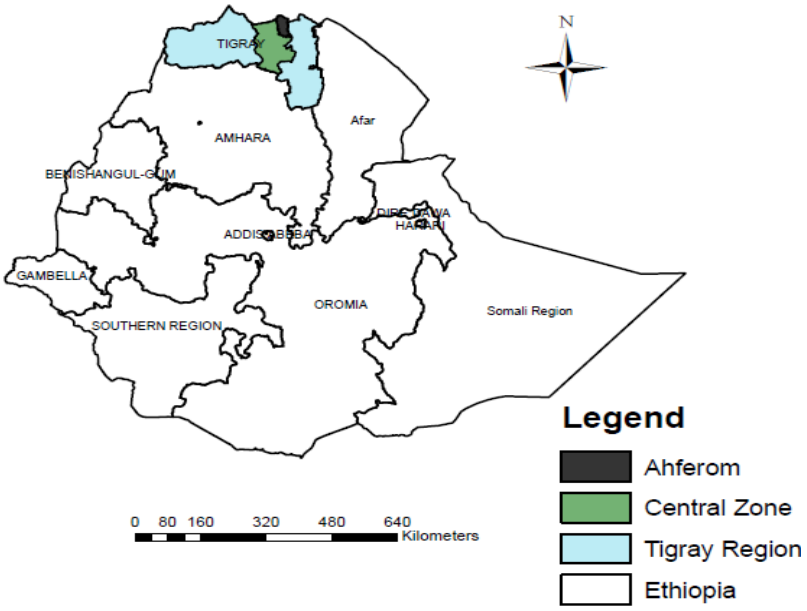

Figure 1. Location map of Ahferom district.

its strategies for poverty reduction and export diversification; in addition different NGOs have been intervening to assist the poor smallholder farmers through the introduction and promotion of box hive to obtain higher honey production of good quality that can enable the smallholder farmers market oriented (GDS, 2009). Similarly, great effort has been made by regional government extension package and Relief Society of Tigray (REST) to promote improved box hive technology in the region to increase the quantity and quality of honey production and build the capacity of beekeepers for better management of bees and hives for honey and beeswax production (Gidey and Mokenen, 2010).

Therefore, the necessary ingredients for achieving market orientation are technologies and service delivery. Service delivery includes generation and introduction of new technologies, the supply of inputs and financing of these inputs, and marketing. In the last seven years, a range of institutional changes has begun to take place. For example, rural extension services are on the threshold of a major shift in extension delivery through the approach that established farmer training centers (FTC) (MoARD-IPMS, 2006). The service is predominantly supply driven. Technology packages were prepared based on the available improved technologies and attempts were made to transfer them to farmers. This supply driven approach of extension was a common feature of all the extension service programs in the country.

Although socio-economic surveys were made to develop the menu of household level packages in Tigray and Amhara regions, it was not clear if farmers' needs and preferences were incorporated in the design of the packages. However, as time goes, the extension service becoming demand driven and community resource based; the wealth of indigenous knowledge of farmers also used as source of improved technology option (Berhanu et al., 2006). Therefore, the agricultural extension service at the FTCs has been playing an active role in linking farmers with other institutional support services such as input supply, credit, co-operative promotion, and agricultural produce marketing, particularly, for apiculture sub-sector development.

Despite all the efforts have been made by government and NGOs at national, regional and district level to provide these supporting services for the improvement of apiculture produces, and whatever the service delivery approach changes from supply to demand driven; there has been no adequate study on determining access to extension, credit and input supply services and the determinant factors of these services at smallholder level. Therefore, the primary objective of the study was to analyze the factors affecting access to extension, credit and input supply (that is, improved box hive) services provided for the improvement of apiculture enterprise by the smallholder beekeepers in Ahferom district.

METHODOLOGY

Description of the study area

Ahferom district (Figure 1) located in 14° 20' 0" N latitude and 39° 10' 0" E longitude is among the major honey producing districts in Tigray region. However, up to around a decade back, all beekeepers of the district were only occupied in traditional production system (OoARD, 2009) though improved box hive has been introduced and promoted in the country since 1970 to overcome the low production, productivity and quality of honey (HBRC, 1997).

Table 1. Sample distribution in the selected *Tabias*.

Sample *Tabia*	THHH*	Total beekeeper HHH**	Sample beekeeper HHH**
Sero	2138	427	41
L. M. Tsemri	1716	396	38
My-Suru	1099	282	27
Degose	1065	251	24
Total	6018	1356	130

Tabias recorded, 2011, *THHH: total household heads, ** HHH: household heads

Sampling technique and sample size

Multi-stage sampling procedure was used to select sample smallholder beekeepers for the study. Ahferom district was selected purposively based on the honeybee production, availability of bee flora and improved box hive promotion. The district comprises of thirty three *Tabias*, of which six are urban *Tabias* and twenty seven are rural *Tabias*. Excluding the five rural *Tabias*[1] that were affected by the Ethio-Eritrea war, four *Tabias* were selected randomly out of the remaining 22 rural *Tabias*. Having the list of beekeeper households from each *Tabia*, 130 sample beekeepers were selected randomly based on the probability proportional to size sampling technique from the selected *Tabias* (Table 1).

Method of data collection

Primary data were obtained from sample respondents during March to April 2011 by using semi-structured questionnaire through interview method. Before embarking into data collection, the questionnaire was pre-tested to check its appropriateness for gathering the required information. Four enumerators who speak the local language, *Tigrigna*, were recruited based on their prior experience in data collection, and also they were familiar with the study area. All the enumerators were qualified with diploma. Enumerators were trained regarding the contents of the questionnaire and procedure of data collection. Trained enumerators were interviewed on the sample respondents under the continuous supervision of the researchers. Secondary data were gathered from various sources such as reports of MoA at different levels, CSA, district BoARD, NGOs, previous research findings, internet and other published and unpublished materials.

Methods of data analysis

Specification of probit model

In the case of categorical dependent variables (binomial or multinomial) qualitative choice models such as the logit and Probit are usually specified. These models are commonly used to analyze situations where the choice problem is whether or not (0-1 value range). The Probit specification has advantages over logit models in small samples (Gujarati, 2004). The present study therefore employed a Probit model to examine determinant factors of beekeeper farmers' decision to access or not access extension, credit or input supply (that is, improved box hive) service. The Probit model specification used in this study is given by:

$$SERV_i = \beta_0 + \beta_i X_i + \varepsilon_i, i = 1,2,3,...,n \quad (1)$$

where $SERV_i$ – is a dummy variable indicating the access to services that is related to the equation as $SERV_i = 1$ if a farmer have access to the services and $SERV_i = 0,$ otherwise, X_i – are explanatory variables in the probit model, β_0 – intercept term estimated by the model, β_i – a vector of parameters to be estimated by the model, ε_i – disturbance term with ε_i ~N (0, σ^2) (Table 2).

RESULT AND DISCUSSION

Descriptive results

Access to apiculture supporting services

The institutional services that increase agricultural production and productivity, among others, are extension service, input supply service, credit service and marketing infrastructures development. Ahferom district Office of Agriculture and Rural Development (OoARD) has three teams: crop production, livestock production and natural resources management teams. The crop production team also includes the input supply expert, an irrigation expert and home economics agent, in addition to other experts of crop production. The livestock production team includes experts in quality controls, an apiculture technician, and an AI technician, in addition to other livestock production experts. The natural resources management team includes soil and water conservation experts, socio-economist expert, forestry and agro-forestry expert. Currently each *Tabia* has three development agents who reside at FTC: one each in crop production, livestock production and natural resource management.

The study result revealed that about 84.6% of the respondents had got extension access (training, workshop and apiary visit). In addition to access to extension service, frequency of farmers' contact with extension agents makes difference in improvement of apiculture produces. Out of those who had extension contact, 30.9, 55.5, 10.0 and 3.6% of sample respondents had contact

[1] Tabia – the smallest administrative unite in Tigray region.

