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# Household–Level Farm–Nonfarm Linkages and Household Welfare Implications

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*Executive Summary*

This report has examined linkages between the farm and nonfarm sectors using data collected from a sample of households in eight villages over the period 2002-2013. The welfare implications of nonfarm participation and income have also been analysed using two welfare indicators at the household level: a composite wealth index and food security. The regression analyses were based on the last two rounds of surveys (2008 and 2013) since these contained the relevant income data which is central to the theme of this report. More detailed analysis is provided using the most recent round survey data because even more detailed income data was collected. Indeed, the analysis using the most recent data is where this report contributes to the existing literature on farm-nonfarm-linkages.

Over the last two waves of the surveys, overall farm size increased significantly, from an average of 2 ha in 2008 to 2.6 ha in 2013. For the three staple crops studies in detail (maize, sorghum and rice) farm sizes increased significantly for maize and rice but not sorghum.[1] Maize yield in the Eastern region remained largely unchanged but all three staple crops experienced significant yield increases in the Upper East region between 2008 and 2013.

This report is in part concerned with examining the effect of nonfarm income on farm output through its effect on farm input use. On farm input use, it is observed that the proportion of farmers using improved seeds declined significantly between the last two waves of the panel. Significantly more farmers were using inorganic fertilisers (47% in 2008 compared with 37% in 2013) but the quantities being used remained largely unchanged. The proportion of farmers using hired farm labour remained unchanged between the two periods. Significantly fewer farmers had contact with agricultural extension agents (57% of farmers in 2008 compared with 50% in 2013).

Significantly fewer maize producing households sold their output in 2013 compared to 2008 (about a 19 percentage point difference), and conditional on selling, the average share put on the market also declined (from 66% in 2008 to 57% in 2013). The opposite is observed for rice: output market participation significantly increased by about 19 percentage points between

[1] Unless otherwise specified, in this report, the word significant or significance is used in the statistical sense.

2008 and 2013; conditional sale shares increased by 11 percentage points (from 41% of output in 2008 to 52% in 2013).

Turning to incomes and the nonfarm sector in particular, it is first observed, as expected, that crop income accounted for the largest share of household total cash income in the higher agro-potential Eastern region (77% in 2008 and 64% in 2013, representing a significant decline over the period). Crop incomes were less important in the Upper East, accounting for 19% and 29% of household income in 2008 and 2013, respectively (the increase over the period is significant). Over the entire sample, crop incomes represent 46% of household total cash income. Participation in nonfarm income increased significantly by 24 percentage points over time (57% in 2008 and 82% in 2013). Similarly, the share of household income derived from nonfarm sources increased by approximately 13 percentage points (30% in 2008 compared with 43% in 2013). Significant regional differences exist: over the two periods, average nonfarm income share among Upper East region households was twice the share among Eastern region households (23% for Eastern region households versus 47% for the Upper East).

The gender disaggregated data from the 2013 survey provide some important results. First, it is observed that using the detailed income data increases the estimated overall nonfarm participation rate by approximately seven percentage points, the difference being highly significant. This means that nonfarm participation was significantly underestimated when not collecting detailed gender disaggregated information. The intra-household descriptive analysis shows that women have significantly fewer number of income sources, earn lower incomes, have a higher nonfarm income share (mostly from nonfarm self-employment income), and have a higher share of income from remittances than men.

The regression analysis based on the panel data and the 2013 cross-section yield results that do not always tell the same story, probably reflecting the importance of controlling for unobserved heterogeneity. The effect of nonfarm income on key household farming decisions were examined in ten equations (counting the Two-Part models as two separate equations). From the panel data estimates, a significant nonfarm participation (or nonfarm income) effect is identified in only two of the ten equations—purchased input expenditure and total cultivated area significantly increased with nonfarm income. The cross-section estimates tell the same story with respect to purchased input expenditure but not cultivated area. Increased nonfarm incomes were associated with reduction in cultivated area, suggesting competition rather complementarity. The 2013 cross-section estimates also recorded significant effects of nonfarm income on three other outcome variables of interest: hired labour use (positive effect), rice output market participation (negative effect), and share of rice output sold (positive effect).

Entering the gender decomposed nonfarm income variables into the regression equations, it is observed that the probability of purchased input use and participation in nonfood cash crop production are decreasing with male nonfarm income earnings while the share of rice output sold is increasing with male nonfarm income earnings. Purchased input expenditure, the probability of maize output market participation, and the probability of nonfood cash crop production are all increasing with female nonfarm income; but total cultivated area is declining with female participation in nonfarm income. Approximately 42% of households in the Afrint 3 sample have both male and female nonfarm income earners. We find that average purchased input expenditure and the probability of improved seed adoption are higher among such households; but such households also have smaller average cultivated areas.

Finally on welfare implications, it is first noted that composite welfare and food insecurity status differs significantly across region and villages. Gyedi (in the Eastern region) has the highest average value of the welfare index and the fewest number of households being food insecure; Shia (in the Upper East region) is at the bottom. Welfare and food security highly discriminates against living in the Upper East region compared with the Eastern region. We find nonfarm incomes to be increasing across per capita income and wealth index quintiles, suggesting that nonfarm income discriminates against the poor, although not in the sense of participation because participation rates are not always increasing across the wealth distribution. The regression results show that composite welfare increases with nonfarm income but the magnitude of effect is often not of practical significance, particularly when compared with other welfare enhancers such is human capital assets and livestock ownership. While food insecurity is reducing with level of nonfarm income, there is a positive relationship between nonfarm income participation food insecurity.

# 1. INTRODUCTION

Until relatively recently, much of the literature on farm-nonfarm-linkages have been largely one-sided in that analyses of the link have been based on the supposition that it is growth in the farm sector that precipitates events that lead to growth in the nonfarm sector (Mellor, 1976; Haggblade *et al.*, 1989; Haggblade *et al.*, 2007b; Diao *et al.*, 2010). Even in this respect foci have been on meso and macro level linkages. Although the role of nonfarm income in triggering farm productivity and output has been conceived by a few during the time when the above mentioned conventional wisdom thrived (e.g. Collier and Lal, 1984), the thinking that nonfarm income could influence farm outcomes through its effect on farm investments arrived later (see, for example, Evans and Ngau, 1991; Reardon *et al.*, 1994; Savadogo *et al.*, 1994; Savadogo *et al.*, 1995; de Janvry, 2005; Davis *et al.*, 2009).

There are a number of reasons to expect nonfarm employment and income to influence farm technology, production mix and farm outcomes in general. The adoption of new farming technologies are potentially risky in sub-Saharan Africa (SSA) where the enabling environment required for such technologies to thrive (water and other complementary input availability, for example) are limiting. The availability of nonfarm income has the potential of mitigating such risk and therefore likely increases the likelihood of technology adoption by smallholder farmers (Evans and Ngau, 1991). If nonfarm incomes indeed reduce the tendency for self-provisioning of household food requirements then, according to Reardon *et al.* (1994), one can expect the availability of such income to influence a smallholder's decision to increase cash crop farm size, participate more in staple crop markets and sell a greater share of output, and use more purchased inputs (including hired labour).

As noted in the next section, that nonfarm employment and income could have positive effects on farm investments and outcomes are not established conceptually *ex ante*. For example, empirical evidence from northern Burkina Faso in the late 1980s showed that households with more nonfarm income invested less in farm capital (Christensen, 1989). As noted by Reardon *et al.* (1994) investment of nonfarm incomes into farming depends chiefly on the preferred choice of enterprise by the farm household in question as well as several conditioning factors including agroclimatic conditions and infrastructure (both hard and soft), institutions (including those central to the working of markets)[2], type of nonfarm activity (i.e. sequential versus contemporaneous), and who controls the nonfarm income in the household.[3]

This report contributes to the existing literature on the effect of nonfarm income on farm activities and outcomes. In particular, the report extends existing knowledge by examining how gender decomposed nonfarm participation influences farming activities and technology adoption. The findings could be a source of hope or concern depending on the identified effect of nonfarm income on farm capital and farm outcomes. If, for example, nonfarm income is found to relax liquidity constraints so that participants are able to invest in improved farming technologies that help raise output, then all else held constant, this could lead to agricultural growth and poverty reduction. This should be the case if participation in nonfarm income does not discriminate against the poor *ab initio*. On the other hand, if at the household level nonfarm labour competes for farm labour in the presence of limited or absent hired labour markets then farm output could suffer, and depending on the acquisition cost of farm output forgone result in household food insecurity. In light of the possible welfare implications of nonfarm participation the empirical work presented in this report encompasses the analysis of: (*i*) the role of nonfarm income (including gendered intra-household nonfarm income) on farm production technology and production mix; and (*ii*) the effect of nonfarm participation and level of participation on household welfare and food security.

## 2. OVERVIEW OF THE LITERATURE

Interactions between farm and rural nonfarm employment follow four main interrelated narratives: agricultural growth linkages (AGL), rural nonfarm employment (RNFE), household livelihoods (HL), and regional development (RD) (Haggblade *et al.*, 2007a). The first two are of primary interest to the analysis in this report. The AGL narrative takes a sectoral perspective and postulates synergies between the farm and rural nonfarm sectors (Hazell and Roell, 1983;Haggblade *et al.*, 1989; Delgado *et al.*, 1994). The distinctive feature of this model is its focus on growth in the farm sector as the 'engine' that propels nonfarm activity and growth in the rural economy (Hazell and Haggblede, 1993). The AGL model postulates employment

[2] Where rural credit markets are limiting, for example, nonfarm income can be an important substitute.

[3] In Ghana, for example, it will depend on existing rainfall patterns. For example, the northern parts of Ghana experience one rainfall season per year while the southern parts usually have a bimodal rainfall pattern. This has implications for both farm outcomes and participation in nonfarm employment.

linkages from the farm to the nonfarm sector (Reardon *et al.*, 1998; Lanjouw and Lanjouw, 2001;Haggblade *et al.*, 2002), production and consumption linkages (Haggblade and Hazell, 1989;Dorosh and Haggblade, 2003; Hossain, 2004; Anriquez and Daidone, 2010), and factor market linkages (Reardon, 1997; Barrett *et al.*, 2001a; de Janvry and Sadoulet, 2002;Foster and Rosenzweig, 2004).

Rather than focus primarily on the farm sector as the engine the propels growth in the nonfarm sector, and thus view farm-RNF linkages as a by-product of growth in the former, the RNFE literature focuses on nonfarm employment in its own right. However, one of the main conclusions of this narrative is that given rural household consumption preferences, rising agricultural incomes will lead to higher expenditure on rural nonfarm output (Hazell *et al.*, 2007) leading to similar conclusions as the AGL model.

A catalogue of theoretically plausible effects of nonfarm activity on the farm sector can be derived from the work of Ellis (2000). According to his analysis, the possible farm output effects of nonfarm activities would depend on household labour allocation decisions, the relative importance of agriculture in the future plans of a household as well as general social and economic dynamics. Household asset endowment likely play an important role in the relative importance of agriculture in the future plans of a household (Barrett *et al.*, 2001b;Winters *et al.*, 2009) through inter-sectoral mobility effects. A brief overview of the empirical literature that guided the analysis in this report is provided in the subsequent paragraphs.

Some have found complementarities between the farm and nonfarm sectors whereby capital flows from nonfarm earnings to finance investment in agriculture at the household level (Evans and Ngau, 1991;Reardon *et al.*, 1992;Ellis and Freeman, 2004). In particular, wage employment income can induce investment in farming only under restricted conditions of positive savings and high nonfarm unemployment (Chikwama, 2004). On the other hand, it was observed in a region of Ethiopia that increased farm output decreases participation in nonfarm wage employment but increases participation in nonfarm self-employment in Ethiopia (Woldenhanna and Oskam, 2001).

A series of articles in the *Agricultural Economics* journal of 2009 (vol. 40 no.2) focused on household-level linkages between RNFE and farming. Most of the articles found positive effect of RNFE on farm input demand and investment in agriculture. Two of the articles, Maertens (2009) and Oseni and Winters (2009) , focused on Sub-Saharan African countries. Using a sample of 240 households from a Senegalese region Maertens (*ibid*) found that households involved in horticultural wage labour used greater quantities of purchased inputs and cultivated their food crop farms more intensively. Oseni and Winters (*ibid*) analysed a nationally representative rural household dataset on Nigeria and found farm input expenditures to be increasing with RNFE activity. Similar results were found elsewhere (e.g. Pfeiffer *et al.*, 2009; Stampini and Davis, 2009; Takahashi and Otsuka, 2009). Hertz (2009), for example, estimated a nonfarm income elasticity of purchased input expenditure of 0.14, an estimate that is consistent with the farm credit constraint in the data used. In Albania, Kilic *et al.* (2009) found that rather than investing nonfarm earnings into farming such income was reinvested into facilitating movement away from farming.

There are a couple of relevant studies using data from Ghana. Canagarajah *et al.* (2001) analysed rounds 1 and 3 of the nationally representative living standards survey data to conclude that Ghana's farm and nonfarm sectors were independent, that is, there were no significant linkages. Per contra, Anriquez and Daidone (2010) employed the fourth round of the survey to study linkages between the two sectors more explicitly and found significant cost complementarities. So, the two studies tell different stories, suggesting change in conduct of the rural economy of Ghana. But the differences in variables and methods employed could account for the different conclusions reached even if identical data sets were employed. Other researchers (Hilson, 2010; Okoh and Hilson, 2011) have used qualitative methods involving case studies from mining areas of Ghana to show important synergies between artisanal and small-scale mining activities and farming. So, even though the hypothesised link between nonfarm activities and farm production is *ex ante* ambiguous (Ellis, 2000, p. 109), overall, household level evidence suggests positive linkages between the two sectors through nonfarm income effects on increased demand for purchased farm inputs.

## 3. DATA

The Ghana Afrint household surveys started in 2002 (known as Afrint 1) with a sample of 416 households drawn from eight villages located in the Upper East and Eastern Regions.[4] The primary focus then was on four food staples: maize, cassava, sorghum and rice. A second round of surveys (Afrint 2) was undertaken in January 2008 with about 86% of households successfully re-interviewed. Additional households were included in the Afrint 2 sample making a total sample of 568 households. The 2008 survey instruments contained a large amount of additional information. A major addition was questions on household income sources and income.

In January 2013, a third round of data collection (Afrint 3) was conducted. A sample of 539 households was achieved during the survey. This is made up of 47 newly sampled households and 492 or approximately 87% (including 3.7% descendant households) of the 568 Afrint 2 households (Table 1). A more thorough scrutiny of the sample, however, revealed that the attrition rate was lower than it appears. The method used in drawing the initial sample (see Dzanku and Sarpong, 2009) made it possible for two members of the same household to be interviewed. There were at least 14 of such cases discovered in the Eastern Region, predominantly in Gyedi. Taking this alone into account reduces the apparent attrition rate by 2.2 percentage points.

There were important modifications to the Afrint 3 household survey instrument. For example, due to difficulties in obtaining reliable cassava production data (particularly output) focus on this crop was drastically reduced. A major addition to the Afrint 3 household questionnaire was the solicitation of gender disaggregated income data.

Given the focus on linkages between the farm and nonfarm sectors and the distributional implications thereof a descriptive summary of the two sectors is first provided below. The income descriptive analysis is based on the 2008 and 2013 datasets since the 2002 data does not contain detailed income information.

[4] See Dzanku and Sarpong (2009) for a more detailed description of the survey and sample. Note that the data reference year is always the year before the survey year.

*(a) The rural farm sector*

The rural farm households being studied are smallholders who cultivate an average of two hectares (minimum and maximum cultivated areas are 0.04 and 10.5 hectares respectively) to food and nonfood cash crops. We observe statistically significant differences in cultivated area over time and region (Table 2). In both the Eastern and Upper East Regions average area decreased between 2002 and 2008 (by approximately 11% and 5% respectively, on average) before increasing over and above the 2002 size in 2013. Indeed, between 2008 and 2013 average total cultivated area more than doubled for the Eastern Region sample, the *t*-statistic on this difference is 7.42 indicating high statistical significance. Given what we believe was a better attempt at getting more accurate measures of cultivated area, which is a challenge in most parts of Ghana, the large (and probably unrealistic) increase in farm size between 2008 and 2013 in the Eastern Region is probably a result of measurement error during the 2002 and 2008 surveys.

