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African Smallholders

Food crops, markets and policy

Edited by
Göran Djurfeldt
Ernest Aryeetey
& Aida Isinika



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AFRICAN SMALLHOLDERS

Food Crops, Markets and Policy



The book is in fond remembrance of the late Dr Gasper Ashimogo

AFRICAN SMALLHOLDERS

Food Crops, Markets and Policy

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8

Agricultural Diversification, Food Self-sufficiency and Food Security in Ghana – the Role of Infrastructure and Institutions

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Food self-sufficiency has been an important policy objective of many nations, including Ghana. Its importance as a policy priority has diminished over time, as food security became a more appealing policy orientation. Self-sufficiency suggests that a nation produces at least all its food needs, while food security implies the availability and physical access to food by the population, irrespective of whether or not it is produced within the country (Thomson and Metz, 1998). At the household level, economic rationality suggests that resources should be allocated optimally to the production of commodities for which returns are highest. Income generated from trading these commodities could then be used to purchase other food needs. If agricultural diversification is defined as the increasing allocation of household resources to the production of non-staples relative to food staples, then households would diversify, given that the returns to land and labour are higher for the production of non-staples than for food staples (Fafchamps, 1992; von Braun, 1994; Goletti, 1999; Govereh and Jayne, 2003; Joshi *et al.*, 2003; Weinberger and Lumpkin, 2007; Shome, 2009). But it is documented that many farm households, particularly in sub-Saharan Africa (SSA), are subsistent or semi-subsistent producers, which implies an inclination towards self-sufficiency in food production (de Janvry *et al.*, 1991; Finkelshtain and Chalfant, 1991; Fafchamps, 1992; Jayne, 1994; von Braun, 1994, 1995; Govereh and Jayne, 2003; Di Falco and Chavas, 2009).

The theory of comparative advantage, however, assumes that markets exist for the exchange of goods and services the household produces and those it needs to ensure food security. The optimal allocation of household resources is also often based on this assumption. Thus, production and consumption decisions are assumed to be separable (Singh *et al.*, 1986). This assumption

may not be realistic because of missing or incomplete markets for some goods and services. High transactions costs in rural Africa make some commodities' market participation prohibitive for some households. Thus, even where markets exist, they fail for some households (de Janvry *et al.*, 1991). Under such circumstances, therefore, household self-sufficiency in food production may be the most reasonable way of achieving food security (Fafchamps, 1992; Minot, 1999) for some households. Transactions cost, a major reason for which markets fail, is largely due to poor or absent infrastructure (both 'hard' and 'soft'),¹ among others (Goletti, 1999). State policy may be warranted to reduce transactions cost as well as to promote diversification (Delgado, 1995; Pingali and Rosegrant, 1995; Delgado and Siamwalla, 1997).

Some synergies, however, have been observed between the self-sufficiency strategy of achieving household food security and diversification into cash crop production (or increased participation in staple crop sales), such that households may first seek to obtain food security insurance through self-sufficiency as a priority (Fafchamps, 1992; von Braun, 1994; Jayne, 1994; Pingali and Rosegrant, 1995; Goletti, 1999; Govereh and Jayne, 2003; Dzanku, 2009; Shome, 2009).

In the context of Ghana, this study addresses two main questions: (i) is the attainment of staple crop self-sufficiency a necessary condition of diversification into non-staple crop production?; and (ii) does the allocation of resources to the production of non-staples hurt or enhance rural household food security? These questions are investigated using panel data collected in 2002 and 2008 from eight Ghanaian villages.

The Policy Context

The national economic development strategy enshrined in the Growth and Poverty Reduction Strategy (GPRS II) aims to achieve accelerated and sustainable shared growth, poverty reduction, gender equity, protection and empowerment of the vulnerable and excluded within a decentralized and democratic environment. Agriculture is a major component of this strategy, and Ghana's Agricultural Development Strategy is rolled out in the Food and Agriculture Sector Development Policy (FASDEP II). The main objective of the policy is to modernize agriculture, culminating in a structurally transformed economy. This transformation is aimed at enhancing food security, among others, in line with the goal set for the sector in the GPRS II paper.

The policy changes in the agricultural sector were prompted by the fact that 80% of Ghana's total agricultural output is predominantly rainfall-dependent and practised on smallholder, family-operated farms using rudimentary technology (MoFA, 2007a). According to the 2000 census, 51% of the labour force is directly engaged in agriculture. The slow growth of agriculture is due to a combination of factors that reduce farmers' incentives to invest. These include lack of technologi-

¹ 'Hard' infrastructure refers to physical facilities such as roads, while 'soft' infrastructure includes institutions and systems that facilitate market transactions.

cal change and poor basic infrastructure. Dissemination of new and improved technologies through extension services is weak, with a high extension worker to farmer ratio (1:1500), which is highly unbalanced between female and male farmers, with as little as 20% of services reaching women.

Annual rainfall varies between 800 and 2400mm, generally decreasing from south to north. A significant proportion of arable land has soils with poor physical properties and low content of organic matter. As a result, agricultural productivity is low and erratic and vacillates between scarcity, sufficiency and glut. The FASDEP II therefore seeks to address these constraints by the promotion of selected products through improved access to markets, the development of and improved access to technology for sustainable natural resource management, improved access to agricultural financial services, improved rural infrastructure and enhanced human resource and institutional capacity.

The policy targets commodities that are food security-enhancing and facilitate agricultural income diversification, as well as the enhancement of productivity of the commodity value chain, through the application of science and technology. In general, agricultural production outcomes are mixed regarding the achievement of set policy objectives. The structure of the economy remains largely agrarian and agriculture contributes the largest share of gross domestic product (GDP), even though agriculture's share has been declining somewhat (Fig. 8.1). There is an estimated self-sufficiency ratio of 100% for roots and tubers, and 90% for cereals (excluding rice). However, seasonal food insecurity is widespread, due to the almost total dependence on rain-fed agriculture and weak postharvest capacities, which limit the shelf life of many commodities. Estimated self-sufficiency ratios for rice (50%), fish (60%) and meat (30%) are much lower (MoFA, 2007a). Despite the high self-sufficiency ratios for most food crops, the food balance, derived from available supply and demand statistics for key food commodities, shows a