Table 2. Summary of variables of access to support services used for probit model.

Variables	Code	Type	Measurement
Access to extension service	SERV[1]	Dummy	No=0, Yes=1
Access to credit service	SERV[2]	Dummy	No=0, Yes=1
Access to input supply (*i.e*. improved box hive)	SERV[3]	Dummy	No=0, Yes=1
Household head sex	SEX	Dummy	Female=0, male=1
Household head age	AGE	Continuous	Years
Household head educational status	EDUC	Dummy	0 = illiterate, 1 = literate
Household head leadership participation	LEADP	Dummy	No=0, Yes=1
Total family size	FAMLYSIZ	Continuous	Number
Working labor force	LABFORC	Continuous	Number
Other off/non-farm activity involvement	OFFACT	Dummy	No=0, Yes=1
Household farm size	FARMSIZ	Continuous	Hectares
Households' livestock holding	TLU	Continuous	TLU
Beekeeping experience	BEEKEEXP	Continuous	Years
Number of bee colonies	BEECOLO	Continuous	Number
Frequency of extension contact	FREQCONT	Continuous	Number per month
Distance to farmers training center	DISTFTC	Continuous	Kilometers
Distance to nearest market	DISTMKT	Continuous	Kilometers
Distance to district town	DISTWRDA	Continuous	Kilometers
Distance to all weathered road	DISTROAD	Continuous	Kilometers
Radio, TV and/or mobile ownership	RTVMOBIL	Dummy	No=0, Yes=1

with extension agents once, twice, three times and four times per month, respectively (Table 3).

Most smallholder farmers in the study area are in need of credit for honey production improvement, hence, some of them may obtained but some of them may not obtained due to high financial constraints of the credit providing organizations. On the contrary, some farmers may not need credit due to problems related to terms of reimbursement and high interest rate. Particularly, interest rate is the main problem in the area since it is as high as 18%. From the total sample farmers, 80.0% needed credit. Of those credit needed sample farmers, 79.8% received credit for improvement of beekeeping activity (Table 3). As the respondents pointed out, Dedebit Credit and Saving Institution (DCSI) is the sole financial organization providing credit for honey production improvements in collaboration with the district OoARD. Most probably farmers who accessed credit service were predominantly selected by the OoARD of the district and had got *Kupen*[2] from DCSI if the credit is in kind.

In the study area, improved inputs were delivered by the OoARD of the district in collaboration with DCSI if the farmers were utilized improved inputs in the form of credit; and model farmers get improved box hive additionally as an incentive from REST. The production, productivity and quality of honey are partly determined by the type of the hive used. Furthermore, the type of accessories, particularly honey extractor and casting mold, used for production of honey also determine honey production, productivity and quality. However, not only the availability of accessories but also the time that the accessories supplied to farmers determine the production, productivity and quality of honey produced as most of the accessories, honey extractor and casting mold, supplied at harvesting season from each *Tabia* rather the individual beekeeper holds. Thus, if the accessories, particularly honey extractor, delayed little time to supply to the beekeepers at harvest season, there would be high probability to deteriorate the produce and this might lead to low production, productivity and low quality of honey. With this in mind, out of the total respondents, 60.0% indicated that they have received improved box hive regardless of their adequacy and timeliness. As the samples asked to answer for improved box hive access problems, about 65.4, 13.8 and 20.8% of the sample responds that improved box hive is constrained by high price, lack of credit and lack of supply, respectively. Moreover, improved box hive accessed respondents were also asked for timely supply of improved box hive accessories, in this case honey extractor and casting mold; hence, 83.3% of them responds that they were obtained casting mold and honey extractor at the time of preparation of foundation sheet and honey harvesting, respectively (Table 3).

Farmers sold part of their agricultural products immediately after harvest to cover their costs of

[2]Kupen is a credit card ordered by DCSI, which represents a farmer to obtain input from OoARD of the district.

Table 3. Institutional characteristics of sample beekeepers for discrete variables.

Characteristics		Total sample beekeepers	
		N	%
Extension access	Yes	110	84.6
	No	20	15.4
Frequency of extension contact per month	Once	34	30.9
	Twice	61	55.5
	Three times	11	10.0
	Four times	4	3.6
Radio, TV and mobile own	Yes	59	45.4
	No	71	54.6
Credit need	Yes	104	80.0
	No	26	20.0
Credit access	Yes	83	79.8
	No	21	20.2
Input supply (improved box hive) access	Yes	78	60.0
	No	52	40.0
Input access constraints	High price	85	65.4
	Lacks credit	18	13.8
	Lacks supply	27	20.8
Accessories timely supply	Yes	65	83.3
	No	13	16.7

Survey output, 2012, *** and ** represents 1% and 5% significance level, respectively, N – Number of observations, % - percentage of observations.

Table 4. Institutional characteristics of sample beekeepers for continuous variables.

Characteristics	Total sample beekeepers
	Mean(STD)
Distance to market/district	12.52(2.79)
Distance to road	4.97(2.23)
Distance to FTC	3.35(1.67)

Survey output, 2012,*** represents 1% significance level, respectively, STD = standard deviation.

production, social obligation and urgent family expenses in the nearby market. The result indicates that the average distance of farmers' residence from the nearest market place was 12.52 km. Infrastructure is another key service for farmers, as it helps them to sell their farm products. The average distance of the farmers' home from all-weather roads was 4.97 km. The FTC has been recently established at each *Tabia* to serve as nodes, which could provide extension service (packages), training (short term and modular), demonstration and, centers of exhibition and information, as a result, disseminates agricultural technologies (Ibrahim, 2004;

Table 5. Maximum likelihood estimation of probit model of apiculture extension service access.

Variables	Coefficients	Robust STD. ERR.	t-value	Marginal effect
SEX	-0.3185414	0.691944	-0.46	-0.0013951
AGE	-0.1092366	0.0442901	-2.47**	-0.0006689
EDUC	-0.1197492	0.5149899	-0.23	-0.0006816
LEADP	0.5719492	0.4252651	1.34	0.002707
LABFORC	0.4698898	0.1778988	2.64***	0.0028774
OFFACT	0.860343	0.7976947	1.08	0.0031714
FARMSIZ	-2.739059	0.986726	-2.78***	-0.0167726
TLU	0.1729471	0.1498836	1.15	0.001059
BEEKEEXP	0.06576	0.0366094	1.80*	0.0004027
BEECOLO	-0.7725696	0.1652418	-4.68***	-0.0047308
DISTFTC	-0.4892228	0.1568134	-3.12***	-0.0029958
RTVMOBIL	2.495484	0.8777245	2.84***	0.031889
_CONS	11.24834	2.132738	5.27***	
Log pseudo likelihood = -22.438155, Number of obs. = 130, Wald chi^2(12) = 48.37, Prob> chi^2 = 0.0000, Correctly predicted = 99.8%.				

***, ** and * represents 1, 5 and 10% significance level, respectively, model output, 2012.

Berhanu et al., 2006; MoARD-IPMS, 2006). The average distance of farmers' home from FTC was 3.35 km (Table 4).

Econometric models results

Factors affecting access to apiculture extension service

Probit maximum likelihood estimation was used to analyze factors affecting access to apiculture extension service. Table 5 shows the model correctly predicted about 99.8% of the observations with significant wald-chi-square of 48.37. The dependent variable in this analysis is a dummy variable, taking the value one if a farmer received extension service and 0, otherwise; whereas the explanatory variables comprises both continuous and discrete. A total of twelve explanatory variables were considered in the model, of which seven variables were found to significantly influence smallholder farmers' access to extension service. Marginal effect (for continuous explanatory variables) indicates that the effect of one unit change in an explanatory variable on the dependent variable, while for the dummy variables the values reported are changes in the dependent variable in response to a change in the binary variable from zero to one.