The Afrint 3 questionnaire contained the question: "If you compare your present farm size to your farm size in 2008, has your farm size increased or decreased since then?" We compare the responses to this question (i.e. area decreased since then, area unchanged or area increased since then) with that calculated from reported cultivated area information. The column totals (in brackets) show about 51% of farm managers reporting no change in cultivated area between 2008 and 2013 (Table 3). Of the remainder households, 27% reported that their farm sizes had increased with the rest indicating a decrease. Calculating the changes from total farm size data reported by farm managers we observed an increase for 62% of all households (see row total percentages in brackets) and a decrease for 33% of households, only about 5% of households have unchanged size of cultivation area. Indeed, comparing the 'reported' and 'calculated' farm size changes we see that there is agreement for 32% of cases, indicating the possibility of measurement error in  a number of cases.

Turning again to Table 2 we observe that aside from maize, cassava, sorghum and rice, most farm households in our sample cultivate other food crops. The most popular among the list in the Eastern Region in 2008 were cocoyam (78% participation), plantain (74% participation), vegetables of local markets (70% participation) and yam (62% participation). Exactly the same order was maintained in 2013 but participation increased for cocoyam (82%) and plantain (81%), decreased for vegetables (68%) and remained largely unchanged for yam. For the Upper

East Region the most widely grown crops in 2008 were: groundnuts (91%), beans (80%), millet (73%) and vegetables (67%). The order changed in 2013 as follows: millet (98%), groundnuts (88%), beans (73%) and vegetables (70%).

Aside other food crops, some households also grow nonfood cash crops. We observe (Table 2) that while participation in nonfood cash crop production increased systematically between 2002 and 2013 in the Eastern Region (from 10.6% of households in 2002 to 42.1% in 2013), participation declined consistently in the Upper East (from 11.1% in 2002 to 1.8% in 2013). Anecdotal evidence from our interactions in the villages suggest that growing preference for maize which serves as both cash and food crop is partly responsible for this decline. The main nonfood cash crops were cocoa and oil palm in the Eastern Region, and tobacco in the Upper East. For households that cultivate nonfood cash crops, a larger average area is devoted to such crops than to ‘other’ food crops (Table 2). We now turn attention to the three staple crops studied in detail: maize, sorghum and rice.

*Farm size, output and yields*

The study collected farm size and output information covering the immediate three seasons prior to the surveys. This makes available a total of nine data points on farm size and production (Table 4). Participation in maize production during the Afrint 1 period (the 1999 production season through 2001) reached nearly 100% in the Eastern Region where maize is the most important staple food crop, but declined to 94% during the Afrint 2 period (from 2005 through 2007), before increasing to about 97% during the most recent survey (2010-2012).

Maize production information was not collected for the Upper East Region during the Afrint 1 period. For the Afrint 2 & 3 periods we observe, as expected, lower participation in maize production in the Upper East than in the Eastern Region. However, participation has been increasing in the Upper East (from about 32% of households in 2005 to 62% in 2012). Focused group discussions suggest that maize is gradually replacing sorghum in the Upper East villages. Not surprising, we observe a significantly reduced participation in sorghum production during the Afrint 3 period (86% participation compared with 94% during the most recent Afrint 2 season). Participation in rice production decreased during the Afrint 2 period compared with Afrint 1 but increased during Afrint 3 although still below the Afrint 1 participation rate (Table 4).

Maize farm size decreased consistently during the Afrint 1 & 2 periods, starting with mean size of just about a hectare in 1999 and reducing to 0.64 ha by the 2007 growing season (Table 5). The Afrint 3 period, beginning at the 2010 growing season, recorded a large increase in farm size compared with the Afrint 2 period. Mean maize farm size was 1.12 ha in 2010 and 1.14 ha in 2012. Table 6 shows a statistically significant 31% decrease in mean maize farm size in the Eastern Region between Afrint 1 and 2. However, mean maize farm size for Afrint 3 is significantly greater than that for Afrint 1 and 2 by 22% and 77% respectively. Average maize farm size did not differ significantly across region during the Afrint 2 periods. Within the Upper East, average maize farm size remained largely unchanged between the Afrint 2 and 3 periods (Table 6). Average sorghum farm size increased significantly between Afrint 1 and 2 as well as between Afrint 1 and 3; between Afrint 2 and 3, however, there was no significant change. Mean rice farm size remained largely constant between Afrint 1 and 2 but increased significantly between Afrint 1 and 3 and between Afrint 2 and 3 (Tables 5 and 6).

We observe that as maize farm size declined between Afrint 1 and 2, output also declined—households were producing an average of 790 kg – 890 kg of maize in the Eastern Region during Afrint 1 but this decreased to 635 kg – 765 kg during the Afrint 2 period (Table 5). As average farm size increased during Afrint 3 output also increased (from 995 kg – 1,145 kg). Because the change in output was offset by the change in farm size between the periods we observe that, at the 5% level of significance, there was no change in average maize yields over the three surveys in the Eastern Region (Table 6). In the Upper East Regions, however, because the increase in maize output outpaced the increase in average farm size we observe that average maize yield grew by more than 200% and is statistically significant.

An average household was producing 382 kg of sorghum and 496 kg of rice during Afrint 1; sorghum output dropped to only 141 kg and rice to 309 kg in Afrint 2 before rising to 258 kg in the case of sorghum and 684 kg in the case of rice during Afrint 3. These production figures meant that both sorghum and rice yields declined between Afrint 1 and 2 and between Afrint 1 and 3. Yields recorded in Afrint 3, however, represent a 167% and a 98% increase over levels in Afrint 2 for sorghum and rice respectively.

*Input use*

We provide a snapshot of farm input use among households over time and across region in Tables 7 and 8. During the 2008 survey we observed a statistically significant increase in the proportion of maize farmers using improved seeds in the Eastern Region, from approximately 37% in 2002 to 64% in 2008. The recent survey shows a reduction in the proportion of farmers using improved maize seed, down to 56%, but the reduction is not statistically significant at the 5% level. For the Upper East Region sample, we observe a drastic reduction in the proportion of maize farmers using improved seed, from about 65% of farmers in 2008 to only about 2% in 2013. The reason for this reduction is that during the Afrint 2 period the Ministry of Food and Agriculture was actively supplying improved seeds in the Upper East Region villages or the environs but this had waned during Afrint 3 although seeds were available in the market. The situation was similar for improved rice seed use: only 8% of farmers were using improved seeds in 2013 compared with 32% in 2002 and 64% in 2008. As for sorghum all farmers use traditional varieties.

Although still less than half of maize farmers were using inorganic fertilizers in the Eastern region, the proportion using the input has been increasing consistently over the survey years, from 24% in 2002 to 35% in 2008 and then to 42% in 2013 (Table 7). Real average fertilizer expenditures (after adjusting for general price level changes) for those using the input decreased from about US$28 in 2008 to US$23 in 2013, the t-statistic on this difference is 1.75 indicating lack of statistical significance at the 5% level. In the Upper East Region, a higher proportion of maize farmers (70%) were using fertilizers in 2013, up from about 45% in 2008 (Table 7). However, real expenditures on the input decreased from approximately US$28 in 2008 to US$20 in 2013, the difference is significant at the 1% level. Although there was an on-going national fertilizer subsidy programme no farmer reported participation in the programme.

Only about 14% of sorghum producers were using fertilizers in 2002 but this dropped further to just 4% of farmers in 2008 before increasing to 16% in 2013 (Table 7). Those using fertilizer on sorghum were spending an average of US$16 on the input in 2008 but this declined to US$12 in 2013, but this difference is due to chance variation (*t*-statistic = 1.2) . A higher proportion of rice farmers (than sorghum farmers) used fertilisers and also spent more real US dollars on the input. The *t*-statistic on the decrease in mean real rice fertilizer expenditures between 2008 and 2013 is 0.83, indicating no statistically significant decrease over the period.

Pesticide and herbicide use on maize, sorghum and rice across regions increased consistently over the three surveys (Table 7). Herbicide use as a land preparation method has become very common in the Eastern Region study villages where focus group discussions revealed that this is a result of the relatively expensive cost of hired labour for land preparation. However, we do not observe a significant reduction in hired labour use from the household data over the panel. Indeed, hiring labour for farm activities is more common in the Eastern than the Upper East Region (Table 8).

We show changes in household use/access to other inputs in Table 8. These include the use of animal manure, contact with government agricultural extension agents, and access to input credit. Animal manure is mainly used in the Upper East Region with 81% of farmers using it in 2002, 92% in 2008 and 88% in 2013. The proportion of farmers reporting contact with agricultural extension agents increased from 57% to 64% between 2002 and 2008 in the Eastern region but decreased from 84% to 50% in the Upper East over the same period. By 2013, agricultural extension agent contact decreased among farmers in both regions, down to 52% and 49% in the Eastern and Upper East respectively. Statistically, only the decrease between 2008 and 2013 was significant for the Eastern Region while for the Upper East only the marginal decrease between 2008 and 2013 was not significant. Except in 2013, the proportion of farmers reporting agriculture extension contact has been significantly higher in the Upper East than the Eastern Region.

Farmer organization membership has significantly decreased in the Upper East from one survey to the other; in the Eastern region the decrease between the 2008 and 2013 surveys was not significantly different from zero (Table 8). Agricultural input credit is not common in the study villages; for all the three surveys less than 15% of farm households reported such credit, which in most cases comes from private individuals, often farm produce aggregators (Table 8).

*Output marketing*

It has been noted (see, for example, Barrett, 2008) that staple crops are not sold by a large proportion of rural farm households, and that agroecological potential is an important determinant of staple crop output sale decisions. We see from Table 9 that very few households in the Eastern region (about 4%) did not sell maize during the first two surveys. The proportion that sold maize during the most recent survey decreased such that nearly 16%

reported no maize sales. The high participation is because, although maize is the single most import cereal staple crop in Ghana (Angelucci, 2012) it is also considered an important cash crop. The effect of agroecological potential differences on market participation is clearly visible as we observe that in 2008 only about 3% of maize producing households in the Upper East Region sold some of the output. By 2013, the proportion selling increased to nearly 22%. This is not surprising for two reasons. First, flooding in the Upper East Region during the 2007 crop year affected production in some of the study villages. Second, as noted earlier, maize is gradually replacing sorghum in the Upper East study villages due to declining yields.

Households selling maize put an average of between 60% (in 2002) to 66% (in 2008) of their output on the market in the Eastern Region compared with about 38%-42% of output in the Upper East Region (Table 9). In terms of actual sale quantities for the two equivalent survey years (i.e. 2008 and 2013) the pooled average was 642 kg for the Eastern Region and 287 kg for the Upper East, the difference being highly significant.

Sorghum is produced mainly for home consumption in the Upper East villages but one out of every four households was selling an average of one-third of output in 2002. As indicated earlier the precarious conditions faced by some households in 2008 meant that only about 3% of households reported some sorghum sales in 2008. But even in a 'normal' year (i.e. 2012) only a little over 10% of sorghum producers put some of their output on the market in 2013. Rice serves as both a staple and cash crop in the Upper East so we see that 56% of rice farmers were selling (an average of 332 kg) in 2002 and even under harsh climatic conditions in 2008 32% put some rice (mean of 246 kg) on the market. In 2013 51% of rice producers sold an average of 725 kg of rice representing 52% of their mean output.

*(b) The rural nonfarm sector*

Rural nonfarm employment is an important part of rural household livelihoods (e.g. Ellis, 2000; Lanjouw and Lanjouw, 2001; Haggblade *et al.*, 2007b; Davis *et al.*, 2010; Ellis, 2010). The descriptive analysis of the rural nonfarm sector provided here is based on the Afrint 2 and 3 surveys. In these surveys information was solicited concerning 12 income sources: sale of food staples, sale of other food crops, sale of non-food cash crops, sale of animals/animal produce, leasing out machinery and/or equipment, work on others' farms/agricultural labour, non-farm salaried employment, micro business, large-scale business, rent and interest, pensions, and remittances. Considering these income source we observe that the average Eastern Region household had 2.8 (minimum of 1 and maximum of 7) income sources in 2008 and 3.3 in 2013 (also ranging between 1 and 7), a statistically significant increase of 20% (Table 10). For Upper East households the average number of income sources rose from 2.4 in 2008 to 3.2 in 2013 representing a significant increase of 31%. The regional difference in average number of income sources per household is significant for the 2008 sample but not 2013.

Household average incomes (both current and real) were significantly higher in the Eastern than Upper East Region in both 2008 and 2013, as one might expect. Over the two periods, there was no significant change in real average household income in the Eastern region, but real income rose by 39% in the Upper East Regions (Table 10). After accounting for household size, however, we observe no significant change in income over time in both regions; there were, however, significant differences in per capita income by region.

For a somewhat more meaningful and concise descriptive analysis we put the income sources into seven groups: food crops, nonfood cash crops, livestock, non-labour, nonfarm wage employment, nonfarm self-employment, and remittances (Table 11). First, at a higher level of aggregation, we observe that income from crops accounted for the largest share of average household income in the Eastern Region (77% in 2008 and 64% in 2013). Crop income was far less important in the Upper East where in 2008 only about 19% of average total income was from crops, increasing to 29% in 2013. These changes over time within region as well as across region are significant at the 1% level (Table 12). While there was near perfect participation in crop income in the Eastern Region in both survey years (98% in 2008 and 95% in 2013), only 39% and 62% of Upper East Region households received some income from crops in 2008 and 2013, respectively. Even after conditioning on participation, still less than half of average Upper East household income came from crops.

Nonfarm income as a whole (income from sources other than crops and livestock but including working on other peoples' farms) accounted for 16% and 43% of average total income in the Eastern and Upper East Regions respectively in 2008. By 2013 average nonfarm income shares had increased to 32% in the Eastern Region and 51% in the Upper East Region. These changes and differences are strongly significant at conventional levels of testing (Table 12). Clearly, nonfarm income is relatively more important in the poorer and lower agroecological potential region with a monomodal rainfall pattern which gives rise to a long nonfarm season.

In the two regions, nearly all of the crop income came from food crops, not nonfood cash crops—only 2.5% and 5.3% of average income in the Eastern Region and 1.1% and 0.5% in the Upper East in 2008 and 2013, respectively, came from nonfood cash crops. Participation in nonfood cash crop income is low in general but very low (4.5% in 2008 and 1.5% in 2013) in the Upper East Region. Participation is much higher in the Eastern Region, up from 11% of households in 2008 to 29% in 2013. Even households participating in nonfood cash crop income, on average, receive a greater share of income from food crops.

Income from livestock completes the components of farm income and is clearly relatively more important in the Upper East than the Eastern region. Approximately 6% and 4% of average income was from livestock in the Eastern Region compared with 38% and 20% for the Upper East, over the two periods. Also, a larger share of households in the Upper East (80% in 2008 and 74% in 2013) than in the Eastern Region (42% in 2008 and 37% in 2013) obtained income from livestock.

The relative importance of nonfarm income sources differ by region. On average, nonfarm self-employment income is the most important in terms of contribution to household income in the Eastern Region, but contributed only 7% of average total household income in 2008 and approximately 17% in 2013. For the Upper East Region, remittance inflows from absent family members contributed the most to household income—approximately 17% in both years—than any other nonfarm income source (Table 11). Nonfarm wage employment and remittances were the second and third most important nonfarm income source in the Eastern Region in 2008 but accounted for less than 5% of total income in each case. In 2013, remittances become more important that nonfarm wage employment in the Eastern region. As for the Upper East Region, beside remittances, nonfarm wage employment was more important than self-employment, both in terms of participation and income shares, for both 2008 and 2013.

The 2013 survey collected gender disaggregated income data which we explore in Tables 13 and 14. First, in Table 13 we compare income and income source variables by household headship as well as intra-household gender differences. The 2013 survey covered 534 households who reported information on their incomes and income sources. Approximately 20% of the 534 households were female headed. At the 5% level, we observe statistically significant differences between the two types of households in 8 out of 12 variables reported in Table 14. The exceptions are per capita income, crop income share, nonfarm self-employment income and its share in total income. Female headed households have a smaller number of income sources, a smaller number of members in nonfarm work, higher crop income, more income from remittances, higher remittance income share, lower nonfarm income, but higher nonfarm income share.