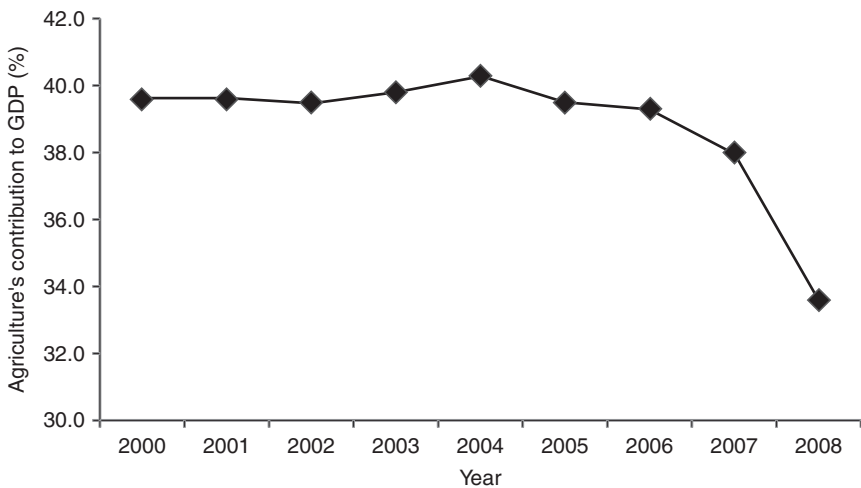


Fig. 8.1. Trends in agriculture's contribution to GDP. (From: Ghana Statistical Service.)

deficit for the major food items, with the exception of cassava, millet, sorghum, plantain, cocoyam and yam. For instance, from 1995 to 2006, Ghana imported, on average, 100% of its wheat and sugar, two-thirds of its rice, half of its beef and one-third of its chicken.

Crop Diversification, Food Self-sufficiency and Food Security

Subsistence production by households could be viewed as a food self-sufficiency strategy (von Braun, 1995; Govereh and Jayne, 2003). Even though economic theory may suggest that this strategy is inferior, the output and marketing constraints faced by farm households in SSA makes it probably the most viable option (von Braun, 1994; Thomson and Metz, 1998; Govereh and Jayne, 2003). Agricultural economists and other researchers have attempted to answer the question as to why rural households in Africa choose the self-sufficiency strategy, even for crops for which they are comparatively disadvantaged. When faced with output and price risks, the profit maximization motive alone cannot explain rural households' crop production choice (Guvele, 2001; Windle and Rolfe, 2005).

Central to the choice of the food self-sufficiency strategy is the attainment of the household food security objective. Thus, given their peculiar economic, agro-ecological and infrastructural circumstances, households would choose a strategy that is most likely to guarantee their food security. The suggestion that subsistence production is an inferior strategy for the attainment of food security is based on the assumption that markets are not missing and that the utility derived by households from participation in markets for the goods and services they produce and those they require for achieving food security exceed the disutility from participating.

The relationship between food self-sufficiency, food security and agricultural diversification would depend on how diversification is defined. If diversification implies increased cultivation or the adoption of cash crops, then risk-averse households may diversify only if they perceive that their food security is not threatened. Fafchamps (1992) presents a model that suggests that, in developing countries, households' cultivation of cash crops is conditional on the attainment of food security, which he suggests could best be realized through food self-sufficiency. The marginal benefit of diversification must exceed the marginal cost if risk-averse households were to diversify (Featherstone and Moss, 1990). Empirical findings by von Braun (1994, 1995), Jayne (1994), Govereh and Jayne (2003) and Joshi *et al.* (2003) have demonstrated that, indeed, households in developing countries strive to achieve food security by maintaining significant levels of subsistence, even when they participate in cash crop production. These empirical investigations, particularly by Bouis (1994), von Braun (1994, 1995) and Govereh and Jayne (2003), also show that diversification into cash crop production has no significant negative effects on household food security. But the cross-sectional data used in most of these studies may not capture the dynamics implied by household food security.

Diversification into cash crop production has been criticized on the basis that households may have to rely more on food purchases as a result, which may lead to deterioration in their food security situation, given the high cost of calories and

price instability (Thomson and Metz, 1998). This is notwithstanding the fact that this hypothesis was tested by Bouis (1994) in six countries, including Kenya, Rwanda, Malawi, Sierra Leone and Gambia, and no significant change in sources of food consumption was found. There was no significant change in staple crop production for households that diversified into cash crop production. In fact, in most of the African countries, households still grew more than half of their food, even after participation in cash-cropping schemes. On the other hand, if agricultural diversification is defined as multiple agricultural output produced by a household, then it could be interpreted as a food security insurance strategy. The uncertain nature of rainfall patterns explains the observation by Joshi *et al.* (2003) in the Asia region that this type of agricultural diversification is more prominent in rain-fed areas. Thus agro-ecology and water supply are important determinants of multiple crop production (Rahman, 2009). Both output and price risk may be reduced by growing crops that differ in their production and marketing characteristics. Since diversification in this sense is an adaptation strategy to climatic variability (Bradshaw *et al.*, 2005), the more diversified a household is, *ceteris paribus*, the better insurance it has against shocks, particularly where livestock is part of the portfolio mix. But Quiroz and Valdes (1995) noted that, in general, agricultural output prices are positively correlated as a result of substitution possibilities in consumption and production as well as common reaction patterns of macroeconomic and global shocks.

Household wealth or asset endowments also influence the relationship between food self-sufficiency, security and agricultural diversification or specialization. Poorer households are less likely to diversify into cash crop production since they may be unable to cope with the transactions cost of ensuring food security through food purchases (Delgado and Siamwalla, 1997). Diversification into cash crop production may also increase labour productivity and employment, as well as increase hired labour engagements at the village and household level (Joshi *et al.*, 2003). To the extent that this increases household income, food and nutrition security could be enhanced (von Braun, 1995). Increased income could also lead to changes in food consumption patterns. If this happens to a significant extent, then the food security effects of the movement of household resources from the production of staples would be somewhat dampened (Joshi *et al.*, 2003; Windle and Rolfe, 2005; Minot *et al.*, 2006).

The Role of Infrastructure and Institutions

The dominance and persistence of subsistent or semi-subsistent agriculture has been attributed to high transactions cost, among other factors. This situation is mostly the result of poor infrastructure, particularly roads. Improved infrastructure reduces marketing risk, improves marketing efficiency and thus reduces preference for a high degree of self-sufficient levels of production (von Braun *et al.*, 1994; von Braun and Immink, 1994; Quiroz and Valdes, 1995; von Braun, 1995; Joshi *et al.*, 2003; Windle and Rolfe, 2005; Weinberger and Lumpkin, 2007; Rahman, 2009). A successful agricultural diversification that leads to increased and sustainable food security would no doubt require adequate

infrastructural development. The development of irrigation facilities would also reduce the reliance on rain-fed agriculture and so lead to a reduction in output risk, which would eventually decrease the need for subsistence and promote diversification into non-staple crops.

Aside from 'hard infrastructure', 'soft infrastructure' in the form of institutions is critical for diversification and improved food security (Goletti, 1999). For example, the development of rural financial institutions which are accessible to smallholders could enhance complementarities between staple crop production and diversification into self-sufficiency. The development of legal and contractual environments, farmers' capacity building, research and extension all reduce the incentive for subsistence and promote diversification.