The probit model result shows that age of the household head had negative and significant influence on extension service access. Given other factors constant, one year increase in household head age the probability of the farmer access to extension service reduced by 0.07%.This implies that older farmers might have less access to extension activities regarding apiculture improvement than younger farmers. On the contrary, labor force illustrated by the total number of productive members (age 15 to 64) associated positively with farmers' access to extension service. As the household productive member increase by one person, probability of access to extension service for honey production improvement increased by 0.30%. This implication might be due to households with large number of productive members more probably participate in different apiculture improvement trainings, workshops and apiary visits than households with small productive members. Farm land holding had negative and significant effect on apiculture extension program participation. As farmer's farm size decrease by one hectare his probability of access to extension service increased by 1.7%. Because apiculture is off-farm activity that required small land and it is usually true that small land holders and landless farmers practice. Hence, farmers with small farm size might be participated in improving beekeeping extension activities than others.

Number of bee colonies holding had negative influence on beekeeping improvement extension service access. Since, in this study, the large portion of bee colonies are in traditional hive and it does not require improved management and inspection, as a result, large number of bee colonies holding farmers had less probability to contact with extension agents as per the number of the bee colonies than small number of bee colonies holders. However, beekeeping experience had positive effect on beekeepers accessed to extension service at 10% significant level. This might be due to beekeepers those who rich in beekeeping experience perhaps acquire indigenous knowledge that helps them to know the

Table 6. Maximum likelihood estimation of probit model of access to apiculture credit service.

Variables	Coefficients	Robust STD. ERR.	t-value	Marginal effect
SEX	0.4240756	0.4193967	1.01	0.1591923
AGE	0.0136609	0.0323777	0.42	0.0048201
EDUC	0.0249541	0.4043023	0.06	0.0088288
LEADP	0.0490634	0.2973156	0.17	0.0172187
FAMYSIZ	0.0133536	0.1153223	0.12	0.0047117
LABFORC	-0.0689404	0.142254	-0.48	-0.0243248
OFFACT	1.198252	0.3519407	3.40***	0.3283266
FARMSIZ	-0.0478802	0.5676487	-0.08	-0.0168939
TLU	-0.067437	0.0790644	-0.85	-0.0237943
BEEKEEXP	-0.0313658	0.0251087	-1.25	-0.011067
BEECOLO	0.3557805	0.0783777	4.54***	0.1255326
DISTFTC	-0.129562	0.0748158	-1.73*	-0.0457143
RTVMOBIL	-0.0545195	0.2865645	-0.19	-0.0192785
DISTWRDA	-0.0509256	0.048536	-1.05	-0.0179684
_CONS	-0.4426221	1.552035	-0.29	
Log pseudo likelihood = -68.01111, Number of obs. = 130, Wald $chi^2(14) = 32.94$, Prob> $chi^2 =$ 0.00, Correctly predicted = 68.9% .				

***, ** and * represents 1, 5 and 10% significance level, respectively, model output, 2012.

advantage of participation in extension activities regarding beekeeping improvement systems than those who less experienced.

The other highly significant variable in this model is distance of farmers' residence from the FTC. This is infact farmers resides far from the FTC have less attended in extension programs such as apiary visit, workshop and trainings regarding beekeeping improvement than those who resides near to FTC. Moreover, farmers also acquire extension information and knowledge regarding apiculture sub-sector improvement through mass Medias, for instance in this case, by possessing radio, TV and mobile. Farmers who owned at least one of these three information source increased the probability of accessed to extension service by 3.2%.

Factors affecting access to apiculture credit service

The econometric model used to analyze this problem was the probit maximum likelihood estimation. The dependent variable in the model is access to apiculture credit service, taking the value one if a farmer received credit service either in cash or in kind and 0, otherwise. The independent variables included here are both continuous and discrete. As shown in Table 6, the choice of explanatory variables correctly predicted farmers' credit condition for about 69% of the observations with significance wald-chi-square of 32.94. Out of fourteen hypothesized explanatory variables, three of them had significant effect on farmers' access to credit service. One of the significant variables had negative correlation with the farmers' access to credit service whereas the two were correlated positively.

Involvement in other off/non-farm activities was among the highly significant factors affecting access to credit service for apiculture improvement. This might be due to farmers involved in other off/non-farm activities probably earn additional income which helps them to repay to the borrowed money relative to those who did not. In addition, the number of bee colonies of beekeepers had significant and positive effect on credit service access. This is due to the fact that bee colony is liquid asset (easily changed into cash) that help beekeepers to take credit confidently for their honey production improvement.

Distance of beekeepers' residence from FTC had significant effect on the beekeepers access to credit service as it was hypothesized negative sign. The marginal effect for distance from FTC indicated that, other variables being constant, as the distance of beekeepers residence from FTC far by one kilometer the probability of these beekeepers access to credit service reduced by 4.6%. In view of the fact that FTC is a bridge to broadcast extension information through extension agents to the farmers concerning requirements, utilization and importance of credit for honey production improvement. As a result, farmers those who reside far apart from FTC have relatively less probability to borrow credit from lending institutions than their counter parts.

Factors affecting input supply service (improved box hive) access

Probit model was employed to analyze the factors

Table 7. Maximum likelihood estimation of probit model of access to input supply service (improved box hive).

Variables	Coefficients	Robust STD. ERR.	t-value	Marginal effect
SEX	1.082474	0.5455031	1.98**	0.411328
AGE	0.042097	0.0364656	1.15	0.0150621
EDUC	-0.5039956	0.4267684	-1.18	-0.1688428
LEADP	-0.4127935	0.2994113	-1.38	-0.1524156
LABFORC	-0.2405052	0.152025	-1.58	-0.0886671
OFFACT	1.457815	0.3854027	3.78***	0.3824946
FARMSIZ	-0.1428221	0.5749504	-0.25	-0.0511009
TLU	0.0963839	0.0840324	1.15	0.0344856
BEEKEEXP	-0.0942801	0.0285285	-3.30***	-0.0337329
BEECOLO	0.0880682	0.0815238	1.08	0.0315103
DISTFTC	-0.1692456	0.0845351	-2.00**	-0.0605551
RTVMOBIL	0.5564423	0.3198151	1.74*	0.1927168
DISTWRDA	-0.1212092	0.0569221	-2.13**	-0.043368
_CONS	1.728543	1.672151	1.03	
Log pseudo likelihood = -57.03387, Number of obs. = 130, Wald $chi^2(13)$ =53.52, Prob> chi^2 = 0.0000, Correctly predicted = 68%.				

***, ** and * represents 1, 5 and 10% significance level, respectively, model output, 2012.

affecting farmers' access to input supply service, taking the value one if farmers received input supply service (improved box hive) and 0, otherwise. Thirteen explanatory variables comprising both continuous and dummy variables were included in the model. Out of these, three continuous and three dummy variables had significant influence on access to input supply service. The model correctly predicted 68% of the observations with significance wald-chi-square of 52.53 (Table 7).

Table 6 illustrates that being male-headed households have more likely to receive improved box hive from the district OoARD and/or from NGOs as males are more informed to the transferring of bee colonies to the box hive, management and inspection of box hive, harvesting of honey from improved box hive than female-headed households. Involvement in off/non-farm activities other than beekeeping may enable to earn additional income so as to purchase improved box hive for honey production improvement. Hence, smallholder farmers involved in other off/non-farm activities had significant effect on input supply service access than those who did not involved in it.