Moving to the intra-household descriptive analysis, first, we observe that out of the 534 households, 59% have both male and female income earners. In total, however, there are at least 851 individual income earners in the surveyed households, of which 47% are females. Out of the 11 relevant variables in Table 13, there exist significant intra-household gender gaps in 9. The two exceptions were nonfarm self-employment income and remittances for the unpaired mean differences; and remittances and nonfarm income for the paired comparison. Otherwise, females have statistically significant fewer income sources, smaller income earnings, smaller crop incomes and crop income shares for both the paired and unpaired analysis, and in addition have smaller nonfarm incomes in the case of the unpaired means.

Within households, more females than males are involved in nonfarm work, have higher share of income from nonfarm self-employment and remittances, and indeed have higher share of their incomes from nonfarm income in general. For households with both male and female income earners, females earn higher average income from nonfarm self-employment—approximately US$509 compared with US$267 for males (Table 13).

We provide detail gender and regional disaggregated income shares and participation descriptive statistics in Table 14. In most cases we observe positive and often significant gender gaps (meaning higher income shares or participation for males), particularly when not conditioned on participation. The three important exceptions where we observed negative intra-household gander gaps for both regions were mean nonfarm self-employment income shares, remittance share and overall nonfarm income share. For example, in the Eastern Region an average of about 53% of female income came from nonfarm sources with average participation rate of 80% compared with nearly 27% nonfarm income share for males with 58%

participation. The importance of nonfarm income for females is even more marked in the Upper East Region where, on average, 74% of all female incomes were generated in the nonfarm sector with participation rate of 94%. Compare this with male nonfarm income share of 48% and participation rate of 88%.

So, overall, how much do women contribute directly to household average cash income in our sample? In the entire sample at the village level this ranges from 27% in Apaa (in the Eastern Region) to 44% in Shia (Upper East region)—the regional averages are 37% and 36% in the Eastern and Upper East regions respectively, the difference being statistically insignificant. Considering only households with both male and female income earners, average female contribution ranges between 28% of household income in Apaa to 48% in Asitey; the regional average is 36%, meaning that females were contributing about 36% of total household income.

## 4. ANALYSING FARM–NONFARM LINKAGES AND DISTRIBUTIONAL ISSUES

The main thrust of this paper is the analysis of the household-level farm-nonfarm linkages and the distributional implications thereof. Linkages between the farm and the nonfarm sectors have been the focus of past research, and in recent times some attention has been given to household level linkages as shown in section 2. The analysis here draws largely from this literature, *mutatis mutandis*, as it adds on the distributional aspects.

### (a) Analytical methods

We rely on descriptive and regression analysis for gaging the link between household nonfarm activities and farm production behaviour as well as the distributional implications. The descriptive analysis uses mainly bivariate analytical tools. We specify the regression models below.

First of all, we are interested in the effect of participation in nonfarm employment or earnings on farm outcomes (i.e. farm output and productivity). Since it is hypothesised that nonfarm earnings likely reduces liquidity constraints, particularly in the presence of credit market failures, it makes sense to conceive that nonfarm participation or earnings affect output and productivity through their effect on production input use decisions. With this in mind we specify the following general regression equation:

$$Y_{it} = \alpha + \beta * nfm_{it} + \delta * X_{it} + c_i + \varepsilon_{it}, \qquad (1)$$

where *i* and *t* indexes household and time respectively; *Y* is the farm related outcome of interest (e.g. purchased input use, hired labour, area under cultivation among others discussed below); *α* is the intercept term; β is the coefficient on the nonfarm participation or earning variable *nfm*, and is of primary interest; *X* is a vector of individual, household and farm characteristics; $c_i$ is the household specific effects or heterogeneity assumed to be time-invariant; and *ε* is the idiosyncratic error term.

Clearly, an estimate of the marginal effect of *nfm* on *Y*, β, is biased if unobserved individual and household characteristics that influence participation in nonfarm activities also affect the outcome decisions of interest. Allowing household specific heterogeneity $c_i$ to be correlated with *nfm* and *X* could take care of this identification problem, making β an unbiased estimate of the marginal effect of interest. Proceeding this way assumes that endogeneity operates through omitted heterogeneity only. However, it is possible that endogeneity arises through correlation between *nfm* and *ε* as well. In this case we consider estimating the structural and reduced for equations simultaneously or use other methods (described below) to account for such possible endogeneity.

We estimate the effect of nonfarm participation/earnings on farm outcomes using six dependent variables: expenditure on purchased inputs (fertilizer, herbicides and pesticides), improved seed adoption, hired labour use, staple crop output market participation, participation in nonfood cash crop production, and total cultivated area.

Aside from area under cultivation, all the other dependent variables are characterised by a fairly large mass at zero. There are at least three approaches to modelling such variables: Tobit (Tobin, 1958), selection models based on the seminal article by Heckman (1979), and two-part models (Cragg, 1971; Duan *et al.*, 1984).

In the present case, the zeros are actually observed data. This is because the population of interest from which the data was taken are all agricultural producers and not a self-selected sample. Thus, theoretically, one is not faced with a sample selection problem *per se* (see Hertz, 2009 for a similar argument). The Tobit model is the most frequently applied in related literature (e.g. Kilic *et al.*, 2009; Pfeiffer *et al.*, 2009; Takahashi and Otsuka, 2009). However, it is important to note its shortcomings: reliance on homoscedasticity and normality of the error term for consistency as well as the assumption that the process generating the zeros and positive outcomes are essentially the same. The two-part model (TPM) estimates the probability of a positive outcome in the first part, and the magnitude of the positive outcome in the second part. This is the preferred choice in the analyses, and Tobit models are used only for comparison.

The general form of the relevant Tobit model can be written as:

$$Y_{it}^* = \alpha + \beta * nfm_{it} + \delta * X_{it} + c_i + \varepsilon_{it},$$
$$Y_{it} = \begin{cases} Y_{it}^* \text{ if } Y_{it}^* > 0, \\ 0 \text{ otherwise} \end{cases} \tag{2}$$

where $Y_{it}$ is the observed dependent variable and $Y_{it}^*$ is the latent variable which is related to the observed as stated above; all other variables are as described in equation (1). Estimating equation (2) in the presence of *nfm* being potentially endogenous presents an econometric challenge because *nfm* itself is semi-continuous (i.e. a substantial number of households neither work nonfarm nor receive nonfarm income).

This challenge can, in part, be surmounted by writing the equations with a bivariate Tobit model structure assuming the error terms are bivariate normally distributed (Amemiya, 1974).

$$\begin{aligned} Y_{it}^* &= \alpha_1 + \beta nfm_{it} + \delta_1 X_{it1} + c_{i1} + \varepsilon_{it1} \\ nfm_{it}^* &= \alpha_2 + \delta_2 X_{it2} + c_{i2} + \varepsilon_{it2} \end{aligned} \tag{3}$$

where it is assumed that $(\varepsilon_{it1}, \varepsilon_{it2}) \sim Normal(0, 0, \sigma_1^2, \sigma_2^2, \sigma_{12})$. This deals with endogeneity arising particularly from simultaneity bias (Chen and Zhou, 2011). But then one has to find a way of sweeping out the unobserved heterogeneity. Given that the time dimension of the panel is the minimum possible (i.e. $T$ = 2), the work of William Greene (see Greene, 2004b; Greene, 2004a) suggests that pooling the data is not a bad idea in the presence of the incidental parameter.

For the two-part model (TPM) we specify a probit model for the first part as:

$$Y_{it}^{*} = \alpha + \beta nfm_{it} + \delta X_{it} + c_i + \varepsilon_{it}$$
$$Y_{it} = 1[Y_{it}^{*} > 0] \qquad (4)$$
$$\varepsilon_{it} \sim Normal(0,1).$$

In order to deal with potential endogeneity of *nfm* we treat it us a dummy variable, which in itself has important advantages. Aside from making it possible to estimate the average treatment effect of participation in nonfarm employment or income, it reduces the chances of measurement error which could be a big problem with household income data (Deaton, 1997; Stampini and Davis, 2009). With this in mind a bivariate probit model is applicable in this instance. Another estimation option for the first part is a linear probability model (Angrist, 2001). For panel data, a fixed effects linear probability model (e.g.Bandiera, 2007; Deininger and Ali, 2008) is useful for modelling unobserved heterogeneity.

The second part of the TPM (i.e. for $Y_{it} > 0$) is:

$$Log\ Y_{it} = \alpha + \beta nfm_{it} + \delta X_{it} + c_i + \varepsilon_{it}. \qquad (5)$$

Again, one has to deal with the possibility that $E(\varepsilon|nfm) \neq 0$. If we allow *nfm* to enter as a dummy, then *nfm* can be seen as capturing the average treatment effect so that equation (5) can be estimated under the treatment-effect model framework where we use the 2013 data only or pool the data.[5] Where *nfm* enters as level of nonfarm income and is treated as endogenous, correction terms are generated from a first-step pooled Tobit or random effects Tobit models and added as additional regressors in the farm outcome equation of interest (Vella, 1993; Vella and Verbeek, 1999).

There is one more estimation issue to address, which is in the case where the share of staples sold is the dependent variable. This is a fractional response variable, $0 \leq y_{it} \leq 1$, with outcomes at the endpoints, zero and one inclusive. In this case, applying the approaches described above could be inappropriate because they cannot ensure that the predicted values of the response variables, given the entire continuous distribution of explanatory variables, lie within the interval of the bounded dependent variable (Papke and Wooldridge, 1996, 2008). Under strict exogeneity the model is specified in a general form as:

[5] We estimate a number of models using the panel data and the 2013 data only because the later allows us to test additional hypotheses which are not possible using the panel. This is because data on some variables were not collected in 2008.

$$E(y_{it} \mid X_i, c_i) = G(\alpha + \beta nfm_{it} + \delta X_{it} + c_i) \quad (6)$$

where $G(\cdot)$ is either a logistic or normal distribution function. We work with $G(\cdot) \equiv \Phi(\cdot)$ and apply the Bernoulli quasi-maximum likelihood estimator (QMLE) following (Papke and Wooldridge, 2008). The panel data component can also apply the generalised estimating equation approach (Zeger and Liang, 1986), allowing misspecification of the model error structure (Papke and Wooldridge, 2008).

Next the study seeks to assess the welfare effects of participation in nonfarm work or income. Specifically, interest is in the effect of nonfarm income on household welfare. Two indicators of welfare are used: a composite welfare index and food security. The welfare index equation is:

$$W_{it} = \gamma + \lambda nfm_{it} + \eta X_{it} + c_i + u_{it}, \quad (7)$$

where $W$ is the fully observed welfare index described below; $\gamma$ is the intercept term; $\lambda$ is the unknown parameter of primary interest; $\eta$ is the a vector of unknown parameters associated with the vector $X$ containing exogenous household and individual characteristics, assets, location dummies; and $u_{it}$ is the error term. Treating *nfm* as exogenous in equation (7) may lead to the estimate of $\lambda$ being biased. This is because households or individuals may choose to participate in nonfarm work or not conditional on unobserved characteristics. Indeed, better-off households may choose to participate in high-return nonfarm activities, and entry barriers may exclude the poor (Barrett *et al.*, 2001a). Similarly, for low-return type nonfarm work, the relatively wealthy may choose not to participate.

In the panel data context we sweep out the unobserved effects that may cause the bias using the fixed effects estimator (which is equivalent to first-differencing for $T = 2$). Supposing this does not suffice we generate correction terms from a pooled or random effects Tobit model for level of nonfarm income to be included in the welfare equation as additional regressors to correct for any bias that may still be working through the idiosyncratic error (Vella, 1993; Vella and Verbeek, 1999).

Where we use the 2013 cross-sectional data only or pool the data, equation (7) is simply an endogenous dummy-variable model which is estimable under the endogenous treatment-regression framework:

$$y_j = X_j\beta + \pi nfm_j + \nu_j$$
$$offm_j = \begin{cases} 1, \text{ if } L_j\tau + e_j > 0 \\ 0, \text{ if otherwise} \end{cases} \quad (8)$$

where $X_j$ is the vector of explanatory variables in the welfare equation; $L_j$ is a vector of covariates that explain participation in nonfarm income; and $v_j$ and $e_j$ are the error terms assumed to be bivariate normally distributed with zero mean and covariance matrix

$$\begin{bmatrix} \sigma^2 & \rho\sigma \\ \rho\sigma & 1 \end{bmatrix}.$$

Finally, we estimate the food security effect of nonfarm participation. Since the food security indicator is binary we allow the nonfarm participation variable to also enter the model as such to make for a simpler estimation procedure when having to deal with endogeneity (Greene, 2012). In this case we specify a general bivariate probit model as

$$fs^* = X_1'\beta_1 + \eta nfm + v_1, \quad fs = 1 \text{ if } fs^* > 0, 0 \text{ otherwise,}$$
$$nfm^* = X_2'\beta_2 + v_2, \quad nfm = 1 \text{ if } nfm^* > 0, 0 \text{ otherwise,} \quad (9)$$
$$\begin{pmatrix} v_1 \\ v_2 \end{pmatrix} | X_1, X_2 \sim Normal\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \rho \\ \rho & 1 \end{pmatrix}\right].$$

Where panel data is used, (9) a correlated random effect bivariate probit model is used where correlation between the unobserved effect and the covariates is captured by group mean variable addition.

## 5. RESULTS

Results of the regression analysis are presented here. Prior to that, descriptive analyses of the main issues appear first.

*(a) Descriptive analysis*

Most of the variables that appear in the regression analyses have already been discussed. Table 18 presents a summary of all variables by nonfarm income participation status. In the Afrint 3 dataset, only 13% of all households did not report any nonfarm incomes.[6] In the pooled panel data, the proportion of households not reporting nonfarm income is 31% (42% during Afrint 2 and only 18% during Afrint 3).[7] We focus on a few selected variables in Table 18. Mean per capita cash income of Afrint 3 households was higher among non-participants than participants; the average difference of $95 is significant at conventional levels. Using the detailed gender-disaggregated income data, the average income obtained by non-participant households was about $200 higher than for participants. This suggests that receiving nonfarm income was not associated with higher overall incomes, on average.

It is observed that average female income as percentage of average household income is statistically lower among non-participants than participants by approximately 12%. This is not surprising since female members tend to be more involved in nonfarm income generating activities than males. For example, there were about 11% more female-headed households among nonfarm income participants than non-participants.

Nonfarm income is hypothesised to improve farm productivity through its potential effect on farm inputs (including hired labour). As Table 18 shows, the proportion of households using purchased inputs is significantly higher by approximately 14% among non-participants than participants during Afrint 3, a result contrary to expectation. However, the extent of use does not differ across the two groups. Also, more non-participants than participants (difference of 28% during Afrint 3 and 18% in the pooled sample) were using improved seeds. The use of hired labour does not differ significantly across the two groups.

One would expect both food crop market participation and nonfood cash crop production to increase with participation in nonfarm income because the latter is expected to serve as a buffer that reduces the orientation towards 'safety first food cropping' and subsistence behaviour (Reardon *et al.*, 1994). There is contrary evidence from the descriptives: a significantly larger proportion of nonfarm income non-participants than participants sell own-

[6] The proportion not reporting nonfarm incomes increases when not using the detailed gender disaggregated income data, up by approximately seven percentage points.
[7] Note that the pooled data does not contain the refreshment sample.

produced maize and rice; also the share of maize output sold by non-participant is significantly larger than that sold by participants. It could be that households participating in nonfarm income generating activities produce staples mainly for consumption while non-participants rely more on this crops for both consumption and income. Aside food crops, it is also observed that a lower proportion of nonfarm income participants participate in commercial vegetable and non-food cash crop production, the difference is significant at conventional levels (Table 18).

A major reason farmers give for their inability to expand their cultivated area is the lack of liquidity. If participation in nonfarm income reduces this liquidity constraint then one would expect that participants in nonfarm income would, on average, cultivate larger areas if there are complementarities between the two sectors. Otherwise, the nonfarm sector may be seen as competing with the farm sector, barring the contribution of the former to intensification in the latter. In the pooled panel data, no significant difference in cultivation area is observed between the two groups. In the Afrint 3 sample, however, non-participants cultivated 0.68 ha more land than participants, and this difference is significant.

Turning to the descriptives on the distributional implications of nonfarm income participation, two measures of welfare are used: a composite welfare indicator and indicators of food (in)security. First, some comments on Table 19 which contains the descriptives on the welfare indicators. The welfare indicator was constructed by aggregating ownership of household durables (mobile phone, motor bike, televisions, sowing machine, sofa set), a household's ability to save money, household dwelling characteristics, and household non-labour income (see, for example, Finan *et al.*, 2005).