The state has an important role to play in determining the type and extent of agricultural diversification since the development of 'hard' infrastructure is largely the role of the state. But the development of infrastructure is not enough; promoting technological change in staple food production at the farm level that increases productivity of land and labour plays a parallel role in diversification into cash crops (von Braun, 1994; Joshi *et al.*, 2003). A comprehensive study by the International Food Policy Research Institute, employing case studies from several developing countries in Africa and Asia, concluded that a smooth transition from subsistence-oriented smallholder production systems to diversification into cash crop production requires macro-policy reforms, infrastructure policy, agricultural technology development and dissemination, land tenure reform and rural financial policies, among others (von Braun and Kennedy, 1994a; Pingali and Rosegrant, 1995). Policies that enhance input supply and output marketing would eventually benefit both staple and cash crop production, thereby reducing the insurance price paid by households to maintain food security through their own food supply.

In this regard, the Millennium Development Authority Programme, which is currently being implemented in Ghana with the aim of improving both 'hard' and 'soft' infrastructure, among other things, is most welcome. It has been argued that diversification should be demand-driven rather than policy-induced through the picking and choosing of commodities (Delgado, 1995), but, depending on the extent of market development, the degree of agricultural transformation and the relative importance of agriculture in the economy, it may be necessary for government to promote diversification as a policy objective (Delgado and Siamwalla, 1997).

Analytical Framework

The basic agricultural household model assumes separability of consumption and production decisions (Singh *et al.*, 1986). This assumption may not be plausible under prohibitive transactions cost. Linked to this is household behaviour under output and price risk, which makes consumption and production decisions inseparable. Since an outcome of a production decision made *ex ante* is unknown with certainty, profit maximization alone is an inappropriate behavioural assumption (Guvele, 2001). Rural households would be concerned about meeting food needs through their own production.

Since subsistence food production can be considered 'an insurance and credit market substitute' (von Braun and Kennedy, 1994b:20), hypotheses concerning the allocation of resources for subsistence (self-sufficient production) versus diversification into cash crop production would be made by considering the marginal utility per unit of additional cash crop production and the marginal disutility that could occur if households were to depend on purchased food for meeting their food needs. Jayne (1994) postulates that this decision would be based on the following decision criterion:

$$\begin{aligned} \text{cultivate cash crop if } E(\pi) > D[SPP * Q_s - VC_s] \\ + (1 - D)[Q_s * SC * x * PS - VC_s] \end{aligned} \quad (8.1)$$

where E is the expectations operator; π is gross margin from cash crop production; D represents a dummy variable which takes on a value of unity if the household expects to be food self-sufficient and zero otherwise;² SPP is staple food crop producer price; Q_s is per hectare expected staple food crop production quantity measured in grain equivalent; VC is the per hectare variable cost of staple food crop production; SC is the proportion of staple food crops consumed over a period of 1 year; x is the extraction rate from grain to meal (per cent); and PS is the acquisition price of staple food meal. The opportunity cost of diversification into non-staple production is given by $Q_s * SC * x * PS - VC_s$. All else held constant, the higher the opportunity cost the less likely it would be for households to diversify. Thus, if the household expects to be food self-sufficient; the decision to diversify (or to allocate more resources to crops other than staples) becomes a comparison of expected gross margins of staples and non-staples. Note that in their choice modelling experiment, Windle and Rolfe (2005) observed risk perception and gross margins as the most important determinants of crop cultivation choice.

Let R_{ijt} be the revenue obtained by household i from choosing to allocate resources to the cultivation of cash crop j in year t , then by ignoring the inequality sign in Eqn 8.1, we can write:

$$R_{ijt} = E(\pi) - D[SPP * Q_s - VC] - (1 - D)[Q_s * SC * x * PS - VC] \quad (8.2)$$

To test whether household food self-sufficiency plays a significant role in household diversification decisions, it is important to note that decisions affecting food self-sufficiency and resource allocation to non-staples are made simultaneously. Let y be the value of staple crop production, \hat{y} is the predicted value of staple crop production, \hat{H}_{fss} is estimated household food self-sufficiency, x is a vector of exogenous variables that affect cash crop production decisions, FS is staple food stock at the beginning of the harvest period, CR is household staple food consumption requirements, y' is the share of land planted to non-staple

² Jayne (1994) notes that, since the relationship between the factors of production and yields are stochastic, the level of self-sufficiency must be assessed *ex ante*.

crops for sale. Then the following equations could be used to estimate the relationship between food self-sufficiency and diversification into non-staples:

$$y = y(x) + \varepsilon_1 \quad (8.3)$$

$$\widehat{H}_{fss} = \hat{y} + FS - CR \quad (8.4)$$

$$y' = y'(x, \widehat{H}_{fss}) + \varepsilon_2 \quad (8.5)$$

In the above setting, household food stock and consumption requirements are assumed to be known *ex ante*. Jayne (1994) estimated the relationship between oilseed cultivation and grain self-sufficiency by allowing the slope and intercept linking cash crop area to the degree of household self-sufficiency in grain to change at the point at which grain self-sufficiency is reached. Under the null hypothesis that if household food self-sufficiency does not exert a significant effect on diversification into cash crop production, these terms will be significantly different from zero. If market constraints are not binding, a household can diversify into non-staples to increase income without negative impact on household food security. These concepts are investigated empirically using panel data instead of the cross-sectional data applied by Jayne (1994).

The Econometric Models

Two main equations are estimated: the first specifies the relationship between staple crop self-sufficiency and diversification into non-staple crop production while the second quantifies the determinants of household food security. We adopt from Jayne (1994), *mutatis mutandis*, a model derived from Eqn 8.3 to estimate the relationship between food self-sufficiency and diversification into non-staple crop production. The observed dependent variable is left-censored at zero (i.e. it takes on positive values for households that cultivate non-staples over the two periods but zero otherwise).³ In the second equation the observed dependent variable is binary, taking the value of one if the household is food secure and zero otherwise. Given the panel data structure, it is possible to control for unobserved factors that may influence a household's preference for the self-sufficiency strategy as well as the probability of being food secure. These factors are referred to as unobserved household heterogeneity. If we assume that all household heterogeneity can be captured by the observed explanatory variables, then we can specify the models for household *i* in period *t* as

$$y_{it}^* = x_{it}\beta + v_{it} \quad (8.6)$$

where $y_{it} = y_{it}^*$ when $y_{it}^* > 0$ but $y_{it} = 0$ when $y_{it}^* \leq 0$ in the diversification equation, while $y_{it} = 1$ if $y_{it}^* > 0$ and $= 0$ otherwise in the food security equation,

³ 15% of households did not cultivate any non-staples.

y^* denotes the latent diversification and food security variables respectively, x is a vector of time-varying and time-invariant explanatory variables (including staple food self-sufficiency, infrastructure and institutional variables in the diversification equation), β is the vector of coefficients associated with the vector x , and v is the composite error term. The above specification leads to the estimation of pooled tobit and probit models for the diversification and food security equations respectively. That is, the data is essentially treated as a cross section: the 2002 and 2008 data are pooled, and tobit and probit models are estimated in each case. These coefficient estimates would be biased if there are significant household unobserved effects. Suppose that the household-specific heterogeneity c is time constant across households, the unobserved effects model can be written as

$$y_{it}^* = x_{it}\beta + c_i u_{it} \quad (8.7)$$

where u_{it} is the idiosyncratic error. We treat c_i , x_{it} and y_{it} as random draws from the population of interest but assume that c_i is uncorrelated with the x_{it} (Wooldridge, 2002). The assumption that $\text{Cov}(x_{it}, c_i) = 0$, $t = 2002, 2008$ leads to the estimation of random effects tobit and probit models. This is mainly to allow for the estimation of the coefficient of the infrastructure variable, which is important to our hypotheses but is invariant across observations. The unobserved effects tobit model also assumes that $u_{it}|x_{it}, c_i \sim \text{Normal}(0, \sigma_u^2)$. The random effects probit model is also estimated under the assumption that $u_{it}|x_{it} \sim \text{IN}(0, \sigma_u^2)$ and $c_i|x_{it} \sim \text{IN}(0, \sigma_c^2)$ (IN refers to independent normal distribution).