Beekeepers' residence distance from FTC had significant effect on access to improved box hive supply as it was hypothesized negative sign. The marginal effect for distance from FTC indicated that, other variables being constant, as the beekeepers reside far from the FTC by one kilometer probability of getting them improved box hive reduced by 6.1%. This implication might be as FTC is a bridge to transmit extension information through extension agents to the farmers in relation to management and inspection of improved box hive and production of honey from this type of hive. As a result, farmers those who reside far apart from FTC have relatively less probability to get improved box hive from providing institutions than their counter parts. Similarly, since the district OoARD is the main source of improved box hive, as farmers become far from their district town it might be difficult for them to get improved box hive supply. Consequently, as farmers' residence becomes far and far from the district town, the probability of having access to improved box hive decreased.

Beekeeping experience had affected negatively input supply accessibility at 1% significant level. This result implies that the experience beekeepers' acquired is mostly traditional. More experienced farmers in traditional honey production system might be indisposed to accept new ideas and take improved box hive than less traditionally experienced beekeepers rather they are more immersed to continue with the use of traditional beehive. However, ownership of radio, TV and mobile positively affected input supply service access at 10% significant level. Ownership of radio, TV and mobile acquires knowledge concerning the relative advantage of improved box hive. Under ceteris paribus condition, 19.3% increased the probability of taking improved box hive as farmers possess at least one of these three information source.

CONCLUSION AND RECOMMENDATIONS

Based on the findings of the study, the following recommendations are suggested to be considered by governmental and non-governmental organizations in their future intervention strategies aimed at providing

apiculture supportive services to improve apiculture produces in the study area in particular and other areas with similar settings. Extension service providing institutions should extend their extension service to the beekeepers who did not have extension service access via apiary visit, training on beekeeping improvement. Distance of beekeepers' residence from FTC limits them from extension service access; therefore, extension service need to be provided at village-levels, Churches and Mosques, at *Idir* and *Mahber;* and beekeepers should develop the habit to focus on mass Medias.

Financial institutions should primarily offer substantial village-level extension information regarding the utilization and repayment of the credit they would be borrowed and followed by credit provision to beekeepers according to their capacity to repay; otherwise it is putting them down in debt. Besides, NGOs and cooperatives are required to intervene in providing financial service to satisfy the credit need of smallholder beekeepers in the area, particularly, to beekeepers who have large number of bee colonies that helps them to purchase as a result transfer their bee colonies from traditional to improved box hive.

Great effort need to be made by the district OoARD, REST and other NGOs to adequately and timely supply improved box hive at reasonable price to every smallholder beekeepers; and extension workers must address accessories to the beekeepers seasonally, particularly honey extractor and casting mold, for the improvement of box hive productivity and honey quality. In addition, mass Media is required to broadcast the relative advantage of improved box hive over traditional beehive.

Conflict of Interest

The authors have not declared any conflict of interest.

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Estimating the impact of a food security program by propensity-score matching

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Reducing poverty and improving household food security remains an important policy objective for rural development in the semi-arid areas of many countries in Africa. Many development programs have been introduced in efforts to bring the cycle of poverty and food insecurity to an end. This paper investigates the impact of a food security package (FSP) program in improving rural household's food consumption in Tigray region, Northern Ethiopia. An empirical analysis based on a propensity score matching (PSM) method, which is a popular approach to estimate causal treatment effects, is employed. Using kernel-matching estimation technique, program beneficiaries were matched with non-beneficiaries. The results show that the program has had a significant effect on improving household food calorie intake. The findings indicated that the program raised the food calorie intake of beneficiary households by 41.8% above that of individuals not involved in the program. Sensitivity analysis also indicated that the observed estimate of impact is not vulnerable to hidden bias or selection on unobservables.

Key words: Propensity score, matching, selectivity bias, average treatment effect, impact, evaluation.

INTRODUCTION

It is increasingly being recognised that improving food security is a basis for reducing poverty and hunger, but also for economic development. Despite notable progress in economic growth and welfare improvement in developing countries over the recent decades, food security has not been attained in most developing countries. In particular, food insecurity continues to form a deep seated problem in several sub-Saharan African (SSA) countries. A recent Food and Agriculture Organization of the United Nations (FAO) report indicates that the number of undernourished people in Africa still remain high at 226.7 million (FAO, 2014). Even now, countries in the Horn of African are overwhelmed by heightened food security crises, making the problem of food security an issue of great concern to governments and the international community.

Like other SSA countries, Ethiopia is one of the least developed countries in the world according to all measures of poverty. Despite the country has made progress in economic growth over recent decade, food

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insecurity is still evident. The 2012-2014 FAO assessment report estimated 32.9 million of the Ethiopian people are undernourished, indicating food shortage as an on-going problem in the country (FAO, 2014). The country's food production is highly vulnerable to the influence of adverse weather conditions as the agricultural sector is totally dependent on rainfall. Previous studies reported that a 10% decline in the amount of rainfall below the long-term average leads to a 4.4% reduction in the country's national food production (Webb et al., 1992). Furthermore, drought has increasingly occurred over the recent decades, as has the proportion of the population adversely affected by it. Consequently, the country has been dependent on food aid to bridge its huge food gap. Devereux (2006) reported that, even in a year where rainfall is favourable, around 4 to 5 million Ethiopians depend on food aid, reflecting how deep-rooted food insecurity is in the country.

The causes of food insecurity problems in Ethiopia are complex and interrelated. Lack of governance and misdirected economic policies during the military regime (1974-1991), unfavourable weather fluctuations, high dependency on rainfed agriculture, and failure to bring about economic transformation have all contributed negatively to the country's agricultural performance in past decades (Gebremedhin, 2006). Declining soil fertility, land degradation, and shrinking landholding due to population pressure had contributed to the deterioration food production. These and other factors are responsible for the country's struggle to ensure food security.

Hence, ensuring food security is one of the top national priorities and forms the cornerstone of the sustainable economic growth and poverty reduction strategy in Ethiopia. To this effect, the current government has embarked in November, 2002 an aggressive economic reform program. Policies that tackle food insecurity at household level are seen as the most effective way to reduce poverty. The integrated household food security package (FSP) program is among the programs introduced for this purpose. The program aims to secure food at household level by diversifying the income base of the poor through provision of credit for a range of activities. Large amounts of money and effort have been spent by the government and multi-lateral development bodies to reduce the problems of widespread rural food insecurity and thus improve people's access to food. However, program implementation is not an end in itself. The question of how the FSP program affects the targeted beneficiaries should be evaluated after a certain period of time to investigate whether the program actually contributed to household's food security.

Despite the FSP program has been implemented in Tigray, Northern Ethiopia, over the recent decade, to our knowledge no attempts has ever been made to systematically evaluate its impacts on household food consumption. Abebaw et al. (2010) studied the impact of food security program on household food consumption in two villages of the Amhara region in the North-western part of Ethiopia using propensity-score matching. However, Abebaw et al. (2010) only provided the average impact of the food security program but did not attempt to analyse the sensitivity of their estimated impact to selection bias. In practice, there may be unobserved variables that simultaneously affect the outcome, and the assignment into program beneficiary. In such circumstances, a 'hidden bias' may influence the robustness of the matching estimators (Rosenbaum, 2002). As Ichino et al. (2006) have suggested, the presentation of matching estimates should therefore be accompanied by sensitivity analysis since propensity-score matching cannot fully account for selection bias. This apparent limitation of Abebaw et al. (2010) provides us with the starting point of this article.

The main objective of this paper is to evaluate the impact of the FSP program upon improving rural household food consumption in Tigray using a propensity score matching (PSM) method. We build up our research on the works of Abebaw et al. (2010). In this paper, we adopt the definition of food security by Siamwalla and Valdes (1980) that is, the ability of households to meet target levels of consumption on a yearly basis.