On food in(security), a household is defined as food insecure in the panel dataset if the number of meals eaten per day during the lean season was less than that eaten during the rest of the year. During Afrint 3, additional questions allows construction of a food (in)security indicator based on three dimensions: meal quantity, quality, and frequency. A binary food insecurity indicator is defined that takes on the value one if a household reduces meal quantity, quality and frequency during the lean season compared to the rest of the year. Additionally, a food security index is constructed which takes on the values zero through three: zero means reduction in all three dimensions; one means reduction in any two dimensions; two means reduction in any one dimension; and three means meal quantity, quality, and frequency remains constant throughout the year.

Table 19 presents a summary of the welfare indicators by household location. The village with the highest value of the average welfare index is Gyedi and the lowest in Shia. Statistical tests (*t*-tests from a regression of welfare on village dummies only) show that the average household in all other villages has significantly lower welfare than the average household in Gyedi. Normalising using Gyedi's average value of the index, Shia, for example, has only 43% of the average welfare value of households in Gyedi. The village with the second highest average value of the index, Asitey, has 77% of Gyedi's average. The panel data shows average welfare increased over time in all villages, averaging a 69% increase across all villages over the panel period (or about 14% per annum).

It is noted using ofs4 (see Table 19) that, overall, the village with the lowest and highest values of the welfare index are also those that have the lowest and highest proportion of households being food secure. For example, in Gyedi 82% of households maintain the quantity, quality and frequency of meals all year round, but in Shia only 11% do same. Statistical tests (z-statistics from a probit regression of ofs4 on village dummies only) show that the likelihood of being food-secure is statistically lower in all other villages than Gyedi—the exceptions are Asitey and Apaa, all in the Eastern Region.

Returning to Table 18, it is expected, crudely, that if participation in nonfarm income has positive distributional implications then participants should have, on average, higher values of the welfare index and have higher proportion of food-secure households. This is the case for the welfare index in the pooled panel data set but the contrary is observed in the Afrint 3 data. As for food security, both the panel data and the Afrint 3 data tell a consistent story but not according to expectation: a larger proportion of non-participants in nonfarm income are food-secure compared to participants, the difference of 12% and 13% in the pooled panel and the Afrint 3 data are both significant at conventional levels of testing.

A bit more detail on the distributional implication can be found in Table 20. Households are grouped by per capita income and welfare index quintiles to help understand the distribution of household income, nonfarm income, income shares and their disaggregation by gender across groups. The gap in average total household cash income between the lowest income quintile group and the highest is wide: approximately 26 times for the Afrint 3 sample and even wider in the pooled panel data. Although per capita income is also increasing consistently across welfare index quintiles, the gap is not so wide. For example, the highest welfare quintile households received only 4.5 and 5.3 times more income than the lowest group in the Afrint 3 and pooled panel, respectively.

It can also be seen in Table 20 that nonfarm incomes are increasing as we move from the lowest to the highest per capita income and wealth index quintiles, which may be viewed as prima facie evidence that nonfarm incomes discriminate against the poor. But, in fact, Table 20 shows that the poor are not participating any less than the rich in nonfarm incomes—nonfarm income participation rates are mostly not increasing throughout the per capita income and welfare index quintiles. A little more critical scrutiny of the data shows that the poor are deriving about the same or higher shares of their income from nonfarm sources, suggesting that they are likely involved in low-return type nonfarm activities (Table 20).

Finally, we see that both male and female nonfarm incomes are increasing with the constructed income and welfare index quintiles, but the gaps appear wider with male than female incomes. For example, average male income at the highest wealth index quintile is six times that at the lowest quintile while for female incomes the gap is only three. Female nonfarm income shares are also highest among the poorest households. For instance, female average nonfarm income share is about 54% among per capita income poorest households compared to 35% among the richest. This would suggest that poorer households have females contributing more of nonfarm incomes than rich households. The story is not different with respect to women's share of overall household income. These findings are generally consistent with those of Reardon (1997) and Owusu *et al.* (2011), for example, the later using data from villages in the Northern region of Ghana.

*(b) Regression results*

The focus of the regressions is twofold: to analyse the effect of nonfarm income on farm outcomes; and to examine the welfare implications of participation in nonfarm income. Prior to discussing the results addressing these, the determinants of nonfarm income participation and extent are briefly explored.

*Nonfarm income: participation and intensity*

A Two-part model (TPM) is used for this purpose. The first part involves a probit model predicting the probability of nonfarm income participation; the second part is a regression of log nonfarm income on a set of covariates. A fixed-effects linear probability (FE-LP) model is also estimated for the panel data first part regression to sweep out unobserved household heterogeneity. For Afrint 3 where gender disaggregated income data was collected a bivariate probit model is estimated in the first part, as the correlation coefficient between the error terms is significantly different from zero at the 5% level.

The panel data results are in Table 21 while that based on the Afrint 3 sample can be found in Table 29. The covariates include household demographic characteristics, household resource endowments and spatial location. Both the penal data and Afrint 3 analysis results show the probability of participation in nonfarm income to be decreasing with the number of 'able' household labour resources, and participation in nonfood cash crop production (particularly commercial vegetables). We included a fallowing dummy in the models. A prior, the expected effect of fallowing was ambiguous. If access to land is limiting then households could leave land fallow while pursuing nonfarm work, bearing entry barriers. On the other hand, only land abundant households could afford following. We observe that the probability of nonfarm income participation is decreasing with land fallowing.

The probability of nonfarm participation is decreasing with farm size in the panel data estimates but not throughout the entire distribution of the farm size distribution. Formal education increases the probability of nonfarm work in the panel but in the Afrint 3 the education effect shows up only in the gender-disaggregated estimates where the effect in positive for men and negative for women.

The largest effect magnitudes on nonfarm participation probability in the panel estimates come from time and spatial located effects: the probability of participation was approximately 20 percentage points higher in 2013; living in the Upper East villages increases the probability of participation by between 15 to 23 percentage points compared with living in the 'wealthiest' village—Gyedi. In Afrint 3, credit access has a relatively high positive effect on the probability of nonfarm participation. Also, the probability of nonfarm participation is significantly higher among female than male farm managers by about 10 percentage points.

The advantages of the TPM over the more restrictive Tobit, for example, is evident as it can be seen that the effect of the covariates on the probability of participation do not always carry through to the level of participation. Examples from the panel data estimates are the number of able household member as well as time and location effects. Particularly on village location, it is observed that locating in the Upper East villages is associated with lower levels of nonfarm income compared with locating in Gyedi, and indeed all other Eastern Region villages. The story is not different for the Afrint 3 cross-sectional estimates. Also, from the Afrint 3 estimates (Table 29), female farm managers receive approximately 25% lower nonfarm incomes compared to their male counterparts, although participation rate is higher among females as the first part regression indicates.

Finally, a bit more commentary on the gender-disaggregated estimates from the Afrint 3 data (Table 29). Clearly, the determinants of the decision to participate in nonfarm work differ across the genders and often in opposite directions; this is evidenced by the negative and significant correlation coefficient, $\rho$, between the error terms in the two equations ($\rho$ = –0.20). This means that, overall, factors that tend to increase female participation decreases male participation. For example, the probability of female participation is increasing with the number of able workers, the proportion of dependents, and credit access but not so for male participation. Similarly, the level of nonfarm income received by males is increasing with level of education, proportion of dependants, and household ownership of sowing machine, but not so for level of income received by females. The most important determinant of level of female income is access to credit and spatial location.

*Nonfarm income effects on farm outcomes*

As mentioned earlier, because of the threat of measurement error in reported household income data both the binary nonfarm income participation and the semi-continuous nonfarm income variables are utilized as explanatory variables in separate equations. Table 44 contains a summary of all the regression results. The full results of both the panel and Afrint 3 cross-section estimates can be found at the end of this document.

We begin with the effect of nonfarm income participation on purchased input use. The a priori expectation is a positive and significant coefficient on the nonfarm income variables. The expected sign is always observed in the panel data results (Table 22) but there is no evidence that either participation or level of nonfarm income significantly increases the probability of purchased input use. For the Afrint 3 cross-section estimates (Tables 30 & 31) we observe a negative and significant male nonfarm participation effect on the probability of purchased input use when using the gender disaggregated variable and accounting for endogeneity via a bivariate probit model under valid exclusion restrictions. The estimated magnitude of effect is non-trivial: on average, nonfarm income participation by male household members lowers the probability of purchase input use by approximately 19 percentage points.

The dependent variable in the second part of the model is log input expenditure. The panel data results again show no significant effect of nonfarm income if endogeneity is allowed through the household specific effect only (Table 22). Once nonfarm participation is allowed to be correlated with the random error the expected positive and significant effect is detected. The story is similar for the Afrint 3 estimates (Table 31) where we find additional evidence of a significant positive association between purchased input expenditures and the level of female nonfarm income. About 42% of households in the Afrint 3 sample have both male and female nonfarm income earning members. We find that average purchased input expenditure of such households is about 22% higher than the rest of the sample.

The next set of farm sector outcome variables of interest are improved seed adoption and hired labour use. Our data contains information on improved seed adoption and a binary indicator of whether or not the household regularly hires farm labour. Previous work (e.g. Oseni and Winters, 2009; Stampini and Davis, 2009; Takahashi and Otsuka, 2009) shows that households receiving nonfarm income spend significantly more on seeds and use more hired labour. In our data (both the panel and Afrint 3), no evidence is found that nonfarm income increases the probability of improved seed adoption (Tables 23 & 32). It is observed, however, that having both male and female nonfarm income earners increase the average probability of improved seed adoption by as much as 38 percentage points, after controlling for endogeneity. We find mild evidence of a significant positive association between hiring farm labour and nonfarm income: on average, nonfarm income participation is associated with a 10 percentage points increases in the probability of hiring farm labour, ceteris paribus.

Next is nonfarm participation and income effect on staple crop output market participation. The TPM is used. The first part predicts the probability of selling own-produced maize and rice, and the second part the share of output put out for sale (Tables 24, 33 & 34). If nonfarm income reduces the 'safety first' attitude that leads to self-provisioning of food requirements then a significant positive effect is expected a priori. The results using the panel data show no evidence that nonfarm income has an effect on either the probability of selling maize and rice or the share of output sold by farm households. Some evidence is found in the cross-sectional data but is not overwhelming, and only in the first part after disaggregating the nonfarm income information by gender in the maize case. In the case of rice (Table 34) it is observed that nonfarm participation lowers the probability of selling own-produced rice by 12 percentage points but conditional on selling, participation increases the proportion sold by about 17%, a result that is consistent with findings in the literature (Reardon *et al.*, 1994).

Disaggregating the income data shows that the positive effect on the share of rice sold comes from male nonfarm participation. Although the first part result is contrary to a priori expectation, this can be explained by the food insecurity situation in the Upper East where the rice producing households are located. Households in this region would generally sell staples only if they are severely constrained. Thus, where nonfarm income is available the probability of selling is reduced, as observed from our results.

A similar argument as above has been made with respect to the possible effect of nonfarm income on cash-crop production (Reardon *et al.*, 1994; Huang *et al.*, 2009). Tables 25 and 35 contain the panel and cross-sectional data estimates that seek to test this hypothesis. Because the nonfood cash crop variable is captured as binary, the panel data estimates are from pooled probit and fixed effects linear probability models while the Afrint 3 estimates are from probit models. No evidence is found in the panel to support the hypothesis. The Afrint 3 estimates provide some evidence of significant nonfarm income relationship, but only after using the gender disaggregated information. It is observed that nonfarm income participation by males is associated with a lower probability of participation in nonfood cash crop production while the hypothesised positive relationship is related to female nonfarm participation. This result makes sense if nonfood cash crop production relies on male family labour such that there is a trade-off between spending their time working off and on farm.

Finally we explore the possible effect of nonfarm income on total cultivated area. One would expect a significant positive effect of nonfarm participation on farm size if farming is viewed by the household as the main occupation and as such see nonfarm income as an avenue for relaxing the liquidity constraint that constrains farm expansion. If not, increased nonfarm participation could serve as a catalyst for exiting the farm. From the panel data estimates (Table 26) a positive and statistically significant coefficient is observed on the semi-continuous nonfarm income variable after allowing endogeneity to operate through the random error. Yet, the magnitude of effect is small: on average, a one dollar increase in nonfarm income is expected to increase average cultivated area by less than 0.1%, all else held constant. In the cross-sectional estimates from the Afrint 3 data, a negative sign is observed on the nonfarm income participation variable, meaning that participation is associated with decreasing cultivated area, on average (Table 36). Allowing participation in nonfarm income to be endogenous, it is estimated that average total cultivated area among participants was approximately 38% less than that of non-participants; under exogeneity, the difference is approximately 15%. The gender disaggregated nonfarm income variables suggest that the negative effect comes largely from female nonfarm participation. Also, households with both male and female nonfarm income earners cultivate smaller farm sizes.

*Distributional implications of nonfarm income*

Attention is now turned to the effect of participation and level of nonfarm income on welfare outcomes. Two household welfare indicators are utilised as described earlier: a welfare index and food (in)security. Estimates of the panel data welfare index equation are in Table 27. They are fixed and random effects estimates assuming the nonfarm income indicators are exogenous (i.e. uncorrelated with the idiosyncratic error). Where this assumption is invalid, we apply the two-step approaches suggested by Vella and Verbeek (see Vella and Verbeek, 1998; Vella and Verbeek, 1999). The cross-section welfare index estimates are fit by OLS assuming exogeneity of nonfarm income. Assuming endogeneity, a dummy endogenous regression model and the two-step approach suggested by Vella (1993) is applied (Table 37). The food insecurity status regressions (Tables 28 & 38) are pooled probit[8] and fixed effects linear probability model estimates for the panel data; probit is used for the cross-sectional data. In

[8] Results from the random effects probit model show clearly that the panel level variance component was unimportant in the current setting, hence the pooled probit estimates.

accounting for possible endogeneity of nonfarm income and participation the bivariate probit model is applied where the binary nonfarm income participation variable is the reduced form equation. Where the semi-continuous nonfarm income level enters the model, the two equations are estimated simultaneously using the multi-equation, multi- conditional mixed-process estimators (Roodman, 2011).

As could be expected, the welfare index is increasing with both nonfarm income participation and level in the panel data estimates. With the Afrint 3 estimates, we observe only a significant positive association between the welfare index and the level of nonfarm income participation. The difference in the average welfare index between nonfarm participants and non-participants (in the panel estimates) is between three to four units—this value is about 26% of the pooled median value of the welfare index. An increase of $100 in nonfarm income is associated with an average increase of only 0.2 units in the average welfare index for the Afrint 3 estimates; the magnitude of effect in the panel is much higher (between 1.4 to 1.7 units).

To get a better sense of magnitude of effect in monetary terms, given that the dependent variable is in welfare units, we compare the welfare value of nonfarm income with that of education by dividing by the nonfarm income coefficient. Doing so, we estimate the average welfare value of a marginal increase in a farm manager's education to be $489 in the Afrint 3 data, and $42 (in constant 2002 prices) for the panel data.

We now turn to the second welfare indicator – food in(security). The first sets of estimates predict the probability of food insecurity using the binary indicator. Recall that prima facie evidence from the initial descriptive analysis suggested that a significantly larger proportion of nonfarm income non-participants were food secure than participants (Table 18). If this follows through after controlling for other factors, including household specific heterogeneity in the panel data context, then it will be evidence against the hypothesis that nonfarm income is associated with reduction in food insecurity. The estimated coefficients can be found in Tables 28 and 38. We observe a positive but statistically insignificant nonfarm participation dummy average marginal effect in the panel data equations, including the fixed effects linear probability model (FELP). Once nonfarm participation is allowed to be endogenous by estimating a pooled bivariate probit model, the average marginal effect is non-trivially positive and highly statistically significant (Table 28).[9] A similar result is seen in the Afrint 3 cross-section estimates (Table 38), meaning that, on average, participation in nonfarm income is associated with an increasing probability of food insecurity.

When the nonfarm income variable enters in levels, the expected negative coefficient is observed whether or not nonfarm income is treated as endogenous. However, the effect magnitudes are very small in the panel data estimates in particular (–0.00176 to –0.00025), and so appears to be of little practical significance. From the Afrint 3 estimates, on average, a marginal increase in nonfarm income is associated with a decreasing probability of being food insecure by approximately four percentage points. Gender decomposition of the nonfarm income effect, through the use of the gender disaggregated income information, point to food insecurity decreasing with male nonfarm participation but increasing with female participation (Table 38). Entering the model in levels of male and female nonfarm income, however, the expected negative coefficient is observed for both, with similar magnitudes of effect, except that the statistical significance of the female nonfarm income variable is not strong.