A detailed description of the diversification and food security variables is given in the Measurement of Key Variables section. Unlike Jayne (1994), who measured diversification into cash crop production as area under oilseed, this study uses the share of cultivated land allocated by household i to non-staples in period t as the dependent variable in the diversification equation. In the food security equation, the possible exogeneity of the diversification variable is tested. The intuition is that food secure households may be less concerned about meeting consumption needs through own staple production, in which case non-staple crop production would depend on households' expected food security status.

Study Villages

This study is based on household-level panel data collected in 2002 and 2008 from eight villages in Ghana. The crop year, however, covered the years 2001 and 2007. The eight villages are located in two administrative regions (the Eastern and Upper-East regions) and in two distinct agro-ecological zones. The population of the villages, based on estimates by the village key informants, ranges from about 371 in Gyedi to 3800 in Zanlerigu. The research was designed to study four major staple crops: two in each region – cassava and maize in the Eastern region; rice and sorghum in the Upper-East region.

A multi-stage random sampling technique was employed to first select the regions, districts, villages and then, finally, the sample households. The regions were selected based on the major staples cultivated in the villages. The districts in each region were selected based on their agricultural potential as per the researchers' assessment based on information from the Ministry of Food and Agriculture (MoFA). From the focus group discussions, participants described households in all the villages except Akatawia, Asitey and Doba as agricultural households. That is, the primary activity of households in the five villages was crop and livestock production, with crop sales generating the largest share of income. In Akatawia, Asitey and Doba 5%, 10% and 5% of households, respectively, were described as non-agricultural households.

During the 2002 survey, 416 households were surveyed from the Manya Krobo, Fanteakwa, Talensi Nabdam and Kassena-Nankana districts. In 2008, 358 (or 86% of households interviewed in 2002) were successfully contacted. These were made up of 328 'original' 2002 households and 30 descendants of the 2002 households.⁴

All the villages were accessible by public transport, with either tarred roads (in the case of Akatawia, Asitey, Gyedi, Doba) or untarred all-weather roads (in the case of Apaa, Gaane, Zanlerigu and Shia). The villages are varying distances away from the district and regional capitals. Gyedi is a suburb of a district capital, while Asitey is located at the outskirts of another district capital. Apaa, Gaane, Zanlerigu and Shia are relatively remote and served by public transport less frequently.

Measurement of Key Variables

The main variables of interest are food self-sufficiency, food security, agricultural diversification and infrastructure. von Braun (1994) used a rule of thumb figure of 170 kg of cereal equivalent per capita per annum to estimate household food self-sufficiency, while Jolly and Gadbois (1996) applied the FAO's 200 kg of refined cereal equivalent. In this study, food self-sufficiency is estimated using 170 kg.⁵ We follow Jolly and Gadbois (1996) and convert all grains and roots to maize equivalent. The maize equivalent of rice and sorghum are calculated to estimate total grain produced and available to the household, i.e. after accounting for postharvest losses. The milled ratios used are adopted from Jolly and Gadbois (1996) and is shown in Table 8.1.

The ratios applied in the conversion to maize equivalent is based on energy (calories) derived from the produce, as reported in Okigbo (1991). We also use ratios from Jolly and Gadbois (1996). Equation 8.4 is combined with information from Table 8.1 to model predicted levels of food self-sufficiency.

⁴ Most of these households are made up of adult children of the 2002 households, mostly living in the same dwelling but whose parents (head of households in 2002) had passed away.

⁵ We also experimented with 200 kg of cereal equivalent and found most households to be food deficient.

Table 8.1. Maize equivalent ratios for estimating food self-sufficiency. (From: authors' calculations based on sources cited.)

	Calories/kg	Milling ratio	Maize equivalent ratio ^a	
			A	B
Maize	3630	0.85	1.00	1.00
Rice	3340	0.65	0.92	0.99
Sorghum	3350	0.90	0.92	0.97
Cassava	1460		0.40	0.43

^aThe conversion ratio in A is estimated based on energy derived (calories) from the product, while we use ratios in Jolly and Gadbois (1996), after adjusting for cassava, in estimating B.

Due to the lack of actual consumption quantities, we are restricted in our measurement of food security. We construct a food security measure based on the definition in Thomson and Metz (1998), which classified households as food secure and food insecure based on whether or not a household's food entitlement is greater than its needs. First, household food needs are estimated using 170 kg of cereal equivalent per person per year multiplied by household size.⁶ To estimate entitlements, own-produced staples are converted into maize equivalent, as in the calculation of self-sufficiency. Let FE be household food entitlements and FN household food needs, then a household is defined as food secure if $FE > FN$. Let $FN_i = 170 \text{ kg} * HHS$, where HHS is household size, and let HP be household food needs met by the amount of own-produced food consumed, then $GAP = FN_i - HP_i$ represents the gap that has to be met from elsewhere. Based on the GLSS 5 (see Ghana Statistical Service, 2008)⁷ results on the actual share of household expenditure on food, we estimate how much of this gap can be met through the food expenditure share of household total income. If that share of income meets this gap then the household is food secure; at least $FE - FN$ should be positive.

Two measures of agricultural diversification are considered in this study. First, diversification into non-staple crop production is measured as the per cent share of land planted to crops other than staples (maize, cassava, sorghum, rice), which are mainly for sale. These were mainly vegetables, beans, groundnuts, cocoa and oil palm. Given observations for a cross section of households over two periods, we can estimate the relative share of area planted to non-staples in total cultivated area over time. Second, diversification as multiple agricultural output production is measured using the Simpson Index:

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

⁶ The data do not allow the use of an adult equivalent measure.

⁷ 26.7% of income is applied to all four villages in the Upper-East region; in Gyedi and Apaa 41.2% is used and in Asitey and Akatawia 48.5% is applied.

where P_i is the proportionate area of the i^{th} crop in gross area cultivated. This measure of diversification has been used severally in the literature (see, for example, Joshi *et al.*, 2003 and Minot *et al.*, 2006).