The household food secirty package program (FSP)

Tigray is one of the most drought-prone areas of Ethiopia, and faces recurrent droughts and food shortages. Most smallholder farmers face sizeable food deficits every year and are vulnerable to recurrent drought shocks. Poverty reduction and ensuring food security is Tigray's most significant development challenges.

The household oriented extension package program known as the integrated household FSP was launched in 2002 (Desta et al., 2006). This program was developed within the framework of the federal government's overall development policy and food security strategy, but addresses the specific and complex problems and causes of food insecurity that plague the region. To this end, a twin-track strategy was employed with target beneficiaries to redress short-term food deficits, while building up sufficient self-help capacity to allow the rural population to attain self-reliant food security in the long term (TFSPC, 2005).

Accordingly, the FSP program has been widely introduced in Tigray. The intention of the program is to secure food at household level by diversifying the income base of the poor through provision of credit for a range of activities in a package. It also provides income transfers through public works. To this end, identifying the basic abilities of the poor and providing the required financial resource, technical assistance and training to engage in their choice of activities is the prime concern of the program.

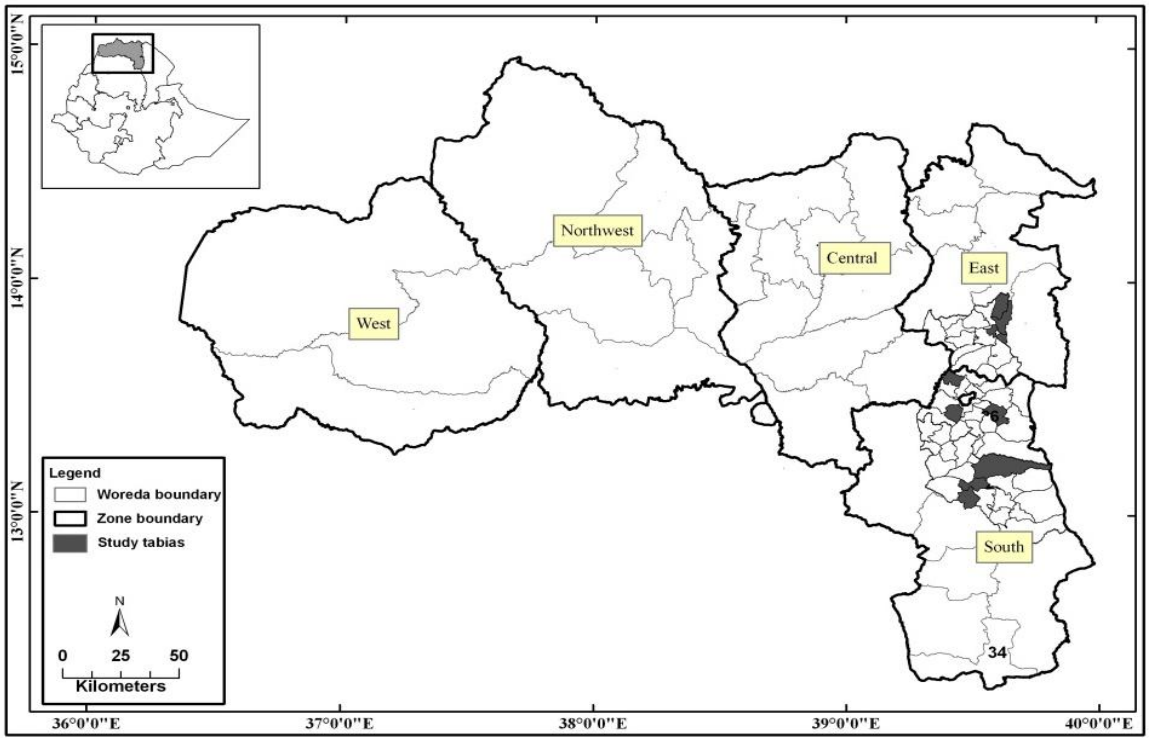

Figure 1. Administrative of map of Tigray region and location of the study villages.

The selection process of a household into the program is clearly defined in the Productive safety net program implementation manual. In each village (locally called *tabia*), beneficiary households were first selected by the local administration (food security task force) based on pre-defined criteria (TFSPC, 2005). Local communities also have discretion to identify food-insecure households based on local knowledge (Coll-Black et al., 2011). Poverty status as expressed by the household's livestock (households without cows and oxen were given priority), land holding size and quality, and severity of food insecurity are the main criteria for selecting households into the program (TFSPC, 2005). After a household is selected for the program, financial support as a loan for a range of activities is provided as a package. Households thus participate in one or more program activities, including vegetable and fruit production, livestock production (oxen and cows), small animals (sheep and goats), poultry, and beehives (Nega, 2008).

The FSP program was thus expected to address the rural household's risks of not having access to sufficient food through increasing food production and promoting employment. Provision of credit to the poor is expected to stabilize consumption and promote self-employment in off-farm activities. The program was also expected to increase household's livestock ownership and provide access to draft power that has been the long-time constraint of the agrarian society in Tigray region (TFSPC, 2005; Nega, 2008).

MATERIALS AND METHODS

The study area

Tigray is one of the regional States of Ethiopia and is located in the northern part of the country, covering a total area of 53,000 km^2. Geographically, it lies between latitudes 12°15' N and 14°57' N, and longitudes 36°27' E and 39°59' E (Figure 1). In the year 2007 the region had a population of 4.4 million with a population growth rate of 2.5% per annum (CSA, 2008). The climate of the region is characterized by large spatial variations in rainfall. The mean annual monsoon rainfall of the region is estimated to be 473 mm, representing 84% of the annual rainfall in the region (Gebrehiwot et al., 2011).

Tigray mainly relies on rainfed agriculture. The tremendous importance of this sector to the regional economy can be gauged by the fact that it directly supports about 82% of the population in terms of employment and livelihood.

Data sources and variable definitions

The data for the study was derived from a household survey conducted in three rural districts from January to February, 2011, and included 400 farm households randomly drawn from 9 villages. A three-stage sampling techniques was employed to draw the samples. Three districts were first chosen: two districts (Enderta and Kilte Awelaelo) from the FSP program areas and one (Hintalo Wajirat) from the non-FSP districts. Second, 4 villages from the program area were purposively chosen. Five comparable non-program villages from Hinatlo Wajirat districts were chosen based on their similarity in social, economic and agro-climatic characteristics with the program villages. Finally, random sampling was employed to draw a total sample size of 189 and 211 farm

households from the program and non-program villages, respectively.

To generate the data, a structured household questionnaire was administered, with a household defined as a group of people in a housing unit living together as a family and sharing the same kitchen. The survey captured information related to demographic characteristics, asset endowment, food consumption, economic activities, wealth and income, expenditure on food and non-food items, and access to basic infrastructures and agricultural services. The sample households were asked to report food items consumed in kind and amount, purchased or otherwise, by their families during the week preceding the survey visit. The physical quantities consumed by a household were then converted into food calories adjusted for household age and sex composition using the national food composition table compiled by the Ethiopian Health and Nutrition Research Institute (EHNRI, 2000).

Enumerators with knowledge of the local language and experience with socio-economic surveying were recruited locally, and trained based on the content of the questionnaire. Prior to the actual fieldwork, the questionnaire was pre-tested. During the survey field work, close and regular supervision was made.

The food security outcome indicator

Determining the food security status of households can help public officials and policy makers to evaluate the effectiveness of existing programs. However, as with other social programs, identifying and quantifying the causal effect of a program on household food security is not straightforward (Abebaw et al., 2010). Identifying an appropriate food security indicator is thus a difficult issue as not all characteristics of food security can be captured by any single outcome indicator (Maxwell et al., 1999; Hendriks, 2005).