Finally we discuss the ordered food security variable (ranges from 0 to 3, with 3 indicating the highest level of food security by construction). With the ordered probit food security models, the a priori expectation is a significant positive coefficient on the nonfarm income variables. Indeed, when entered in the model as level of nonfarm income a significant positive coefficient is observed. This means that, increasing average nonfarm income, all else held constant, is associated with an increasing probability of food security in all dimensions (i.e. meal quantity, quality and frequency) but a decreasing probability of being food insecure (Table 39). Exploiting the gender disaggregated income reveals familiar results; that female nonfarm participation and level of income are associated with decreasing probability of food security but increasing probability of food insecurity in the three meal dimensions. We also observe that households having both male and female nonfarm income earners are less likely to be food secure and more likely to be insecure.

[9] Fitting the pooled probit model to the current data is appropriate for two reasons. First, for panels with small $T$ (such as $T$=2 in the present case) the pooled estimator is preferred in the presence of the incidental parameter (Greene, 2004a); second on empirical grounds, the estimate of the panel-level variance component, ρ, from the data was 1.2e-05 and 5.1e-06 with the associated likelihood ratio chi-squared statistics being so small that the null hypothesis that the variance component is unimportant (i.e. ρ=0) cannot be rejected.

*Other determinants*

Highlights of other determinants of cropping input, staple crop output market participation and welfare are briefly discussed here. First on the differences by sex of farm manager, we observe in the Afrint 3 cross-section that female farm managers are less likely to use purchased inputs, although conditional on use we find no significant difference in expenditures between the two groups. Female farm managers are also more likely to use hired labour; they sell a smaller share of their rice output; are less likely to participate in nonfood cash crop production; and cultivate smaller farm sizes.

In the Afrint 3 composite welfare index equation estimates (Table 37), contrary to expectation, we observe a positive sign on the female farm manager household dummy in all models, although not significant in most cases. In the panel data estimates (Table 27) where we control of unobserved heterogeneity, we observe a negative sign, but yet again they are without statistical significance. So, we conclude that, in respect of average composite welfare, female manager households do not differ significantly from their male counterparts. An important point though is that ignoring unobserved heterogeneity may lead to contrary results about welfare differences between males and females.

The rest of the findings are summarised under each of the outcome variables as follows:

*Purchased inputs*: The probability of purchased input use is increasing with livestock commercialization, but conditional on use, average expenditures are decreasing with livestock commercialization. Non-food cash crop producers are more likely to use purchased inputs but conditional on use report lower input expenditures compared with staple crop farmers. Approximately 10% of households reported access to input credit; these households have a higher probability of purchase input use and also report higher purchase input expenditures. Purchased input use probabilities and expenditures differ significantly across villages.

*Improved seeds & Hired labour*: The probability of improved seed adoption by maize and rice farmers is generally increasing with farm size, nonfood cash crop production, and agriculture extension contact, but decreasing over time. There are also differences is adaption rates by regional location, with adoption higher in the Eastern region. The probability of hiring farm labour is increasing with farm size, livestock commercialisation, non-food cash crop production, and access to input credit.

*Staple crop output market*: The probability of selling maize and the share of output put on the market is increasing with farm size, participation in nonfood cash crop production, and available calories per consumption unit; but decreasing over time. The probability of selling own-produced rice is also increasing with farm size, nonfood cash crop production, available calories per consumption unit, and over time; but decreasing with livestock commercialisation. By far the most important determinant of staple crop market participation and extent is the ability of the household to satisfy consumption needs through own production.

*Participation in nonfood cash crop production*: The probability of participation in nonfood cash crop production is observed to be increasing with the availability of land, contact with agricultural extension service agents, and past year's available calories per consumption unit. The time effect was negative, meaning that the probability of non-food cash crop production has declined over time. This is likely the result of the commercialisation of crops that were previously considered staples meant largely for home consumption. We also observe significantly large location differences in the probability of nonfood cash crop production with the Upper East Region villages less likely to participate.

*Cultivated area*: Total cultivated area is observed to be increasing with land availability, household labour availability, livestock commercialisation, participation in non-food cash crop production, agricultural extension agent contact, and over time. It is, however, decreasing with fallowing, that is, households leaving land to fallow, cultivate smaller farms, on average. There also exist significant inter-village differences in area of land cultivated by households in the panel data estimates but such differences are not necessarily by region or agroecology.

*Welfare and food security*: As expected, education has a highly significant positive welfare value in both the panel and Afrint 3 estimates. In monetary terms, based on nonfarm income receipts, a marginal increase in farm manager's education level is estimated to increase welfare by 42 constant 2002 US dollars (this is approximately 40% of the pooled average household nonfarm income receipt). The estimated marginal welfare value of education in the Afrint 3 estimates is about US$484 (approximately 34% of the sample average household nonfarm income). In the panel data estimates, no statistically significant effect of education on reducing the probability of food insecurity is observed, but there is evidence from the Afrint 3 cross-section, although the marginal effect of an extra year of education is small.

Household assets such as land and livestock are associated with significantly large welfare effects. From the panel data estimates, increasing land endowment by one hectare increases average welfare by US$48 (in 2002 constant prices) and associated with US$161 according to the Afrint 3 estimates. The marginal welfare value of livestock (in Tropical Livestock Units) is even larger from the Afrint 3 estimates, about US$428 (US$38 in 2002 constant prices for the panel data estimates). Livestock wealth is also important for reducing food insecurity. Increasing livestock wealth at the margin is associated with about a two percentage point decrease in the probability of food insecurity. This is consistent with findings from other studies particularly relating to the importance of livestock in mitigating food insecurity during the lean season in northern Ghana (IFAD, 1998; Yaro, 2006; Quaye, 2008).

The debate about whether or not and how resource allocation to nonfood cash crops by smallholders could have negative implications for household food security has appeared in the literature (e.g von Braun J. and Kennedy, 1994; Poulton *et al.*, 1998; Govereh and Jayne, 2003; Dzanku and Sarpong, 2011). Our results suggest (form both the panel and cross-sectional estimates) that participation in nonfood cash crop production, on average, increases the probability of food insecurity by about 9 and 15 percentage points. Indeed, from the panel data estimates, the predicted probability of food insecurity is 31% for non-participants in nonfood cash crop production but 40% for participants.

The north-south welfare divide in Ghana is well known and documented (e.g. Aryeetey and McKay, 2007; Vanderpuye-Orgle, 2008). By far the most significant (both statistical and practical) determinant of welfare and food in(security) is spatial location of household. We observe a high welfare cost associated with locating in the Upper East villages. For example, locating in any of the four villages in the Upper East region reduces welfare by between US$582 (in Doba) to US$761 (in Gaane) compared with locating in Gyedi in the Eastern Region, according to the panel data estimates. For a more meaningful sense of magnitude note that average unconditional nonfarm earnings in the pooled sample is about US$106 (the conditional mean is US$154 and the median is US$61).

Also, the predicted probabilities of food insecurity in the estimated models are highly spatially dependent. For example, including a regional dummy in the panel data model and estimating the average partial effect of regional location on food insecurity decomposed over time suggests that the average predicted probabilities of food insecurity for households in the Eastern Region were 15% and 18% in 2008 and 2013, respectively, compared with 52% and 56% for Upper East Region households in the corresponding years, respectively. Including village dummies show even larger differences. For example, the predicted probability of food insecurity is 3% in Gyedi but as high as 62% in Shia in the Upper East.

## 6. CONCLUSIONS

This report is based on three waves of data collected from a sample of households in eight villages located in two of Ghana's ten regions, the Upper East and Eastern regions, over the period 2002-2013. The report focused on identifying the nature and extent of linkages, if any, between the farm and nonfarm sectors. Prior to doing so an overview of the two sectors—farm and nonfarm—was provided from the data.

On the farm sector, overall, average farm size increased by a significant 0.6ha between 2008 and 2013. Average maize yields in the Eastern region remained largely unchanged whereas all three staple crops studies in detail (maize, rice and sorghum) experienced yield increases in the Upper East region. Farm input use is central to the theme of this report as we expect nonfarm income to affect farm outcomes mainly through investment in productivity enhancing inputs. A decrease in the proportion of farmers using improved seeds was observed but significantly more farmers were using fertilizers, although the quantities being used remained largely constant.

On the nonfarm sector, participation and nonfarm income shares increased significantly between 2008 and 2013 but there are wide regional variations, with the Upper East region relying more on nonfarm incomes than the higher agro-potential Eastern region. The analysis shows that nonfarm participation, and hence the importance of the nonfarm sector, is significantly underestimated when not collecting detailed income data on all household income earning members.

Results of the regression analyses of the effect of nonfarm income on key household farming decisions have been examined in ten equations using the panel dataset as well as the Afrint 3 cross-section. Nonfarm participation (or nonfarm income) has a significant (positive) effect on only two outcome variables of interest—purchased input expenditure and total cultivated area. The cross-sectional estimates tell the same story with respect to purchased input expenditure but not cultivated area. Increased nonfarm incomes are associated with reduction in cultivated area, suggesting competition rather complementarity.

Using the gender decomposed nonfarm income variables in the regression equations , we observe that the probability of purchased input use and participation in nonfood cash crop production are decreasing with male nonfarm income earnings while the share of rice output sold is increasing with male nonfarm income earnings. Purchased input expenditure, the probability of maize output market participation, and the probability of nonfood cash crop production are all increasing with female nonfarm income; but total cultivated area is declining with female participation in nonfarm income.

On welfare implications from the regressions, although composite welfare is observed to be increasing with nonfarm income the magnitude of effect is often not of practical significance, particularly when compared with other welfare enhancers such is human capital assets and livestock ownership, for example. While food insecurity is reducing with level of nonfarm income, nonfarm income participation appears to be food insecurity increasing.

These results have important policy implications. In spite of all the reported effort in Ghana's policy documents (e.g. the various annual budgets and economic policy statements) it does not appear from our data that agriculture in the villages we have studied is on a modernisation path. Thus although we see a growing nonfarm sector, it does not appear that the increasing engagement in nonfarm work is being precipitated by growth and development in the farm sector. This calls for thorough scrutiny of policy implementation from the top to the grassroots, and vise versa.

A key message from the analysis is that, overall, agriculture remains critical for improving household welfare in the studied villages, particularly given that the nonfarm sector has a practically insignificant effect on welfare of the sampled households. Indeed, households specialising in farming are more likely to be food secure than those straddling the farm and nonfarm sectors. This means that the 'safety first' attitude that constrains nonfarm participation still lingers. This calls for more concerted effort at the implementation of already existing polices for improving both hard and soft infrastructure which helps reduce market constrains (including credit market constrains) that mitigates this risk and allow for inter-sector mobility that does not worsen household food security positions. In addressing all these, gender inequalities within agriculture need to be addressed simultaneously to ensure that men and women benefit equally. Related to this is the need to increase efforts aimed at enhancing women's capacity to engage in high-return nonfarm work. This is because although we observe that more women than men are involved in the rural nonfarm sector, we do not observe that this sector increases average welfare meaningfully.

REFERENCES

Amemiya, T. (1974). Multivariate regression and simultaneous equation models when dependent variables are truncated normal. *Econometrica,* 42(6), 999-1012.

Angelucci, F. (2012). Analysis of incentives and disincentives for maize in Ghana. Technical notes series. FAO, Rome. Available: htto://www.fao.org/mafap, Last accessed: 15 June 2014.

Angrist, J. D. (2001). Estimation of limited dependent variable models with dummy endogenous regressors: Simple strategies for empirical practice. *Journal of Business & Economic Statistics,* 19(1), 2-16.

Anriquez, G. & Daidone, S. (2010). Linkages between the farm and nonfarm sectors at the household level in rural Ghana: A consistent stochastic distance function approach. *Agricultural Economics,* 41(1), 51-66.

Aryeetey, E. & McKay, A. (2007). Ghana: The challenge of translating sustained growth into poverty reduction. In: Besley, T. & Cord, L. J. (Eds.) *Delivering on the promise of pro-poor growth: Insights and lessons from country experiences*, pp. 147-168. Washington D.C, Palgrave Macmillan and the World Bank.

Bandiera, O. (2007). Land Tenure, Investment Incentives, and the Choice of Techniques: Evidence from Nicaragua. *The World Bank Economic Review,* 21(3), 487-508.

Barrett, C. B. (2008). Smallholder market participation: Concepts and evidence from eastern and southern Africa. *Food Policy,* 33(4), 299-317.

Barrett, C. B., Bezuneh, M. & Aboud, A. (2001a). Income diversification, poverty traps and policy shocks in Côte d'Ivoire and Kenya. *Food Policy,* 26(4), 367-384.

Barrett, C. B., Reardon, T. & Webb, P. (2001b). Nonfarm income diversification and household livelihood strategies in rural Africa: Concepts, dynamics, and policy implications. *Food Policy,* 26(4), 315-331.

Canagarajah, S., Newman, C. & Bhattamishra, R. (2001). Non-farm income, gender, and inequality: evidence from rural Ghana and Uganda. *Food Policy,* 26(4), 405-420.

Chen, S. & Zhou, X. (2011). Semiparametric estimation of a bivariate Tobit model. *Journal of Econometrics,* 165(2), 266-274.

Author (Year). Title. *Series Title.* Institution, City.

Christensen, G. (1989). Determinants of Private Investment in Rural Burkina Faso. Ph.D Thesis, Cornell University.

Collier, P. & Lal, D. (1984). Why poor people get rich: Kenya 1960–1979. *World Development,* 12(10), 1007-1018.

Cragg, J. G. (1971). Some statistical models for limited dependent variables with application to the demand for durable goods. *Econometrica,* 39(5), 829-844.

Davis, B., Winters, P., Carletto, G., Covarrubias, K., Quinones, E. J., Zezza, A., Stamoulis, K., Azzarri, C. & Digiuseppe, S. (2010). A cross-country comparison of rural income generating activities. *World Development,* 38(1), 48-63.

Davis, B., Winters, P., Reardon, T. & Stamoulis, K. (2009). Rural nonfarm employment and farming: Household-level linkages. *Agricultural Economics,* 40(2), 119-123.

de Janvry, A. & Sadoulet, E. (2002). World poverty and the role of agricultural technology: Direct and indirect effects. *The Journal of Development Studies,* 38(4), 1-26.

de Janvry, A. D. (2005). *The role of non-farm incomes in reducing rural poverty and inequality in China*. California Agricultural Experiment Station, Giannini Foundation of Agricultural Economics.

Deaton, A. (1997). *The analysis of household surveys: A microeconometric approach to development policy*. The World Bank, Washington DC.

Deininger, K. & Ali, D. A. (2008). Do Overlapping Land Rights Reduce Agricultural Investment? Evidence from Uganda. *American Journal of Agricultural Economics,* 90(4), 869-882.

Delgado, C., Hazell, P., Hopkins, J. & Kelly, V. (1994). Promoting intersectoral growth linkages in rural Africa through agricultural technology and policy reform. *American Journal of Agricultural Economics,* 76(5), 1166-1171.

Diao, X., Hazell, P. & Thurlow, J. (2010). The role of agriculture in African development. *World Development,* 38(10), 1375-1383.

Dorosh, P. & Haggblade, S. (2003). Growth linkages, price effects and income distribution in sub-Saharan Africa. *Journal of African Economies,* 12(2), 207-235.

Duan, N., Manning, W. G., Jr., Morris, C. N. & Newhouse, J. P. (1984). Choosing between the sample-selection model and the multi-part model. *Journal of Business & Economic Statistics,* 2(3), 283-289.

Dzanku, F. M. & Sarpong, D. B. (2009). Afrint II: Ghana Micro and Meso Study report. Available: http://blog.sam.lu.se/afrint/?page_id=84, Last accessed: 2 May 2011.

Dzanku, F. M. & Sarpong, D. B. (2011). Agricultural diversification, food self-sufficiency and food security in Ghana: The role of infrastructure and institutions. In: Djurfeldt, G., Aryeetey, E. & Isinika, A. C. (Eds.) *African Smallholders: Food Crops, Markets and Policy*, pp. 189-213. London, CAB International.