Infrastructure is measured by distance to market outside the village (km) and marketing cost (US\$/kg/km), while the effect of institutions is captured by agricultural extension contact, active membership of farmer-based organizations (FBOs) and a dummy measuring land tenure security. It takes on a value of unity if the household believes they have full control over land (i.e. they do not need to consult anyone for permission before cultivation) and zero otherwise. All other variables used in the empirical models are described in Table 8.2.

Results

Before presenting the econometric results, some important descriptive statistics are presented. The dynamics of food self-sufficiency and food security are shown in Table 8.3. With regard to food self-sufficiency, the majority of households (68.3%) are in chronic food deficit, with only 8.2% of households being self-sufficient over the period of observation. Less than one-quarter (23%) of the surveyed households were food secure in both 2002 and 2008. A larger proportion (38.5%) of households were transitory food insecure, with about the same percentage being chronic food insecure.

There are also observed changes in agricultural extension contact and FBO membership. About 44.5% of households had frequent extension contacts in both periods, while 12.5% did not have frequent contacts in both periods. It is important to note that extension contact over the two periods is significantly greater among males than females at the 5% level. For example, while 25% of female farmers never had agricultural extension contact over the two periods, only 10% of male farmers had no contact. Gender differences in extension have been observed at the national level (MoFA, 2007b). Though there are similar differences with regard to FBO membership, the differences are not statistically significant, even at the 10% level. Next the econometric results are presented.

Is staple food self-sufficiency necessary for diversification into non-staple crops?

Two main hypotheses are tested: (i) given non-separation of production and consumption decisions, a staple food self-sufficient rural household would allocate a greater share of its resource (land) to the production of non-staples than a food-deficit household; and (ii) improved infrastructure and rural institutions would both improve staple crop productivity and enhance diversification into non-staples. Prior to testing these hypotheses using multivariate econometric models, a two sample t -test is performed. Assuming equal sample variance, staple food self-sufficient households allocate statistically significant larger shares of land to non-staples than staple food-deficient households (Table 8.4).

To control for other factors, we estimate a pooled tobit (see Appendix, Table 8A.1) and a household random effects tobit (Table 8.5) model for each

Table 8.2. Description of variables.

Variable	2002		2008	
	Mean	Std dev.	Mean	Std dev.
Share of non-staples in total cropped area (%)	28.19	21.09	26.14	20.27
Simpson Index of Diversification	0.57	0.11	0.53	0.16
Food self-sufficiency dummy (1 = food self-sufficient)	0.24	0.43	0.16	0.37
Food self-sufficiency level (kg)	140.25	199.35	119.05	288.98
Food security dummy (1 = food secure)	0.33	0.47	0.52	0.50
Food security level (kg)	-464.61	138.92	1748.20	633.31
Real marketing cost (US\$/kg/km)	0.06	0.04	0.09	0.06
Distance to an all-weather road (km)	0.97	1.44	0.97	0.44
Distance to main market outside village	5.32	3.06	5.32	3.06
Extension contact (1 = received extension advice regularly)	0.73	0.44	0.59	0.49
Active membership of FBO (1 = member)	0.37	0.48	0.26	0.44
Land rights measure (1 = complete control)	0.80	0.40	0.75	0.43
Credit access (1 = has access)	0.40	0.49	0.36	0.48
Sex of farm manager (1 = female)	0.14	0.35	0.16	0.37
Household size	9.04	6.21	7.64	4.63
Proportion of household members below 16 years (%)	37.84	20.19	36.15	21.33
Proportion of household members above 60 years (%)	5.91	12.55	9.91	16.95
Dependency ratio	0.99	0.84	1.15	1.36
Age of farm manager	45.06	14.56	54.05	18.98
Education level of farm manager (years)	4.68	5.11	5.28	5.46
Total area under cultivation (farm size in ha)	2.56	2.16	2.09	1.67
Staple crop farm size (ha)	1.78	1.78	1.35	1.08
Own-produced staples in maize equivalent (kg)	881.29	967.76	713.34	1133.49
Remittance income (US\$)	98.98	146.81	116.45	172.72
Other non-farm income (US\$)	374.46	793.09	594.38	1258.88
Asset index	0.22	0.13	0.28	0.17
Number of cows (Upper-East region only)	1.79	3.14	2.37	3.97
Number of sheep/goats	5.47	7.89	6.53	9.44
Number of poultry	13.12	18.34	17.80	21.12
Livestock index (poultry equivalent)	83.20	121.78	89.58	118.38

Table 8.3. Food self-sufficiency, food security and institutional dynamics. (From: computed from survey data, 2002 and 2008.)

	Freq.	Per cent	
<i>Dynamics of food self-sufficiency</i>			
Became food deficient	51	15.6	Transitory food deficient (23.5%)
Became self-sufficient	26	7.9	
Chronic food deficient	224	68.3	
Food self-sufficient	27	8.2	
<i>Dynamics of food security</i>			
Became food insecure	31	9.5	Transitory food insecure (38.5%)
Became food secure	95	29.0	
Chronic food insecure	126	38.4	
Food secure	76	23.2	
<i>Dynamics of agricultural extension contact and FBO membership</i>			
Stopped agricultural extension contact	95	28.96	
Began agricultural extension contact	46	14.02	
Never had agricultural extension contact	41	12.50	
Always had agricultural extension contact	146	44.51	
Dropped out of farmer-based organization	77	23.48	
Joined a farmer-based organization	41	12.50	
Never been member of farmer-based organization	167	50.91	
Always been member of farmer-based organization	43	13.11	

Table 8.4. Land allocation to non-staples, by staple crop self-sufficiency status.

	Per cent share of land allocated to non-staples ^a		
	Self-sufficient in staples	Staple crop-deficient	t-statistic
Upper-East region	26.3 (25.4)	19.0 (19.1)	1.82
Eastern region	22.3 (28.8)	14.1 (16.6)	3.01***
Combined	23.0 (28.1)	17.0 (18.4)	2.82***

^aStandard deviation in parentheses.