Maxwell and Frankenberger (1992) reported 25 broadly defined indicators. In the work by Maxwell and Frankenberger, a distinction is made between process indicators describing food supply and outcome indicators describing adequate food consumption and food access. Chung et al. (1997) found that there is little correlation between a very large set of process indicators and measures of food security outcomes. von Braun et al. (1990) described outcome indicators as proxies for adequate food consumption measured directly as food expenditure and caloric consumption.

Similarly, different organisations and government agencies use different food security indicators depending on their primary objectives. Per capita food intake per day in kilocalories is used as the indicator for food security for regional and global assessments. For example, according to FAO (2003), at national level a per capita food intake of less than 2,200 kcal/day is taken as indicative of a very poor level of food security. The most common methods of poverty measurement have also used the nutritional norm and defined a poverty line in terms of minimum calorie requirements (Greer and Thorbecke, 1986; Ahmed et al., 1991; Ravallion and Bidani, 1994). Swindale and Ohri-Vachaspat (2005) also reported that the percentage of minimum daily food calorie requirements consumed provides a good indication of overall household food security.

For this study, food calorie intake which is one of the most direct indicators related to food security and nutritional security (Hoddinott and Skoufias, 2004; Gilligan and Hoddinott, 2007) was considered as an outcome indicator to measure the impact of FSP program. In Ethiopia, food poverty is defined in terms of food calorie intake (MoFED, 2006). This implies that this indicator has direct relevance to local conditions and the food security context, which is identified as one of the criteria by Davies et al. (1991). As is also reported by Baker (2000), establishing measurable indicators that correspond directly to planned interventions is a key step in social program impact evaluation.

Empirical approach

A valid measure of the impact of a household FSP would be to compare the outcomes in households receiving FSP benefits with the presumed outcomes that had the same households and not received any benefits. Assessing the impact of any intervention thus requires making an inference about the outcome that would have been observed had the program participants not participated. Following Heckman et al. (1997) and Smith and Todd (2001), let Y_1 be the mean of the outcome conditional on participation, that is, membership of the treatment group, and let Y_0 be the outcome conditional on non-participation, that is, membership of the control group. The impact of participation in the program is the change in the mean outcome caused by participating in the program, which is given by:

$$\Delta Y = Y_1 - Y_0, \quad (1)$$

Where Δ is the notation for the impact for a given household.

The fundamental problem of evaluating this individual treatment effect arises because for each household, only one of the potential outcomes either Y_1 or Y_0 can be observed, but Y_1 and Y_0 can never be observed for the same household simultaneously. This leads to a missing-data problem, which is the heart of the evaluation problem (Smith and Todd, 2005). The unobservable component in Equation 1, be it Y_1 or Y_0, is called the counterfactual outcome. Measuring impact as the difference in mean outcome between all households involved in the FSP and those not involved may thus give a biased estimate of program impact. Since there will never be an opportunity to estimate individual treatment effects in Equation 1 directly, one has to concentrate on sample averages for the impacts of a treatment.

Average impact of the treatment on the treated (ATT), which focuses explicitly on the effect on those for whom the program is actually introduced, is the most commonly used evaluation parameter. In random program assignment, the expected value of ATT is defined as the difference between expected outcome values with and without treatment for those who actually participated in the program (Heckman et al., 1998), which is given by:

$$\Delta Y_{ATT} = ATT(\Delta Y \mid X; Z=1) = E(Y_1 - Y_0 \mid, Z=1) = E(Y_1 \mid, Z=1) - E(Y_0 \mid, Z=1), \quad (2)$$

Where Z is an indicator variable indicating whether a household i actually received treatment or not: Z_i being equal to 1 if the household is a beneficiary of FSP and 0 otherwise. X denotes a vector of control variables. Data on program beneficiaries identify the mean outcome in the treated state E (Y_1|X, Z=1). The mean outcome in the untreated E (Y_0|X, Z=1) is not observed, and a proper substitute for it has to be chosen in order to estimate ATT. As noted earlier, the FSP program followed a non-random process in targeting its beneficiaries. As Gilligan and Hoddinott (2007) have noted, this gives rise to a biased estimate of program impact and the procedure in Equation 2 should not be applied in our case. Applying PSM approach is therefore the most appealing approach to estimate the impact of the program for our study.

Propensity score matching (PSM)

The majority of the literature on evaluation methodology is centred on the use of matched-comparison evaluation techniques, which are among quasi-experimental design techniques generally considered a second-best alternative to experimental design (Baker, 2000). The propensity score is defined by Rosenbaum and Rubin (1983) as the conditional probability of receiving a treatment given pre-treatment observable characteristics. Let P = Pr (Z=1| X)

denote the probability of participating in the FSP program, that is, the propensity score. PSM constructs a statistical comparison group by matching observations on the FSP participants to non-participants for similar values of propensity score. PSM estimators are based on two assumptions:

i) That non-participants provide the same mean outcomes as participants would have provided had they not received the program. This reflects a major strand of evaluation literature that focuses on the estimation of treatment effects under the assumption that the treatment satisfies some form of exogeneity (Imbens, 2004). Thus, testing is important to check if a household's characteristics within its group are similar.

$$E(Y_0|P, Z = 1) = E(Y_0| P, Z= 0) = E(Y_0|P) \quad (3)$$

ii) That households with the same Z values have a positive probability of P being both participants and non-participants [the common support assumption; Heckman et al. (1999)]:

$$0<P<1 \quad (4)$$

If assumptions (i) and (ii) are both satisfied, then, after conditioning on P, the Y_0 distribution observed for the matched non-participant group can be substituted for the missing Y_0 distribution for participants. Under these assumptions, the ATT of the program can be estimated as:

$$\begin{aligned} \text{ATT} &= E(Y_1 - Y_0 \mid Z = 1) \\ &= E(Y_1 \mid Z = 1) - E_{P|Z=1}\{E_Y(Y_0 \mid Z = 1, P)\} \\ &= E(Y_1 \mid Z = 1) - E_{P|Z=1}\{E_Y(Y_0 \mid Z = 0, P)\} \end{aligned} \quad (5)$$

Where the first term on the right-hand side of the last expression can be estimated from the treatment group and the second term from the mean outcomes of the matched (on P) comparison groups.

Based on Baker (2000), and Heckman et al. (1997, 1998) criterion, the PSM will provide reliable and low-bias estimates of FSP program impact because: (i) similar questionnaire was used to elicit data from beneficiaries and non-beneficiaries, (ii) the dataset came from farm households with similar socio-economic and demographic conditions as well as a similar economic environment, (iii) the propensity score was estimated by using the sample households' observable characteristics that were relevant for both participation in the program and for the outcome variable of interest, and (iv) the dataset has a larger sample of non-beneficiaries households.

In implementing the PSM, an empirical model has to be specified to derive the propensity score. For the FSP program, we estimated the propensity score for participation in the program with a logit model using observable variables that included both determinants of participation in the program and factors that affected the outcome. Once we estimated the propensity score that appeared to capture the similarities, we used these similarities to match each beneficiary with his/her closest non-beneficiary. We performed several tests to select a preferred estimator and chose the estimator that yielded statistically identical covariate means for both groups (Caliendo and Kopeinig, 2008). Moreno-Serra (2009) indicated that a good matching estimator is expected to retain relatively larger observations for evaluating the impact of a program. We implemented a kernel-matching estimator using the PSM algorithm with the software package STATA 12 to compute the average impact of the program among FSP households based on the above indicators. Morgan and Winship (2007) argued that kernel-matching, introduced by Heckman et al. (1998) appears to be the most efficient and preferred algorithm.

Finally, the PSM approach cannot fully account for selection bias or unobservable characteristics. In practice there may be unobserved variables that simultaneously influence treatment allocation as well as potential outcomes (Becker and Caliendo, 2007). In such circumstance, a 'hidden bias' might arise that influence the robustness of the matching estimators (Rosenbaum, 2002). Thus, the bias due to selection on unobservables remains as its drawback. Hence, following Rosenbaum (2002) we performed sensitivity analysis to examine the vulnerability of the estimated impact to unobservables.