Ellis, F. (2000). *Rural livelihoods and diversity in developing countries*. Oxford University Press, Oxford.

Ellis, F. (2010). Strategic dimensions of rural poverty reduction in sub-Saharan Africa. In: Harriss-White, B. & Heyer, J. (Eds.) *The Comparative Political Economy of Development: Africa and South Asia*, pp. 47-63. New York, Routledge.

Ellis, F. & Freeman, H. A. (2004). Rural livelihoods and poverty reduction strategies in four African countries. *The Journal of Development Studies,* 40(4), 1-30.

Evans, H. E. & Ngau, P. (1991). Rural-urban relations, household income diversification and agricultural productivity. *Development and Change,* 22(3), 519-545.

Finan, F., Sadoulet, E. & de Janvry, A. (2005). Measuring the poverty reduction potential of land in rural Mexico. *Journal of Development Economics,* 77(1), 27-51.

Foster, A. D. & Rosenzweig, M. R. (2004). Agricultural productivity growth, rural economic diversity, and economic reforms: India, 1970-2000. *Economic Development and Cultural Change,* 52(3), 509-542.

Govereh, J. & Jayne, T. S. (2003). Cash cropping and food crop productivity: synergies or trade-offs? *Agricultural Economics,* 28(1), 39-50.

Greene, W. (2004a). The behaviour of the maximum likelihood estimator of limited dependent variable models in the presence of fixed effects. *Econometrics Journal,* 7(1), 98-119.

Greene, W. (2004b). Fixed effects and bias due to the incidental parameters problem in the tobit model. *Econometric Reviews,* 23(2), 125-147.

Greene, W. (2012). *Econometric analysis,* 7th edition. Pearson Education Limited, Essex.

Haggblade, S. & Hazell, P. (1989). Agricultural technology and farm-nonfarm growth linkages. *Agricultural Economics,* 3(4), 345-364.

Haggblade, S., Hazell, P. & Brown, J. (1989). Farm-nonfarm linkages in rural Sub-Saharan Africa. *World Development,* 17(8), 1173-1201.

Haggblade, S., Hazell, P. & Reardon, T. (2002). Strategies for stimulating poverty-alleviating growth in the rural non-farm economy in developing countries. EPTD Discussion paper 92. International Food Policy Research Institute, Washington DC. Available: http://www.ifpri.org/, Last accessed: 20 February 2010.

Haggblade, S., Hazell, P. B. R. & Reardon, T. (2007a). Introduction. In: Haggblade, S., Hazell, P. B. R. & Reardon, T. A. (Eds.) *Transforming the rural nonfarm economy: Opportunities and* *threats in the developing world*, pp. 3-24. Washington D.C, Johns Hopkins University Press.

Haggblade, S., Hazell, P. B. R. & Reardon, T. A. (Eds.) (2007b). *Transforming the rural nonfarm economy: Opportunities and threats in the developing world.* Johns Hopkins University Press.

Hazell, P. & Haggblede, S. (1993). Farm-nonfarm growth an the welfare of the poor. In: Lipton, M. & J. Van der Gaag (Eds.) *Including the Poor*, pp. 190-204. Washington DC, The World Bank.

Hazell, P. & Roell, A. (1983). *Agricultural growth linkages in sub-saharan Africa*. International Food Policy Research Institute, Washington, DC.

Hazell, P. B. R., Haggblade, S. & Reardon, T. A. (2007). Structural transformation of the rural nonfarm economy. In: Haggblade, S., Hazell, P. B. R. & Reardon, T. A. (Eds.) *Transforming the rural nonfarm economy: Opportunities and threats in the developing world*, pp. 83-98. Washington D.C, Johns Hopkins University Press.

Heckman, J. J. (1979). Sample selection bias as a specification error. *Econometrica,* 47(1), 153-161.

Hertz, T. (2009). The effect of nonfarm income on investment in Bulgarian family farming. *Agricultural Economics,* 40(2), 161-176.

Hilson, G. (2010). 'Once a miner, always a miner': Poverty and livelihood diversification in Akwatia, Ghana. *Journal of Rural Studies,* 26(3), 296-307.

Hossain, M. (2004). Rural non-farm economy in Bangladesh: A view from household surveys. Occasional Papers Series 40. Centre for Policy Dialogue (CPD). Available: http://ideas.repec.org/p/pdb/opaper/40.html, Last accessed: 23/09/2009.

Huang, J. K., Wu, Y. H. & Rozelle, S. (2009). Moving off the farm and intensifying agricultural production in Shandong: a case study of rural labor market linkages in China. *Agricultural Economics,* 40(2), 203-218.

IFAD (1998). Ghana - Women's contribution to household food security. The International Fund for Agricultural Development Available: http://www.ifad.org/gender/, Last accessed: 19/06/2009.

Kilic, T., Carletto, C., Miluka, J. & Savastano, S. (2009). Rural nonfarm income and its impact on agriculture: evidence from Albania. *Agricultural Economics,* 40(2), 139-160.

Lanjouw, J. O. & Lanjouw, P. (2001). The rural non-farm sector: Issues and evidence from developing countries. *Agricultural Economics,* 26(1), 1-23.

Maertens, M. (2009). Horticulture exports, agro-industrialization, and farm-nonfarm linkages with the smallholder farm sector: evidence from Senegal. *Agricultural Economics,* 40(2), 219-229.

Mellor, J. W. (1976). *The new economics of growth: A strategy for India and the developing world*. Cornell University Press, Ithaca.

Okoh, G. & Hilson, G. (2011). Poverty and livelihood diversification: Exploring the linkages between smallholder farming and artisanal mining in rural Ghana. *Journal of International Development,* 23(8), 1100-1114.

Oseni, G. & Winters, P. (2009). Rural nonfarm activities and agricultural crop production in Nigeria. *Agricultural Economics,* 40(2), 189-201.

Owusu, V., Abdulai, A. & Abdul-Rahman, S. (2011). Non-farm work and food security among farm households in Northern Ghana. *Food Policy,* 36(2), 108-118.

Papke, L. E. & Wooldridge, J. M. (1996). Econometric methods for fractional response variables with an application to 401 (k) plan participation rates. *Journal of Applied Econometrics,* 11(6), 619-632.

Papke, L. E. & Wooldridge, J. M. (2008). Panel data methods for fractional response variables with an application to test pass rates. *Journal of Econometrics,* 145(1-2), 121-133.

Pfeiffer, L., López-Feldman, A. & Taylor, J. E. (2009). Is off-farm income reforming the farm? Evidence from Mexico. *Agricultural Economics,* 40(2), 125-138.

Poulton, C., Dorward, A. & Kydd, J. (1998). The revival of smallholder cash crops in Africa: Public and private roles in the provision of finance. *Journal of International Development,* 10( 1), 85-103.

Quaye, W. (2008). Food security situation in northern Ghana, coping strategies and related constraints. *African Journal of Agricultural Research,* 3(5), 334-342.

Reardon, T. (1997). Using evidence of household income diversification to inform study of the rural nonfarm labor market in Africa *World Development,* 25(5), 735-747.

Reardon, T., Crawford, E. & Kelly, V. (1994). Links between nonfarm income and farm investment in African households: Adding the capital-market perspective. *American Journal of Agricultural Economics,* 76(5), 1172-1176.

Reardon, T., Delgado, C. & Matlon, P. (1992). Determinants and effects of income diversification amongst farm households in Burkina Faso. *The Journal of Development Studies,* 28(2), 264-296.

Reardon, T., Stamoulis, K., Cruz, M.-E., Balisacan, A., Berdegue, J. & Banks, B. (1998). Rural non-farm income in developing countries. In: *The State of Food and Agriculture 1998: Part III*, pp. Rome, Food and Agricultural Organisation.

Roodman, D. (2011). Fitting fully observed recursive mixed-process models with cmp. *Stata Journal,* 11, 159-206.

Savadogo, K., Reardon, T. & Pietola, K. (1994). Farm productivity in Burkina-Faso: Effects of animal traction and nonfarm income. *American Journal of Agricultural Economics,* 76(3), 608-612.

Savadogo, K., Reardon, T. & Pietola, K. (1995). Mechanization and Agricultural Supply Response in the Sahel: a Farm-Level Profit Function Analysis. *Journal of African Economies,* 4(3), 336-377.

Stampini, M. & Davis, B. (2009). Does nonagricultural labor relax farmers' credit constraints? Evidence from longitudinal data for Vietnam. *Agricultural Economics,* 40(2), 177-188.

Takahashi, K. & Otsuka, K. (2009). The increasing importance of nonfarm income and the changing use of labor and capital in rice farming: the case of Central Luzon, 1979-2003. *Agricultural Economics,* 40(2), 231-242.

Tobin, J. (1958). Estimation of relationships for limited dependent variables. *Econometrica,* 26(1), 24-36.

Vanderpuye-Orgle, J. (2008). The north-south devide and the disappearing of the middle class: An analysis of spatial inequality and polarization in Ghana. In: Amoako-Tuffour, J. & Armah, B. (Eds.) *Poverty reduction strategies in action: Perspectives and lessons from Ghana*, pp. 49-71. Plymouth, UK, Lexington Books.

Vella, F. (1993). A simple estimator for simultaneous models with censored endogenous regressors. *International Economic Review,* 34(2), 441-457.

Vella, F. & Verbeek, M. (1998). Whose Wages do Unions Raise? A Dynamic Model of Unionism and Wage Rate Determination for Young Men. *Journal of Applied Econometrics,* 13(2), 163-183.

Vella, F. & Verbeek, M. (1999). Two-step estimation of panel data models with censored endogenous variables and selection bias. *Journal of Econometrics,* 90(2), 239-263.

von Braun J. & Kennedy, E. (Eds.) (1994). *Agricultural commercialization, economic development, and nutrition.* Baltimore, Johns Hopkins University Press.

Winters, P., Davis, B., Carletto, G., Covarrubias, K., Quinones, E. J., Zezza, A., Azzarri, C. & Stamoulis, K. (2009). Assets, activities and rural income generation: Evidence from a multicountry analysis. *World Development,* 37(9), 1435-1452.

Woldenhanna, T. & Oskam, A. (2001). Income diversification and entry barriers: Evidence from the Tigray region of northern Ethiopia. *Food Policy,* 26(4), 351-365.

Yaro, J. A. (2006). Is deagrarianisation real? A study of livelihood activities in rural northern Ghana. *Journal of Modern African Studies,* 44(1), 125-156.

Zeger, S. L. & Liang, K.-Y. (1986). Longitudinal data analysis for discrete and continuous outcomes. *Biometrics,* 42(1), 121-130.

**Table 1. Afrint 3 household sample category**

| Sample category | Freq. | Percent |
|---|---|---|
| Re-interviewed Afrint 2 households | 472 | 87.6 |
| Descendants of Afrint 2 households | 20 | 3.7 |
| New sample (including 2 immigrant) households | 47 | 8.7 |
| Total | 539 | 100 |

**Table 2. Total cultivated land and participation in nonfood cash crop production**

| | Eastern Region | | | Upper East Region | | |
|---|---|---|---|---|---|---|
| | 2002 | 2008 | 2013 | 2002 | 2008 | 2013 |
| Total cultivated area (ha) | 1.7 | 1.5 | 3.0 | 2.1 | 2.0 | 2.2 |
| % cultivating other food crops | 81.3 | 91.8 | 96.3 | 97.1 | 76.1 | 93.5 |
| Other food crop area (ha) | 0.6 | 0.6 | 1.4 | 0.8 | 0.7 | 0.5 |
| % cultivating nonfood cash crops | 10.6 | 21.1 | 42.1 | 11.1 | 3.8 | 1.8 |
| Nonfood cash crop area (ha) | 1.0 | 1.2 | 1.2 | 0.5 | 0.4 | 0.5 |

*Note*: 'other food crops' refer to all other food crops other than maize, cassava, rice and sorghum.

**Table 3. Comparison of reported and calculated change in cultivated area between 2008 and 2013**

| | | Calculated from data | | | |
|---|---|---|---|---|---|
| | | decreased | unchanged | increased | Total |
| Reported by farm manager | decreased | 76 | 16 | 120 | 212 |
| | | (35.9) | (7.6) | (56.6) | (100) |
| | | [23.5] | [34.8] | [19.7] | [21.6] |
| | unchanged | 194 | 26 | 282 | 502 |
| | | (38.7) | (5.2) | (56.2) | (100) |
| | | [59.9] | [56.5] | [46.2] | [51.2] |
| | increased | 54 | 4 | 208 | 266 |
| | | (20.3) | (1.5) | (78.2) | (100) |
| | | [16.7] | [8.7] | [34.1] | [27.1] |
| | Total | 324 | 46 | 610 | 980 |
| | | (33.1) | (4.7) | (62.2) | (100) |
| | | [100] | [100] | [100] | [100] |

*Note*: row and column percentages in parenthesis and brackets respectively.

**Table 4. Participation in maize, sorghum and rice production over time (%)**

| | Eastern Region | Upper East Region | | |
|---|---|---|---|---|
| | maize | maize | sorghum | rice |
| 1999 | 94.9 | n.a | 97.6 | 82.7 |
| 2000 | 99.0 | n.a | 96.2 | 84.1 |
| 2001 | 99.5 | n.a | 97.6 | 84.1 |
| 2005 | 77.8 | 32.2 | 92.0 | 66.4 |
| 2006 | 84.6 | 34.6 | 96.5 | 68.9 |
| 2007 | 94.3 | 26.6 | 94.1 | 66.8 |
| 2010 | 91.1 | 52.5 | 85.6 | 69.8 |
| 2011 | 89.7 | 57.2 | 85.6 | 72.7 |
| 2012 | 96.7 | 61.9 | 85.6 | 74.7 |

**Table 5. Farm size, output and yields of maize, sorghum and rice over time**

| | Eastern Region | | | Upper East Region | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Maize | | | Maize | | | Sorghum | | | Rice | | |
| year | farm size (ha) | Output (kg) | Yield (kg/ha) | farm size (ha) | Output (kg) | Yield (kg/ha) | farm size (ha) | Output (kg) | Yield (kg/ha) | farm size (ha) | Output (kg) | Yield (kg/ha) |
| 1999 | 1.02 | 790 | 1224 | n.a | n.a | n.a | 0.80 | 364 | 543 | 0.57 | 505 | 1092 |
| | (0.80) | (877) | (1550) | n.a | n.a | n.a | (0.59) | (384) | (486) | (0.49) | (526) | (1170) |
| 2000 | 0.98 | 812 | 1289 | n.a | n.a | n.a | 1.05 | 375 | 481 | 0.54 | 470 | 981 |
| | (0.77) | (918) | (1502) | n.a | n.a | n.a | (0.93) | (399) | (457) | (0.47) | (514) | (786) |
| 2001 | 0.94 | 890 | 1414 | n.a | n.a | n.a | 0.77 | 411 | 616 | 0.56 | 525 | 1096 |
| | (0.73) | (984) | (1555) | n.a | n.a | n.a | (0.51) | (435) | (606) | (0.41) | (583) | (1151) |
| *Average* | *0.97* | *830* | *1309* | n.a | n.a | n.a | *0.87* | *382* | *547* | *0.55* | *496* | *1052* |
| | *(0.71)* | *(864)* | *(1436)* | n.a | n.a | n.a | *(0.51)* | *(383)* | *(465)* | *(0.43)* | *(519)* | *(949)* |
| 2005 | 0.66 | 635 | 1326 | 0.60 | 237 | 508 | 0.99 | 179 | 194 | 0.66 | 338 | 561 |
| | (0.68) | (621) | (1199) | (0.43) | (222) | (528) | (0.55) | (143) | (136) | (0.46) | (424) | (458) |
| 2006 | 0.65 | 677 | 1295 | 0.59 | 235 | 512 | 0.98 | 163 | 185 | 0.65 | 327 | 535 |
| | (0.65) | (741) | (932) | (0.44) | (228) | (483) | (0.52) | (132) | (131) | (0.45) | (9440) | (455) |
| 2007 | 0.64 | 765 | 1432 | 0.59 | 124 | 234 | 0.97 | 86 | 103 | 0.61 | 265 | 421 |
| | (0.60) | (702) | (999) | (0.37) | (402) | (313) | (0.54) | (109) | (117) | (0.45) | (528) | (443) |
| *Average* | *0.64* | *683* | *1358* | *0.56* | *200* | *448* | *0.98* | *141* | *159* | *0.63* | *309* | *499* |
| | *(0.58)* | *(618)* | *(857)* | *(0.40)* | *(186)* | *(408)* | *(0.53)* | *(112)* | *(106)* | *(0.44)* | *(451)* | *(408)* |
| 2010 | 1.12 | 995 | 1241 | 0.71 | 378 | 530 | 0.99 | 262 | 282 | 0.80 | 668 | 775 |
| | (0.81) | (802) | (1451) | (0.53) | (363) | (300) | (0.56) | (191) | (176) | (0.56) | (856) | (544) |
| 2011 | 1.23 | 1102 | 1172 | 0.67 | 375 | 593 | 0.96 | 267 | 292 | 0.77 | 676 | 797 |
| | (0.91) | (955) | (1237) | (0.57) | (368) | (350) | (0.53) | (181) | (182) | (0.56) | (864) | (535) |
| 2012 | 1.13 | 1145 | 1245 | 0.65 | 428 | 716 | 0.93 | 241 | 275 | 0.74 | 712 | 836 |
| | (0.77) | (987) | (1204) | (0.53) | (439) | (445) | (0.51) | (168) | (171) | (0.56) | (931) | (555) |
| *Average* | *1.14* | *1057* | *1199* | *0.66* | *392* | *630* | *0.96* | *258* | *283* | *0.76* | *684* | *812* |
| | *(0.72)* | *(817)* | *(1134)* | *(0.51)* | *(358)* | *(291)* | *(0.52)* | *(161)* | *(150)* | *(0.54)* | *(861)* | *(504)* |