***Significant at 1% level.

region separately as well as for the entire Ghana sample. These models predict the share of land cultivated to non-staple crops and are statistically significant (as shown by the respective wald chi-squared values). To test hypothesis (i), a joint test is performed on the coefficients of the predicted self-sufficiency dummy and that of its interaction with the predicted level of household food

Table 8.5. Determinants of diversification into non-staple crops (random effects tobit).^a

	Upper-East region	Eastern region	Combined sample
Expected staple food self-sufficiency level (SFSSL)	-0.0339*** (5.66)	0.0050 (1.35)	0.0059 (1.95)
Expected staple food self-sufficiency dummy (SFSSD)	-4.3967 (0.86)	-7.2438 (1.35)	-4.7079 (1.28)
Self-sufficiency dummy × self-sufficiency level (SFSSLD)	0.0014 (0.08)	0.0461*** (3.63)	0.0302*** (2.98)
Distance to main market outside village (MD)	-0.5864 (1.00)	-19.6320** (2.22)	-0.9225** (2.05)
Year × distance to market	1.2348 (1.19)	11.5624 (1.00)	-0.3087 (0.56)
FBO membership (FBO)	-1.3486 (0.55)	8.9503** (2.53)	2.6470 (1.30)
Agricultural extension contact (AE)	11.9495*** (4.03)	5.5867 (1.58)	6.2060*** (2.79)
Extension contact × sex of household head (AE_Sex)	-0.6797 (0.10)	-4.7856 (0.63)	-2.7811 (0.55)
Credit access (Cr)	-0.5530 (0.23)	-0.4857 (0.17)	-0.2637 (0.14)
Complete control over cultivated land (LR)	-5.5178 (1.60)	4.8885 (1.57)	0.3596 (0.16)
Female-headed household	-18.7997*** (3.24)	-1.6176 (0.29)	-1.3626 (0.35)
Adult-equivalent labour unit (L)	-5.4057*** (5.91)	2.0981** (2.29)	1.2021** (2.56)
Dependency ratio (DR)	-2.9292** (2.43)	-2.2588 (1.43)	-0.5248 (0.63)
Education level of household head (EDUC)	-0.6461** (2.38)	-0.1392 (0.42)	-0.0800 (0.38)
Age of household head (Age)	-0.1393 (0.41)	0.1372 (0.31)	-0.1284 (0.47)
Square of age of household head (Agesq)	0.0027 (0.92)	-0.0021 (0.55)	0.0011 (0.45)
Remittances (RI)	-0.0213 (1.46)	-0.0084 (0.40)	-3.9896 (1.86)
Other non-farm income (Masakure <i>et al.</i> , 2008)	-0.0036 (1.32)	0.0043** (2.21)	0.0014 (0.92)
Physical asset index (AI)	-1.1792 (0.14)	20.3720** (2.04)	14.1480** (2.18)
Year dummy (2008 = 1)	-11.8409*** (4.70)	-0.7923 (0.12)	0.2959 (0.08)
Constant	67.9623*** (6.64)	3.9483 (0.30)	12.0961 (1.42)
Number of observations	375	280	613
Log likelihood value	-1476.70	-1108.11	-2417.86

Continued

Table 8.5. Continued.

	Upper-East region	Eastern region	Combined sample
Wald chi-squared	90.62	77.16	124.74
R ^{2b}	0.218	0.270	0.180
Rho ^c	0.080	0.034	0.086
	(0.078)	(0.369)	(0.058)
Ho: SFSSD = SFSSLD = 0	$\chi^2 = 2.10$	$\chi^2 = 14.21$	$\chi^2 = 9.92$
	[Prob = 0.350]	[Prob = 0.001]	[Prob = 0.007]

Significant at 5% level; * significant at 1% level.

^aAbsolute value of *t*-statistics in parentheses.

^bR² between the predicted and observed values.

^cStandard errors in parentheses.

self-sufficiency. In the combined sample, the hypothesis that these coefficients are jointly equal to zero is rejected at the 1% level, suggesting that staple food self-sufficient households have a higher propensity than staple food-deficient households to allocate more resources (land) to non-staples. This result is consistent with Jayne (1994), who applied cross-sectional data from Zimbabwe and used land allocated to oilseed production rather than its share in total land cultivated as the dependent variable.

The regional subsample estimates produce a similar outcome in the Eastern region ($F = 6.96$, P value = 0.001) but not in the Upper-East ($F = 1.67$, P value = 0.189). A priori, it was expected that, given the monomodal rainfall pattern in the Upper-East region, the self-sufficient strategy would be relatively more important than in the Eastern region.

A possible reason for the contrary outcome is the already very low level of per capita staple crop output in the region: the majority of households are staple food deficient even though they consume more than 95% of their staple output. In some of the villages, however, some farmers participate in an irrigation scheme and dry-season vegetable cultivation.

The second hypothesis is confirmed in the combined sample estimates: the further the distance to markets outside the village the less likely it is for households to diversify into non-staples; FBO membership and regular contact with agricultural extension services increases the predicted share of land allocated to non-staples by about 4% and 5% compared to non-FBO members and farmers who rarely have contact with agricultural extension respectively, *ceteris paribus*. In the regional subsample, the distance effect is not significant, even at the 10% level, in the Upper-East villages. FBO membership is relatively more important in the Eastern region, while agricultural extension contact is more important in the Upper-East for diversification into non-staple crop production.

Other significant predictors of non-staple production in the entire sample are number of adult-equivalent labour units and physical assets index (human capital and wealth indicators respectively). This is consistent with the literature,

which predicts a positive relationship between household wealth variables and cash crop production (Delgado and Siamwalla, 1997). However, regional differences exist, as shown in the regionally disaggregated estimates. While an adult-equivalent labour unit has a significant positive effect in the Eastern region, the opposite is the case in the Upper-East region. The long lean season in the Upper-East, which results in low labour productivity, may account for this situation. Dependency ratio has a strong negative effect on resource allocation to non-staples in the Upper-East. Indeed, a calculation of the marginal effects on the probability that a household would diversify into self-sufficiency show that a unit decrease in dependency ratio increases this probability by 0.18, *ceteris paribus*. Given that the household allocates some land to non-staples (i.e. if the household is not censored at zero), a unit decrease in dependency ratio increases the per cent share of land allocated to non-staples by 16 units (i.e. 16%). Female-headed households in the Upper-East region are significantly less likely to allocate land to non-staples. Non-farm sources of income exert a significant positive effect on diversification into non-staples in the Eastern region. Thus, there appear to be complementarities between non-farm activity and diversification into 'high value' crops in those villages. The time dummy is negative and statistically significant at the 1% level in the Upper-East region but not in the Eastern region, indicating significant reduction in resources allocation to non-staple production in 2008 compared to 2002 in that region. This is partly attributable to floods that affected some of the villages in the region.

Does diversification into self-sufficiency hurt or enhance household food security?

Next, the determinants of household food security are estimated to test two main hypotheses: (i) if markets are incomplete, the allocation of resources to the production of non-staples would hurt household food security; and (ii) households with multiple crop portfolios are more likely to be food secure. Since we fail to reject the exogeneity of diversification into non-staples in the food security equation, we estimate random effects and pooled probit models using the latent binary measure of food security as the dependent variable. The coefficients of both models were approximately the same,⁸ but since we fail to reject the null hypothesis that ρ (rho) = 0 in the random effects probit estimation, even at the 10% level, the pooled probit model is favoured.⁹

The conclusion on our hypotheses depends on the regional location of villages (Table 8.6 and Table 8A.2). The results from the combined sample estimates

⁸ Given the correlation structure between two successive error terms $\frac{\sigma_c^2}{\sigma_c^2 + \sigma_u^2}$ where σ_c^2 and σ_u^2 are the variance of the random unobservable component and the idiosyncratic error respectively, then if $\sigma_c^2 = 0$ the pooled probit parameters would be equal to those estimated by the random effects probit.