Conditioning variables for program participation

In PSM, it is desirable to condition the match on variables that are highly associated with the outcome variables (Heckman and Navarro-Lozano, 2004). Smith and Todd (2005) noted that there is little guidance available to researchers on how to select the set of conditioning variables used to construct the propensity score. Thus we focussed on finding a set of conditioning variables that were highly associated with program eligibility and the outcome variable. Fortunately, our data set contained a set of conditioning variables to control program participation decisions.

As described earlier, the FSP program is intended to serve the food insecure households. One way of judging the welfare level of rural households in the study region would be on the basis of assets owned. Hence, we included the two basic assets in the Ethiopian rural economy, land and livestock owned. Lack of these assets was associated with program eligibility. Pre-intervention demographic variables such as type of household headship, age of household head, family size, number of children under five and dependency ratio associated with program eligibility and the outcome variables were also included.

Furthermore, we included as a control variable the households' proximity to basic physical infrastructure. With this rich set of control variables (Table 1) and relatively large and comparable sample sizes (in both the treatment and the comparison group), we could capture many of the determinants of participation typically unobservable to researchers.

RESULTS AND DISCUSSION

Descriptive

Participation in the FSP program, the dependent variables in the impact assessment analysis, takes the value of 1 if a household participates in the program and 0 otherwise. Summary statistics of FSP participants and non-participants are presented in Table 2. About 26% of the participating individuals were women. As presented in Table 2, household FSP program beneficiaries and non-beneficiary had significant differences on certain pre-intervention characteristics, which are elicited using respondents recall. The main differences between the two groups of households were in particular observed with respect to family size, dependency ratio, size of land, livestock ownership, and distance to all-weather roads and to the nearest market. As compared to non-beneficiary households, FSP program beneficiary households' had smaller number of livestock and oxen ownership and smaller size of land.

Table 1. Variable description and measurement.

Variable	Type	Measurement
Dependent variable, treated	Dummy	1 if yes-participants of FSP, 0 otherwise
Explanatory variables		
Sex of household head	Dummy	1 if head is male, 0 otherwise
Age of household head	Continuous	Age of the household head in years
Education	Dummy	1 if he/she can read and write, 0 otherwise
Farm size	Continuous	Size of the household in numbers
Children under 5 years	Integer	Number of children under five
Dependency ratio	Continuous	Ratio of dependent members to the productive age group
Land holding size	Continuous	Hectare
Livestock ownership in TLU[a]	Continuous	Tropical Livestock Unit
Oxen ownership	Continuous	Tropical Livestock Unit
Value of agricultural equipment owned	Continuous	Ethiopian Birr
Distance to the market	Continuous	Walking distance in minutes
Distance to all-weather road	Continuous	Walking distance in minutes

Table 2. Summary statistics: characteristics of beneficiaries and non-beneficiaries.

Variable	Sample households N = 400		FSP beneficiary HHs N = 189		FSP non-beneficiary HHs N = 211		Difference		t-value
	Mean	STD	Mean	STD	Mean	STD	Mean	STD	
Sex	0.77	0.42	0.74	0.44	0.80	0.40	-0.06	0.04	-1.42
Age	39.04	12.22	39.61	13.57	38.52	10.87	1.09	2.70	0.88
Education	0.46	0.49	0.46	0.49	0.48	0.50	-0.02	-0.01	-0.40
Family size	5.30	1.77	4.98	1.76	5.57	1.72	-0.59	0.04	-3.38***
Dependency ratio	1.28	0.81	1.37	0.94	1.21	0.66	0.16	0.28	1.94*
Land size	0.96	0.47	0.72	0.39	1.19	0.42	-0.27	-0.15	-5.54**
Livestock ownership	2.35	1.61	1.15	0.95	3.44	1.20	-2.29	-0.25	-21.26***
Oxen	1.35	1.04	0.79	0.87	1.85	0.91	-1.06	-0.04	-11.90***
Value of agri. Equip.	230.19	187.13	141.05	73.56	307.35	221.42	-166.30	-147.86	-10.29***
Distance to all-weather road	35.12	11.76	28.76	7.86	40.83	11.75	-12.07	-3.89	-12.19***
Distance to the nearest market	43.36	19.57	35.00	11.82	50.85	21.98	-15.85	-10.16	-6.80***

* = Significant at 10%; ** = Significant at 5%; and *** = Significant at 1%.

Table 2 also clearly depicts that FSP and non-FSP households had a food calorie intake of 2512 and 1748 cal, respectively indicating that households' in the FSP program are better off. Abebaw et al. (2010) reported similar findings.

Nonetheless, descriptive result cannot explain whether the observed difference in calorie intake between the two groups of household is due to FSP program or other exogenous factors. Indeed identification of a casual effect cannot be made before accounting for the effects of confounding factors.

Propensity score estimate

Prior to non-parametrically estimating the impact of the scores required specification justifying that a household had been included in the FSP. Thus, we had to respect the conditional independence assumption that the covariates are exogenous and unaffected by the program. Caliendo and Kopeinig (2008) noted that the basic idea of matching is to compare a beneficiary with one or more non-beneficiaries who are similar in terms of a set of observed characteristics. This requires predicting the propensity scores for each individual using a logit or a probit model. In this study, we used a logit model to predict the probability that a household participates in the food security program; in this model, different household characteristics are included as regressors.

[a] The total number of livestock ownership is measured in Tropical Livestock Units (TLU), an index that aggregates different types of livestock a household owned into a single number. It is calculated using the following weighing index factors from ILRI (1990): cow = 0.8, sheep and goat = 0.09, donkey = 0.36, horse and mule = 0.8, 0x = 1.1

Table 3. Logit estimates for participation in the FSP program (n = 400).

Logit specification	Model
Sex of household head	1.519* (2.08)
Age in years	-0.461* (1.85)
Education	-1.387** (3.15)
Farm size	-0.189 (-0.13)
Number of children under 5 years	1.185** (3.85)
Dependency ratio	0.387 (1.32)
Size of land holding	-3.198** (4.88)
Livestock ownership in TLU	-1.772** (5.18)
Oxen ownership in TLU	-1.026*** (3.79)
Value of agricultural equipment's	-0.158** (5.72)
Distance to the nearest market	-0.102** (5.21)
Distance to all weather road	-0.045** (3.48)
Constant	12.19** (8.17)
Log likelihood	-87.07
Pseudo R2	0.27
Chi2	400.07**
P	0.000

Dependent variable equals 1 if household participated in the FSP program and 0 otherwise. Absolute value of z-statistics are in parentheses. * and ** significant at probability levels of 10 and 1%, respectively.

Chaouani (2010) argued that the functional form of propensity score is chosen based on the results of the logit estimation of the probability of going public. We tried various alternative specifications and chose the logit model presented in Table 3 because it seemed to be the more significant and robust specification. The 'common support' restriction was imposed to improve the quality of the matches and the balancing property was set and passes the balancing tests at the 95% level of statistical significance. Hence, we ensured that the mean propensity score was not different for the treatment sample and the sample of comparison observations at various levels of propensity scores. Significant coefficients in the estimated equation implied that FSP and non-FSP households were different with respect to the corresponding variable.

As indicated in Table 3, size of landholding, livestock ownership, oxen ownership and proximity to an input and output markets significantly influenced household participation in the FSP program. As expected, participation in the program was negatively and significantly influenced by the value of agricultural equipment owned. Distances to all-weather roads and to a market were also directly correlated with a household's participation in the program.

The estimated mean propensity score using the main specification for the whole sample was 0.472 (with a standard deviation of 0.453) implying that the average probability of participating in the FSP program for all individual households was 47%.