Note: Figures in parentheses are standard deviations; n.a denotes not available

**Table 6. Percent change in farm size and yields, by region**

| VARIABLES | Maize | | Sorghum | | Rice | |
|---|---|---|---|---|---|---|
| | Farm size | Yield | Farm size | Yield | Farm size | Yield |
| Eastern Region | | | | | | |
| 2002–2008 | –31.1*** | 1.3 | n.a | n.a | n.a | n.a |
| | (–5.7) | (0.1) | | | | |
| 2002–2013 | 22.3** | –11.6 | n.a | n.a | n.a | n.a |
| | (2.5) | (–1.3) | | | | |
| 2008–2013 | 77.4*** | –12.7 | n.a | n.a | n.a | n.a |
| | (5.9) | (–1.8) | | | | |
| Upper East Region | | | | | | |
| 2002–2008 | n.a | n.a | 25.6*** | –83.3*** | 8.6 | –61.6*** |
| | | | (3.5) | (–51.1) | (1.0) | (–14.6) |
| 2002–2013 | n.a | n.a | 20.6*** | –55.3*** | 31.9*** | –23.9*** |
| | | | (2.9) | (–15.5) | (3.2) | (–3.4) |
| 2008–2013 | 9.5 | 206.3*** | –4.0 | 167.4*** | 21.4** | 98.1*** |
| | (0.9) | (4.2) | (–0.8) | (7.9) | (2.4) | (5.6) |

*Note*: estimates are based on most recent season data for each survey round; n.a denotes not available; *t*-statistics in parentheses; *** and ** represent statistical significance at the 1 and 5 percent levels, respectively.

**Table 7. Input use on maize, sorghum and rice farms over time and region**

| | % using improved seed | | | Inorganic fertilizers | | | | | | | | % using pesticides/herbicides | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Eastern | Upper East | | Eastern | | Upper East | | | | | | Eastern | Upper East | | |
| Survey | | | | Maize | | Maize | | Sorghum | | Rice | | | | | |
| year | Maize | Maize | Rice | % using | exp | % using | exp | % using | exp | % using | exp | Maize | Maize | Sorghum | Rice |
| 2002 | 36.9 | n.a | 32.0 | 23.9 | n.a | n.a | n.a | 13.8 | n.a | 37.1 | n.a | 13.2 | n.a | 2.0 | 10.3 |
| 2008 | 64.1 | 64.9 | 64.2 | 35.4 | 28.3 | 45.5 | 27.7 | 4 | 15.9 | 50.3 | 26.7 | 52.1 | 19.5 | 2.9 | 26.9 |
| 2013 | 55.8 | 2.3 | 8.0 | 41.8 | 22.6 | 69.6 | 19.7 | 16.5 | 12.2 | 54.7 | 24.4 | 88.5 | 62.6 | 19 | 55.7 |

*Note*: n.a denotes not available; exp is constant (at 2002 prices) conditional (on using fertilizers) expenditure in US dollars

**Table 8. Household use of other farm input over time and region**

| Year | % using animal manure use | | % with agric extension contact | | % being member of farmer organization | | % obtaining agric input credit | | % using hired farm labour | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Eastern | Upper East | Eastern | Upper East | Eastern | Upper East | Eastern | Upper East | Eastern | Upper East |
| 2002 | 3.0 | 80.8 | 57.1 | 83.7 | 32.3 | 39.9 | 13.1 | 14.4 | 77.8 | 61.1 |
| 2008 | 7.9 | 92.4 | 64.2 | 50.2 | 16.1 | 24.9 | 8.6 | 6.9 | 79.6 | 49.8 |
| 2013 | 4.2 | 87.7 | 52.3 | 49.1 | 15.9 | 17.3 | 9.3 | 11.2 | 80.8 | 60.3 |

*Note*: ESR & UER represent Eastern Region and Upper East Region respectively.

**Table 9. Maize, sorghum and rice output markets over time and region**

| | Maize market | | | | | | Upper East | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Eastern | | | Upper East | | | Sorghum market | | | Rice market | | |
| Year | Partici–pation (%) | Sale (kg) | % of output | Partici–pation (%) | Sale (kg) | % of output | Partici–pation (%) | Sale (kg) | % of output | Partici–pation (%) | Sale (kg) | % of output |
| 2002 | 96.4 | 600(400) | 60.3(60.0) | n.a | n.a | | 25.1 | 189(109) | 33.3(26.9) | 56.0 | 332(164) | 41.4(37.5) |
| 2008 | 95.8 | 547(375) | 66.2(70.0) | 2.6 | 100(100) | 41.7(41.7) | 3.3 | 67(55) | 31.4(28.5) | 32.1 | 246(150) | 41.1(40.0) |
| 2013 | 84.1 | 777(600) | 60.7(60.0) | 21.6 | 297(300) | 38.5(40.0) | 10.5 | 94(100) | 32.3(20.0) | 51.2 | 725(350) | 51.8(56.7) |

*Note*: Quantity sold is conditional on participation in output markets for the various crops; median values in parentheses.

**Table 10. Number of income sources, household income and change in income over time**

| | Eastern Region | | | Upper East Region | | |
|---|---|---|---|---|---|---|
| | 2008 | 2013 | % change | 2008 | 2013 | % change |
| Number of income sources | 2.8 | 3.3 | 20.5*** | 2.4 | 3.2 | 31.4*** |
| | (3.0) | (3.0) | [4.8] | (2.0) | (3.0) | [7.0] |
| Household income (current) | 940 | 1740 | | 296 | 761 | |
| | (568) | (1263) | | (134) | (447) | |
| Household income (constant)[a] | 423 | 474 | 12.0 | 145 | 202 | 39.3** |
| | (255) | (344) | [1.2] | (66) | (119) | [2.3] |
| Per capita household income (current) | 236 | 353 | | 53 | 128 | |
| | (138) | (218) | | (23) | (72) | |
| Per capita household income (constant)[a] | 106 | 96 | –9.5 | 26 | 34 | 32.2 |
| | (62) | (59) | [–0.9] | (11) | (19) | [1.6] |

*Note*: Median values in parentheses; a. constant income s in 2002 prices; t-statistic in brackets; *** and ** represent statistical significance at the 1 and 5 percent levels, respectively.

**Table 11. Shares and participation in rural income generating activities (%)**

| | Eastern Region | | Upper East Region | |
|---|---|---|---|---|
| | 2008 | 2013 | 2008 | 2013 |
| Crop income share | 77.4 | 64.0 | 18.7 | 28.9 |
| Participation in crop income | 98.2 | 94.9 | 39.4 | 62.1 |
| Crop income share conditioned on participation | 78.9 | 67.5 | 47.4 | 46.5 |
| Nonfarm income share | 16.1 | 32.3 | 43.3 | 51.1 |
| Participation in nonfarm income | 41.6 | 69.2 | 73.0 | 93.4 |
| Nonfarm income share conditioned on participation | 38.8 | 46.7 | 59.4 | 54.8 |
| Food crop income share | 74.9 | 58.7 | 17.6 | 28.4 |
| Participation in food crop income | 98.2 | 94.4 | 38.1 | 61.4 |
| Food crop income share conditioned on participation | 76.3 | 62.2 | 46.3 | 46.2 |
| Nonfood cash crop income share | 2.5 | 5.3 | 1.1 | 0.5 |
| Participation in nonfood cash crop income | 10.8 | 29.0 | 4.5 | 1.5 |
| Nonfood cash crop income share conditioned on participation | 23.4 | 18.2 | 23.9 | 34.3 |
| Livestock income share | 6.4 | 3.7 | 38.0 | 20.0 |
| Participation in livestock income | 41.6 | 37.4 | 80.3 | 74.3 |
| Livestock income share conditioned on participation | 15.4 | 9.9 | 47.3 | 26.9 |
| Non-labour income share | 0.9 | 1.8 | 1.9 | 3.6 |
| Participation in non-labour income | 4.3 | 6.1 | 6.6 | 8.5 |
| Non-labour income share conditioned on participation | 20.0 | 29.8 | 28.8 | 42.3 |
| Nonfarm wage-employment income share | 4.8 | 5.9 | 13.6 | 15.4 |
| Participation in nonfarm wage employment income | 10.0 | 16.4 | 25.6 | 48.2 |
| Nonfarm wage income share conditioned on participation | 48.0 | 36.1 | 52.9 | 32.1 |
| Nonfarm self-employment income share | 6.9 | 16.6 | 11.3 | 14.7 |
| Participation in nonfarm self-employment income | 21.9 | 42.5 | 31.8 | 40.8 |
| Nonfarm self-emp. income share conditioned on participation | 31.5 | 39.0 | 35.6 | 36.1 |
| Remittance income share | 3.6 | 8.0 | 16.6 | 17.4 |
| Participation in remittance income | 16.1 | 31.3 | 41.5 | 61.4 |
| Remittance income share conditioned on participation | 22.2 | 25.5 | 39.9 | 28.3 |

*Note*: non-labour income excludes remittances.

**Table 12. Change in income shares over time and regional differences in income shares (%)**

| | Change over time | | Between Region difference | |
|---|---|---|---|---|
| | Eastern Region | Upper East Region | 2008 | 2013 |
| Crops | –13.5*** | 10.2*** | 58.8*** | 35.1*** |
| All nonfarm | 16.2*** | 7.8*** | –27.2*** | –18.9*** |
| Food crop | –16.2*** | 10.8*** | 57.3*** | 30.3*** |
| Nonfood cash crop | 2.8*** | –0.6 | 1.4** | 4.8*** |
| Livestock | –2.7*** | –18.0*** | –31.5*** | –16.2*** |
| Non-labour | 1.0 | 1.7 | –1.0 | –1.8* |
| Nonfarm wage | 1.1 | 1.9 | –8.7*** | –9.5*** |
| Nonfarm self | 9.7*** | 3.4 | –4.4*** | 1.8 |
| Remittances | 4.4*** | 0.8 | –13.0*** | –9.4*** |

*Note*: *** and ** represent statistical significance at the 1% and 5% levels; A positive value denotes higher average income shares from a given income source in 2013 or in the Eastern Region compared with the Upper East Region, and vice versa if value is negative.

**Table 13. Comparison of income variables by Gender, 2013 data only**

| | Household headship | | | Intra–household differences | | | |
|---|---|---|---|---|---|---|---|
| | | | | Unpaired | | paired | |
| | *n=427* | *n=107* | | *n= 454* | *n=397* | *n=317* | |
| Variable | Male | Female | % Diff. | Males | Females | Males | Females |
| Income sources (#) | 4.3 | 3.4 | 25.8*** | 3.0 | 2.1*** | 3.0 | 2.0*** |
| Members with nonfarm income(#) | 1.7 | 1.4 | 18.9** | 0.9 | 1.1*** | 1.0 | 1.1** |
| Total income (US$) | 3529 | 2165 | 63.0*** | 2781 | 1198*** | 2479 | 1109*** |
| Total per capita income (US$) | 667 | 517 | 29.0 | n.a | n.a | n.a | n.a |
| Crop income (US$) | 1822 | 1077 | 69.2** | 1590 | 431*** | 1430 | 368*** |
| Crop income share (%) | 43.8 | 36.0 | 21.7* | 47.2 | 28.5*** | 45.2 | 26.6*** |
| Nonfarm income (US$) | 1543 | 966 | 59.8** | 1046 | 724*** | 875 | 702 |
| Nonfarm income share (%) | 46.9 | 54.7 | –14.3** | 39.3 | 66.3*** | 38.2 | 68.0*** |
| Nonfarm self–emp. income (US$) | 808 | 457 | 77.0 | 424 | 507 | 267 | 509*** |
| Nonfarm self–emp. share (%) | 19.7 | 22.1 | –11.0 | 10.1 | 38.7*** | 8.9 | 41.4*** |
| Remittance income (US$) | 139 | 197 | –29.4** | 97 | 110 | 85 | 73 |
| Remittance income share (%) | 9.6 | 19.4 | –50.4*** | 8.6 | 15.0*** | 7.9 | 12.5*** |

*Note*: *** and ** represent statistical significance at the 1% and 5% levels.

**Table 14. Share and participation in income generating activities by gender, 2013 survey only (%)**

| | Eastern Region | | | Upper East Region | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|
| | (A) | (B) | (C) | (A) | (B) | (C) | (A) | (B) | (C) |
| crop income | | | | | | | | | |
| Male | 70.9 | 97.9 | 72.4 | 30.5 | 59.0 | 51.7 | 47.2 | 75.1 | 62.9 |
| Female | 45.2 | 73.8 | 61.2 | 18.5 | 35.5 | 52.1 | 28.5 | 49.9 | 57.2 |
| Nonfarm income | | | | | | | | | |
| Male | 26.6 | 58.0 | 45.8 | 48.4 | 88.0 | 55.0 | 39.3 | 75.6 | 52.1 |
| Female | 53.3 | 79.9 | 66.7 | 74.1 | 94.0 | 78.9 | 66.3 | 88.7 | 74.8 |
| Food crop income | | | | | | | | | |
| Male | 65.0 | 96.8 | 67.2 | 28.6 | 56.4 | 50.7 | 43.7 | 73.1 | 59.7 |
| Female | 41.9 | 73.8 | 56.8 | 17.3 | 33.9 | 51.2 | 26.6 | 48.9 | 54.4 |
| Nonfood cash crop income | | | | | | | | | |
| Male | 5.8 | 30.3 | 19.3 | 1.9 | 5.6 | 34.1 | 3.5 | 15.9 | 22.3 |
| Female | 3.3 | 12.8 | 25.5 | 1.1 | 2.0 | 57.0 | 1.9 | 6.0 | 32.1 |
| Livestock income | | | | | | | | | |
| Male | 2.6 | 29.3 | 8.8 | 21.1 | 69.9 | 30.2 | 13.4 | 53.1 | 25.3 |
| Female | 1.5 | 12.8 | 11.9 | 7.4 | 25.4 | 29.1 | 5.2 | 20.7 | 25.2 |
| Non-labour income | | | | | | | | | |
| Male | 2.0 | 6.9 | 29.2 | 5.3 | 10.9 | 48.4 | 3.9 | 9.3 | 42.4 |
| Female | 0.8 | 2.0 | 38.8 | 0.2 | 0.4 | 40.0 | 0.4 | 1.0 | 39.1 |
| Nonfarm wage-employment income | | | | | | | | | |
| Male | 8.5 | 20.2 | 42.3 | 22.5 | 49.6 | 45.4 | 16.7 | 37.4 | 44.7 |
| Female | 4.1 | 6.7 | 60.5 | 17.2 | 30.2 | 56.7 | 12.2 | 21.4 | 57.2 |
| Nonfarm self-employment income | | | | | | | | | |
| Male | 11.8 | 28.7 | 41.2 | 8.8 | 25.9 | 34.1 | 10.1 | 27.1 | 37.2 |
| Female | 39.8 | 65.1 | 61.2 | 38.0 | 56.5 | 67.3 | 38.7 | 59.7 | 64.8 |
| Remittance income | | | | | | | | | |
| Male | 4.2 | 21.8 | 19.1 | 11.7 | 49.2 | 23.8 | 8.6 | 37.9 | 22.7 |
| Female | 8.6 | 27.5 | 31.3 | 18.8 | 44.0 | 42.8 | 15.0 | 37.8 | 39.6 |