⁹ The fact that we reject the null hypotheses of $\rho = 0$ suggests the absence of significant household unobserved heterogeneity.

Table 8.6. Determinants of rural household food security (random effects probit.)^a

	Marginal effects		
	Upper-East region	Eastern region	Combined sample
Share of land cultivated to non-staples	-0.0044	0.0120**	0.0045
	-0.89	2.26	(1.28)
Staple crop farm size	0.1151	0.3286***	0.1770***
	1.22	3.46	(2.80)
Simpson's Index of Diversity	0.3133	1.0665	0.2520
	0.50	1.28	(0.52)
Age of household head	-0.0863***	-0.0281	-0.0607***
	-3.42	-0.87	(-3.09)
Age of household head squared	0.0008***	0.0003	0.0005***
	3.40	0.86	(3.10)
Sex of household head	0.2863	-0.3742	-0.3732
	1.06	-1.49	(-1.58)
Upper-East female head of household			0.5281
			(1.50)
Education of household head	0.0479**	0.0328	0.0285**
	2.53	1.60	(1.97)
Dependency ratio	-0.4795***	-0.3861***	-0.3932***
	-3.02	-3.62	(-4.51)
Physical asset index	1.1548	0.8002	1.0723**
	1.76	1.02	(2.24)
Remittance income	0.0056***	0.0044**	0.0044***
	3.08	2.04	(4.27)
Other non-farm income	0.0045***	0.0068***	0.0049***
	3.50	3.1	(3.16)
Number of cows owned	-0.0262		-0.0452
	-0.86		(-1.56)
Number of sheep and goats owned	0.0014	0.0110	0.0054
	0.12	0.42	(0.58)
Number of poultry owned	0.0048	0.0074	0.0051
	1.00	1.04	(1.35)
Social capital	0.1558	-0.0901	0.1532
	0.80	-0.37	(1.01)
Credit access	-0.2133	0.1891	0.0513
	-1.07	0.94	(0.38)
Distance to market	-0.1066**	0.0243	0.0337
	-2.19	0.86	(1.36)
Year dummy (2008 = 1)	-0.2057	0.8325***	0.3090**
	-0.95	3.51	(2.05)
Number of observations	375	277	652
Log likelihood	-130.41	-119.89	-256.2
Per cent correctly predicted	79.5	77.5	76.0
Wald chi-squared	64.59	71.60	202.48
Rho ^b	1.1 × 10 ⁻⁵	1.8 × 10 ⁻⁶	2.8 × 10 ⁻⁶
	(2.5 × 10 ⁻⁴)	(4.8 × 10 ⁻⁴)	(5.3 × 10 ⁻⁶)

^aAbsolute value of robust z-statistics in parentheses.

^bStandard errors in parentheses.

Significant at 5% level; *significant at 1% level.

reject the hypothesis that resource allocation to non-staples hurts household food security but is also inconclusive on whether non-staple production enhances food security. A priori, a negative sign was expected on the coefficient of the self-sufficiency crop production variable. Even though we observe a negative sign in the Upper-East region, the effect is not statistically significant, even at the 10% level. In the Eastern region, however, we find a significant positive relationship between non-staple crop production and household food security. The predicted probability of food security for a household that devotes all its land to the production of staples in this region is about 0.51, while for a household that cultivates the sample mean share of land (23.7%) to non-staples, the predicted probability of food security is 0.67, *ceteris paribus*. The different outcomes in the two regions may be attributable to better market conditions (higher prices and higher potential demand due to proximity to larger urban centres) in the Eastern region. The second hypothesis test is carried out on the coefficient of the Simpson's Index of Diversity – a positive sign was expected a priori. This was observed but was not statistically significant at the 5% level. Thus, in general, there is no evidence that multiple agricultural portfolios necessarily enhance food security. It is possible that there are no significant negative or weak positive correlation between agricultural-based portfolios.

Other important predictors of rural household food security include resource allocation to staple crop production, household characteristics (sex, age, household composition and education), physical asset wealth, remittances, other non-farm income and distance to main market outside the village. In general, female-headed households are more likely to be food insecure than their male counterparts, but the difference is statistically significant only in the Eastern region. In this region, the reported marginal effects (of the pooled probit model) show that female-headed households are 9% less likely to be food secure than male-headed households.

Human capital assets are important for household food security. This is measured by dependency ratio and education. The probability of food security decreases with increasing dependency ratio, while education is a significant positive predictor of food security in both regions. Household wealth indicators – physical asset index and small ruminant ownership (in the Upper-East region) – are positively associated with household food security. It appears food security is more responsive to physical asset ownership in the Upper-East than the Eastern region. Even though at the sample mean the predicted probability of food security is 0.65 for the Eastern region sample and only 0.15 for the Upper-East region, a 10% increase in asset index (from the mean), however, increases the probability of food security by only 0.4% in the Eastern but 13% in the Upper-East region. Households who own sheep and goats in the Upper-East region are more likely to be food secure. This is not surprising because, during the lean season, the sale of livestock becomes very important in those villages. Finally, the transactions cost variable shows the expected negative association with food security in the Upper-East region villages, suggesting that the higher the transactions cost, the less likely it is for households to be food secure.

Conclusions and Policy Implications

Using panel data from eight villages in two distinct agro-ecological zones in Ghana this study has examined whether or not rural households seek food security insurance through production of their own staples as a priority before diversifying into the production of non-staples. Since transactions cost has been noted as an important reason for which rural households may choose the self-sufficiency strategy, we have explored the role road infrastructure and institutions play in this relationship. Secondly the study has estimated the determinants of household food security in order to verify if the allocation of resources to the production of non-staples hurts or enhances rural household food security. The results suggest that geographic location is important in the determination of the nature of the relationships. Overall, households in the study villages (particularly in the Eastern region) are more likely to allocate resources to the production of non-staples when household food requirements are met. Even though, by rural African standards, roads linking the villages are fairly good, we find some evidence that transactions cost significantly influences this relationship. Institutions (regular contact with agricultural extension and FBO membership) significantly reduce the need for self-sufficiency in staples and increase the probability of resource allocation to the production of non-staples. This is consistent with the literature, suggesting that the development of both 'hard' and 'soft' infrastructure are necessary for diversification into self-sufficiency (Goletti, 1999; Govereh and Jayne, 2003). This may be because regular access to agricultural extension advice and FBO membership are likely to increase staples crop productivity through technology adoption, which increases the ability of the household to meet its food requirements. Other important determinants of self-sufficiency crop production are adult-equivalent labour resource, dependency ratio and wealth indicators.