Average impact of participation in the FSP

Using estimated propensity scores for the program from the model specification in Table 3, the impact of the integrated FSP program on household calorie intake is estimated with kernel-based matching. We also estimated the FSP impact using other matching estimators particularly the nearest neighbor (NN) matching estimator, to assess the robustness of the results. Matching with replacement was performed. The latter minimized the propensity-score distance between the matched comparison units and the treatment unit, each treatment unit being matched to the nearest comparison unit, even if a comparison unit was matched more than once. This is important in terms of bias reduction. By contrast, when matching without replacement, and with few comparison units similar to the treated units, one may be compelled to match treated units to comparison units that are quite different in terms of the estimated propensity score. This increases bias, but could improve the accuracy of the estimates (Mendola, 2007). Dehejia and Wahba (2002) have reported that the results of matching without replacement are potentially sensitive to the order in which the treatment units are matched.

Table 4 presents estimates of the average impact of participation in the FSP. Overall, matching estimates show that the FSP program has a positive and robust effect on household food calorie intake. The findings indicate that the program improved household's food

Table 4. FSP program impacts on households' food calorie intake, matching estimates (n = 400).

Outcome variable	Model specification
Household food calorie intake	772.19* (6.13)
Observations	
FSP households	97
Non-FSP households	211

Absolute values of t statistics on ATT are in parentheses. * Significant at probability levels of 1%.

calorie intake by 772.19 kcal/day per adult equivalent unit. This means that, if we selected someone to be in the FSP (that is, provided with access to a loan for a package of activities and training), his/her food calorie intake would on average increase to 41.8% above that of individuals not involved in the program. This suggests that the FSP program has a causal influence on total food consumption when individuals are matched according to relevant socio-demographics, assets and other covariates. In a population made up of poor households where the major income-earning asset is human labour, increased calorie intake may imply increase productivity, increased income and hence increased nutrition (Aromolaran, 2004). Nega (2008) similarly reported that the importance of the food-for-work and food security program for the chronically poor and transiently poor households in Tigray region. Abebaw et al. (2010) also found a positive impact of the FSP on household consumption in two villages of the Amhara region in the Northwest part of Ethiopia.

An explanation for this significant effect of the FSP program may be: first, the household-level FSP program is a coordinated one involving key players in the rural development of the region, in particular the Regional Bureau of Agriculture and Rural Development, the Food Security Coordination Office and the Dedebit Credit and Saving Institute - the leading locally operating micro-finance institute in Ethiopia. Second, the nature of the program provided better opportunities for the beneficiaries to engage in their choice of activities and obtain the required resources, technical assistance and training. Third, the number of development agents assigned to each village centre also increased from one to three over recent decade.

Sensitivity analysis

As indicated, the PSM approach cannot fully be controlled for unobservable characteristics. As Ichino et al. (2006) have suggested, the presentation of matching estimates should be accompanied by sensitivity analysis. Accordingly, we checked the sensitivity of the estimated treatment effects to selection on unobservables using the bounding approach developed by Rosenbaum (2002). We applied the 'mhbounds' procedure by Becker and Caliendo (2007) in STAT programs to aid in the construction of Rosenbaum bounds for the sensitivity testing. This procedure uses the matching estimates to determine the confidence intervals of the outcome variable for different values of Γ (gamma)[1]. Γ captures the degree of association of an unobserved characteristic with the treatment and outcome required for it (the unobserved characteristic) to explain the observed impact (Duvendack and Palmer-Jones, 2011). DiPrete and Gangl (2004) indicated that, if the lowest Γ, which encompasses 0, is relatively small (say < 2), then one may state that the probability of such an unobserved characteristic is relatively high and the estimated impact is therefore sensitive to the existence of unobservables.

Table 5 reports the Mantel-Haenszel (mh) bounds results, showing that under the assumption of no hidden bias, when Γ = 1, the Q_{mh} test statistic indicates a highly significant treatment effect for improved food security program intervention on household food calorie intake. The two bounds in the Mantel-Haenszel output table (Table 5) can be interpreted in the following way: The Q_{MH+} statistic adjusts the MH statistic downward for positive (unobserved) selection. In our case, positive selection bias occurs when those most likely to participate tend to have higher food calorie intake even without participation in the program, and given that they have the same χ vector of covariates as the individuals in the control group. This effect leads to an upward bias in the estimated treatment effect[2]. The effect is significant under Γ = 1 and becomes even more significant for increasing values of Γ > 1 if we have underestimated the true treatment effect. The Q_{MH+} reveals that the study is insensitive to hidden bias at the 5% significance level. The sensitivity analysis thus indicates that the observed results on the impact of food security program on households' food calorie intakes are insensitive to

[1] Γ is the ratio of the odds that the treated have this unobserved characteristic to the odds that the controls have it.

[2] The Q_{MH-} statistic adjusts the MH statistic downward for negative (unobserved) selection.

Table 5. Mantel-Haenszel bounds for outcome = food calorie intake.

Γ	Q_{MH+}	Q_{MH-}	P_{MH+}	P_{MH-}
1	3.057	3.057	0.0012	0.0012
1.1	1.931	4.738	0.0586	0.0003
1.2	1.468	4.877	0.0336	0.0073
1.3	1.027	5.229	0.0132	0.0111
1.4	0.759	5.444	0.0289	0.0106
1.5	0.368	6.088	0.0324	0.0146

Source: MH Bounds using STATA 12. Γ = 1 ≈ No 'hidden' bias; Q_{mh+} : Mantel-Haenszel statistic; Q_{mh-}: Mantel-Haenszel statistic; p_{mh+} : significance level; and p_{mh-}: significance level.

selection on unobservable or hidden bias.

Conclusions

Reducing poverty and improving household food security is an important policy objective for rural development in the semi-arid areas of many countries in Africa. While much has been achieved in reducing rural poverty in recent years, the problem of food insecurity is still evident. It is thus pertinent to understand whether food security program contribute to household's food security. Systematic evaluation of the FSP program is therefore necessary in order to grasp how successful implemented household food security program has been. We used a survey data of 400 rural households in the Tigray region in Northern Ethiopia to analyse the impact of the most widely implemented household FSP program. To examine the impact of the program, observed outcomes were compared with the outcomes that would have resulted had the targeted group not participated in the program. We estimated the impact of the FSP program on calorie intake using PSM as a method of estimating the counterfactual outcome for program beneficiaries. Use of PSM ensured that the program beneficiaries and the comparison group shared almost exactly the same characteristics so that selection bias could be mitigated in the sample.

The findings indicate that the FSP program had a significant effect on improving household food calorie intake of poor farm households in the region. After matching participants in the FSP program with non-participants on the basis of some socio-demographic characteristics, asset and other variables, we found that the level of food calorie intake of the FSP program participants was 41.8% higher than the intake of households not involved in the program. Sensitivity testing of the results carried out using Rosenbaum bounds indicated that the observed estimate of impact is not sensitive to hidden bias or selection on unobservables. Thus, this study appears to have the successfully captured and used variables associated with provision of the program.

We concluded that the impact of pro-poor focussed programs, and the FSP program in particular, indeed show the insight that appropriate development policies and programs have a role to play in improving food security outcomes and reducing poverty in rural areas where most of the poor live. However, like all studies, ours is not without limitations. First, our analysis is limited to cross-sectional data. This limits the observation of short and long-term fluctuations in household food consumption level, and food calorie intake in particular. Accordingly, the seasonal dimension to household food security, and particularly food calorie intake, is not considered. Second, the PSM approach cannot fully eliminate bias caused by unobserved confounders and the bias due to selection on unobservables remains as its drawback. These limitations should be kept in mind when evaluating the conclusions of our study.

Conflict of Interest

The author(s) have not declared any conflict of interest

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