Two hypotheses were advanced regarding the second research issue. Overall, we found no evidence that the allocation of resources to non-staple production hurts or enhances household food security. In the Eastern region, however, there are significant synergies; the allocation of resources to non-staples had a positive and significant effect on food security. The second hypothesis, that a more diverse crop portfolio enhanced household food security, was inconclusive. The sign of the coefficient was positive but not statistically significant. Even though all households had diverse crop portfolios, a more diverse crop portfolio is not associated with a higher probability of being food secure. Other important predictors of rural household food security in the entire sample estimates include age, education, household composition, wealth, remittance income and other non-farm sources of income.

In order to speed up poverty reduction in rural Ghana through income growth, there would be the need for farmers to participate more in both staple and non-staple ('high-value crop') markets. But this would not just happen. It would be conditioned on, among other things, increased staple crop productivity. This is because, as productivity of staples increases, households are more likely be food secure, which is important for both staple crop market participation and the allocation of resources to the production of non-staples for the growing urban

markets. A policy approach that aims at increasing staple crop productivity is likely to have two effects: first, household food security would be enhanced and, second, households would then allocate more resources towards the production of 'high-value' crops to increase household income and reduce rural poverty.

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Appendix

Table 8A.1. Determinants of non-staple crop production (pooled tobit).^a

	Upper-East region ^b	Eastern region ^b	Combined sample ^b
Expected staple food self-sufficiency level (SFSSL)	-0.0315*** (5.22)	0.0044 (1.25)	0.0066** (2.21)
Expected staple food self-sufficiency dummy (SFSSD)	-6.0289 (1.15)	-7.9937 (1.49)	-4.9951 (1.36)
Self-sufficiency dummy × self-sufficiency level (SFSSLD)	0.0044 (0.24)	0.0462*** (3.66)	0.0307*** (3.06)
Distance to main market outside village (MD)	-0.8180 (1.41)	-16.4420*** (3.06)	-1.0845*** (3.19)
FBO membership (FBO)	-0.9805 (0.39)	8.1204** (2.44)	2.9086 (1.44)
Agricultural extension contact (AE)	14.7088*** (4.93)	6.4812 (1.86)	6.2322*** (2.80)
Extension contact × sex of household head (AE_Sex)	0.5882 (0.08)	-5.5693 (0.73)	-2.7033 (0.53)
Credit access (Cr)	-1.1612 (0.47)	-0.1548 (0.05)	-0.3802 (0.20)
Complete control over cultivated land (LR)	-5.7454 (1.61)	4.5574 (1.53)	0.7743 (0.35)
Female-headed household	-19.3641*** (3.26)	-1.8148 (0.33)	-1.2506 (0.33)
Adult-equivalent labour unit (L)	-4.8262*** (5.28)	1.8771** (2.15)	1.3455*** (2.97)
Dependency ratio (DR)	-3.2320*** (2.62)	-2.1366 (1.39)	-0.6284 (0.76)
Education level of household head (EDUC)	-0.6919** (2.54)	-0.1216 (0.37)	-0.0723 (0.35)
Age of household head (Age)	-0.2981 (0.87)	0.1437 (0.32)	-0.1555 (0.58)
Square of age of household head (Agesq)	0.0032 (1.06)	-0.0019 (0.48)	0.0012 (0.49)
Remittances (RI)	-0.0313** (2.11)	-0.0072 (0.35)	-4.1845 (1.96)
Other non-farm income (Masakure <i>et al.</i> , 2008)	-0.0050 (1.81)	0.0043** (2.23)	0.0013 (0.86)
Physical asset index (AI)	-10.9081 (1.29)	20.9170** (2.18)	13.6514** (2.18)
Constant	67.9526*** (6.56)	3.0021 (0.24)	12.3093 (1.51)

Continued

Table 8A.1. Continued.

	Upper-East region ^b	Eastern region ^b	Combined sample ^b
Number of observations	375	280	613
Log likelihood value	-1486.39	-1109.52	-2419.51
Wald chi-squared	66.02	74.73	117.73
R ^{2c}	0.205	0.259	0.18
Ho: SFSSD = SFSSLD = 0	F = 1.67 [Prob = 0.189]	F = 6.96 [Prob = 0.001]	F = 5.15 [Prob = 0.006]

^{*}Significant at 10% level; ^{**}significant at 5% level; ^{***}significant at 1% level.

^aDistrict dummies included but not reported.

^bAbsolute value of *t*-statistics in parentheses.

^cR² between the predicted and observed values.

Table 8A.2. Determinants of rural household food security (pooled probit).^a

	Marginal effects		
	Upper-East region	Eastern region	Combined sample ^b
Share of land cultivated to self-sufficiency	-0.0011 (0.81)	0.0008 ^{***} (2.81)	0.0017 (1.30)
Staple crop farm size	0.0374 (1.57)	0.0139 ^{***} (2.75)	0.0610 ^{***} (2.65)
Simpson's Index of Diversity	0.1135 (0.60)	0.0794 (1.71)	0.0940 (0.43)
Age of household head	-0.0250 ^{***} (3.48)	-0.0018 (1.04)	-0.0245 ^{***} (3.11)
Age of household head squared	0.0002 ^{***} (3.47)	0.0000 (1.25)	0.0002 ^{***} (3.26)
Sex of household head	0.0836 (1.06)	-0.0392 ^{**} (2.07)	-0.1615 (1.89)
Upper-East female head of household			0.2176 (1.78)
Education of household head	0.0143 ^{**} (2.54)	0.0021 (1.90)	0.0112 ^{**} (2.03)
Dependency ratio	-0.1425 ^{***} (3.49)	-0.0208 ^{***} (3.62)	-0.1533 ^{***} (4.85)
Physical asset index	0.3065 (1.52)	0.0573 (1.37)	0.4749 ^{**} (2.37)
Remittance income	0.0015 ^{***} (4.29)	0.0004 ^{**} (2.52)	0.0022 ^{***} (4.93)
Other non-farm income	0.0012 ^{***} (4.67)	0.0006 ^{***} (2.80)	0.0019 ^{***} (5.95)
Number of cows owned	-0.0071 (0.86)		-0.0187 (1.62)
Number of sheep and goats owned	0.0005 (0.20)	0.0001 (0.06)	0.0020 (0.60)
Number of poultry owned	0.0012 (0.92)	0.0007 (1.69)	0.0024 (1.57)

Table 8A.2.

	Marginal effects		
	Upper-East region	Eastern region	Combined sample ^b
Social capital	0.0555 (0.98)	0.0225 (1.39)	0.0411 (0.68)
Credit access	-0.0672 (1.20)	0.0123 (1.19)	0.0686 (0.52)
Distance to market	-0.0315** (2.15)	0.0016 (1.01)	0.0143 (1.52)
Number of observations	375	277	652
Log likelihood	-130.89	-127.00	-258.3
Per cent correctly predicted	82.1	80.1	78.0
Wald chi-squared	77.74	52.09	232.47
Pseudo R ²	0.348	0.256	0.419

^aAbsolute value of z-statistics in parentheses.

^bDistrict dummies included but not reported.

*Significant at 10% level; **significant at 5% level; ***significant at 1% level.