*Notes*: Columns (A) ≡ income shares; (B) ≡ participation; (C) ≡ income share conditional on participation

**Table 15. Income, production and farm input characteristics by nonfarm income quartiles**

| Variable | 1 | 2 | 3 | IV | V |
|---|---|---|---|---|---|
| Real total household income (US$) | | | | | |
| Sample | 256 | 101 | 176 | 249 | 756 |
| Eastern | 328 | 224 | 371 | 515 | 1077 |
| Upper East | 84 | 59 | 121 | 169 | 420 |
| Total cultivated area | | | | | |
| Sample | 2.5 | 2.1 | 2.3 | 2.4 | 2.6 |
| Eastern | 2.5 | 2.4 | 2.3 | 2.3 | 3.0 |
| Upper East | 2.5 | 2.1 | 2.2 | 2.5 | 2.3 |
| Share of households producing nonfood cash crops (%) | | | | | |
| Sample | 78 | 45 | 42 | 41 | 56 |
| Eastern | 86 | 65 | 73 | 52 | 78 |
| Upper East | 59 | 44 | 30 | 35 | 30 |
| Hectares of nonfood cash crops as % of total | | | | | |
| Sample | 31 | 14 | 15 | 14 | 18 |
| Eastern | 38 | 27 | 36 | 23 | 25 |
| Upper East | 15 | 11 | 7 | 7 | 7 |
| Share of households using purchased inputs (%) | | | | | |
| Sample | 62 | 55 | 52 | 59 | 67 |
| Eastern | 66 | 70 | 69 | 77 | 85 |
| Upper East | 51 | 41 | 54 | 61 | 67 |
| Share of households hiring labour (%) | | | | | |
| Sample | 70 | 50 | 60 | 74 | 79 |
| Eastern | 77 | 75 | 85 | 83 | 91 |
| Upper East | 51 | 41 | 54 | 61 | 67 |
| Sorghum yield (kg/ha) | | | | | |
| Upper East | 124 | 173 | 204 | 187 | 213 |

***Note***: 2, 3, IV and V represent the nonfarm income quartiles constructed for households receiving some nonfarm income; 1 represent nonparticipants in nonfarm income activities.

**Table 16. Maize production input and market participation by nonfarm income quartiles**

| Variable | 1 | 2 | 3 | IV | V |
|---|---|---|---|---|---|
| Share of maize producers using fertilizer (%): | | | | | |
| Sample | 39 | 54 | 55 | 55 | 43 |
| Eastern | 35 | 41 | 48 | 34 | 42 |
| Upper East | 61 | 57 | 62 | 67 | 64 |
| Real fertilizer expenditure (US$): | | | | | |
| Sample | 10 | 10 | 12 | 13 | 12 |
| Eastern | 9 | 10 | 10 | 8 | 13 |
| Upper East | 15 | 9 | 12 | 15 | 15 |
| Share of maize producers using pesticides/herbicides (%): | | | | | |
| Sample | 58 | 56 | 56 | 64 | 76 |
| Eastern | 59 | 66 | 71 | 79 | 89 |
| Upper East | 46 | 41 | 58 | 53 | 48 |

Table 16 continued

| Variable | 1 | 2 | 3 | IV | V |
|---|---|---|---|---|---|
| Share of maize producers using improved varieties (%): | | | | | |
| Sample | 60 | 36 | 30 | 36 | 55 |
| Eastern | 63 | 58 | 53 | 52 | 71 |
| Upper East | 42 | 15 | 13 | 18 | 27 |
| Maize yield (kg/ha) | | | | | |
| Sample | 1201 | 849 | 860 | 1173 | 1103 |
| Eastern | 1317 | 1162 | 1602 | 1532 | 1237 |
| Upper East | 429 | 541 | 714 | 553 | 552 |
| Share of maize producers selling output (%): | | | | | |
| Sample | 84 | 44 | 43 | 52 | 73 |
| Eastern | 96 | 84 | 84 | 87 | 90 |
| Upper East | 9 | 11 | 22 | 14 | 21 |
| Maize sold as % of output: | | | | | |
| Sample | 54 | 26 | 22 | 28 | 49 |
| Eastern | 62 | 53 | 48 | 57 | 61 |
| Upper East | 3 | 3 | 8 | 5 | 10 |

***Note***: 2, 3, IV and V represent the nonfarm income quartiles constructed for households receiving some nonfarm income; 1 represent nonparticipants in nonfarm income activities.

**Table 17. Rice production input and market participation by nonfarm income quartiles**

| Variable | 1 | 2 | 3 | IV | V |
|---|---|---|---|---|---|
| Share of rice producers using fertilizer (%) | 61 | 51 | 55 | 49 | 47 |
| Real fertilizer expenditure (US$) | 15 | 11 | 15 | 13 | 13 |
| Share of rice producers using pesticides/herbicides (%) | 39 | 37 | 45 | 43 | 43 |
| Share of rice producers using improved varieties (%) | 53 | 40 | 31 | 28 | 27 |
| Rice yield (kg/ha) | 579 | 548 | 714 | 666 | 667 |
| Share of rice producers selling output (%) | 46 | 41 | 51 | 40 | 35 |
| Rice sold as % of output | 20 | 20 | 24 | 20 | 17 |

**Table 18. Descriptive statistics of variables used in the regression analysis**

| | Afrint 3 | | | Pooled Panel | | |
|---|---|---|---|---|---|---|
| Variable definition | Part. N=470 (87%) | Non-Part. N=69 (13%) | Diff. in mean | Part. N=729 (69%) | Non-Part. N=331 (31%) | Diff. in mean |
| Total cash income ($)† | 1,386 | 1,576 | 190 | 319 | 256 | –63.0* |
| Per capita income ($)† | 237 | 332 | 95* | 64 | 61 | –3.00 |
| Farm income ($)† | 693 | 1,495 | 801* | 165 | 251 | 86.0* |
| Total cash income ($):males & females | 3,166 | 3,624 | 458 | n.a | n.a | n.a |
| Per capita income ($):males & females | 598 | 797 | 200* | n.a | n.a | n.a |
| Farm income ($): males & females | 1,509 | 3,003 | 1,494* | n.a | n.a | n.a |
| Female income as percent of total income | 38.7 | 27.1 | –11.6* | n.a | n.a | n.a |
| 1 if uses purchased inputs (%) | 66.3 | 80.7 | 14.4* | 42.6 | 38.2 | –4.40 |
| Purchased input expenditure ($)† | 83 | 87 | 3.90 | 33.1 | 30.0 | –3.15 |
| 1 if used improved seeds (%) | 25.2 | 53.0 | 27.8* | 42.4 | 60.1 | 17.7* |
| 1 if used hired labour (%) | 67.9 | 74.3 | 6.40 | 65.4 | 69.2 | 3.75 |
| 1 if sells maize (%) | 50.3 | 82.1 | 31.8* | 54.3 | 83.6 | 29.3* |
| Share of maize sold (%) | 26.8 | 51.3 | 24.5* | 59.7 | 64.1 | 4.33* |
| 1 if sells rice (%) | 71.9 | 94.1 | 22.2* | 41.6 | 43.8 | 2.24 |
| Share of rice sold (%) | 25.9 | 26.6 | 0.70 | 20.3 | 19.2 | –1.13 |
| 1 if commercial vegetables producer (%) | 33.0 | 66.1 | 33.0* | 36 | 55 | 19.2* |
| 1 if nonfood cash crop producer (%) | 39.8 | 70.6 | 30.9* | 62 | 88 | 26.6* |
| Share of land to nonfood cash crops (%) | 4.1 | 12.2 | 8.00* | 15 | 31 | 15.7* |
| Total cultivated area (ha) | 2.5 | 3.2 | 0.68* | 2.3 | 2.3 | –0.03 |
| Composite welfare index | 22 | 24 | 1.90 | 19 | 15 | –3.00* |
| 1 if food secure (%) | 39.7 | 53.2 | 13.4* | 59.8 | 72.2 | 12.4* |
| 1 if female farm manager | 23.3 | 11.9 | –11.3* | 21 | 18.4 | –2.56 |
| Age of farm manager | 51 | 49 | –2.10 | 51 | 49 | –1.65* |
| Level of education of farm manager (years) | 5 | 6 | 1.70* | 4.7 | 5.5 | 0.76* |
| Number of able workers | 3 | 4 | 0.30 | 3.6 | 3.7 | 0.09 |
| Number of males | 2.8 | 2.5 | –0.40* | 2.4 | 2.0 | –0.25* |
| Number of females | 2.9 | 2.5 | –0.50* | 2.5 | 2.1 | –0.38* |
| Dependent proportion | 45.1 | 40.4 | –4.70* | 41.1 | 32.6 | –8.45* |
| 1 if regularly sells livestock (%) | 36.3 | 24.8 | –11.5* | 47.1 | 42.6 | –4.45 |
| Livestock (in tropical livestock units) | 2.2 | 1.3 | –1.00* | 2.3 | 1.4 | –0.89* |
| Distance from homestead to village centre (km) | 2.2 | 0.9 | –1.30* | 1.7 | 1.0 | –0.77* |
| 1 if accessed input credit (%) | 8.8 | 13.9 | 5.00 | 9.1 | 8.8 | –0.03 |
| 1 if access to agriculture extension (%) | 48.6 | 55.0 | 6.40 | 51.0 | 60.4 | 9.34* |
| 1 if member of farmer organization (%) | 15.8 | 15.6 | 0.20 | 19 | 18 | –1.32 |
| 1 if leaves land fallow (%) | 62.1 | 69.7 | 7.60 | 58 | 77 | 19.3* |
| 1 if has unlimited land rights (%) | 80.7 | 70.4 | –10.3* | 80 | 67 | –13.5* |
| 1 if access to credit (%) | 22.1 | 13.9 | –8.20* | 11 | 7 | –4.70 |
| 1 if aces to credit for women (%) | 17.0 | 12.0 | 5.00 | n.a | n.a | n.a |
| 1 if owns sowing machine (%) | 24.9 | 19.4 | –5.40 | 28 | 23 | –4.91* |
| 1 if used exchange labour (%) | 54.2 | 32.4 | –22.0* | 59 | 46 | –13.9* |
| 1 if experiences labour shortage (%) | 45.3 | 48.1 | 2.30 | n.a | n.a | n.a |
| Total land endowment (ha) | 4.2 | 6.5 | 2.30* | 3.7 | 3.9 | 0.23* |
| Extra uncultivated land available (ha) | 1.3 | 1.8 | 0.50* | 1.3 | 1.5 | 0.15* |
| Per capita maize produced | 138 | 253 | 114* | 132 | 198 | 66.1* |
| 000 of past seasons produced calories per capita | 570 | 829 | 258* | 476 | 599 | 122* |
| Per hectare calorie per hectare | 309 | 346 | 36.5 | 555 | 842 | 287* |
| 1 if owns mobile phone (%) | 79.5 | 74.1 | –5.50 | 55 | 38 | –16.9* |

Note: * denotes statistical significance at 10% or better

† the pooled panel values are in 2002 constant prices.

**Table 19. Composite welfare and food security by village location**

| Village | Afrint 3 | | | | | | | | Panel | | | | Pooled | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 2008 | 2013 | 2008 | 2013 | | |
| | welf | fsec1 (%) | fsec2 (%) | fsec3 (%) | ofs1 (%) | ofs2 (%) | ofs3 (%) | ofs4 (%) | welf | welf | fsec3 (%) | fsec3 (%) | welf | fsec3 (%) |
| Akatawia | 21 | 73 | 79 | 69 | 68 | 5 | 8 | 19 | 10 | 23 | 13 | 71 | 16 | 40 |
| Asitey | 27 | 14 | 23 | 9 | 6 | 6 | 16 | 72 | 20 | 26 | 19 | 9 | 23 | 15 |
| Gyidi | 35 | 12 | 12 | 5 | 2 | 7 | 10 | 82 | 25 | 32 | 3 | 6 | 28 | 4 |
| Apaa | 24 | 22 | 19 | 11 | 11 | 6 | 6 | 76 | 14 | 22 | 7 | 15 | 18 | 10 |
| Gaane | 16 | 44 | 59 | 24 | 20 | 27 | 13 | 40 | 8 | 17 | 49 | 24 | 12 | 37 |
| Doba | 23 | 63 | 83 | 65 | 58 | 9 | 21 | 13 | 11 | 23 | 57 | 64 | 17 | 60 |
| Zanlerigu | 20 | 51 | 59 | 52 | 44 | 11 | 8 | 37 | 12 | 19 | 56 | 55 | 15 | 55 |
| Shia | 15 | 73 | 85 | 55 | 45 | 34 | 10 | 11 | 11 | 14 | 68 | 55 | 13 | 61 |

***Note***: welf: composite welfare index; fsec1: 1 if household reduces quantity of meals during lean season, 0 otherwise; fsec2: 1 if household reduces quality of meals during lean season, 0 otherwise; fsec3: 1 if household reduces frequency of meals during lean season, 0 otherwise; ofs1: 1 if household reduces meal quantity, quality and frequency during lean season; ofs2: 1 if household reduces any two of three dimensions during lean season; ofs3: 1 if household reduces any one of three dimensions during lean season; ofs4: 1 if household maintains meal quantity, quality and frequency throughout the year.

**Table 20. Composition of household income by levels of per capita income and composite welfare**

| | Afrint 3 | | | | | | | | Pooled Panel † | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pcy quintiles | pcy | offy | offysh | ofprt | offy_m | offy_f | offy_fsh | fysh | pcy | offy | offysh | ofprt |
| 1 | 77 | 328 | 55.2 | 83.2 | 162 | 165 | 53.5 | 41.8 | 5 | 14 | 38.1 | 65.4 |
| | (30) | (267) | (31.7) | (37.6) | (220) | (190) | (38.9) | (36.0) | (2) | (18) | (37.3) | (47.7) |
| 2 | 179 | 755 | 60.9 | 88.0 | 356 | 399 | 54.7 | 45.8 | 14 | 40 | 40.8 | 73.9 |
| | (35) | (537) | (32.7) | (32.7) | (455) | (430) | (40.3) | (37.6) | (3) | (44) | (35.1) | (44.0) |
| 3 | 335 | 931 | 45.6 | 79.2 | 513 | 417 | 44.9 | 38.4 | 29 | 63 | 35.0 | 69.7 |
| | (55) | (797) | (33.2) | (40.7) | (676) | (562) | (41.1) | (37.6) | (6) | (73) | (35.3) | (46.1) |
| IV | 596 | 1,432 | 40.2 | 75.7 | 742 | 613 | 53.0 | 36.5 | 60 | 110 | 32.5 | 65.9 |
| | (110) | (1,401) | (31.2) | (43.1) | (1,048) | (755) | (39.7) | (33.1) | (13) | (138) | (34.2) | (47.5) |
| V | 2,010 | 2,925 | 40.0 | 76.4 | 1,998 | 715 | 34.9 | 19.5 | 211 | 309 | 33.1 | 71.0 |
| | (1,353) | (2,941) | (32.3) | (42.7) | (2,557) | (1,051) | (38.2) | (25.8) | (155) | (402) | (33.9) | (45.5) |
| welf quintiles | | | | | | | | | | | | |
| 1 | 269 | 458 | 48.4 | 86.1 | 233 | 225 | 52.5 | 40.3 | 23 | 31 | 34.7 | 63.7 |
| | (254) | (465) | (33.3) | (34.7) | (422) | (309) | (40.9) | (35) | (25) | (57) | (36.3) | (48.2) |
| 2 | 361 | 1,038 | 52.1 | 83.3 | 619 | 343 | 43.5 | 31.7 | 33 | 50 | 32.9 | 63.7 |
| | (364) | (1,364) | (32.6) | (37.4) | (997) | (491) | (36.1) | (32.7) | (51) | (119) | (35.7) | (48.2) |
| 3 | 619 | 1,207 | 49.8 | 75.0 | 697 | 430 | 50.2 | 37.5 | 59 | 88 | 34.5 | 66.5 |
| | (889) | (1,792) | (34.6) | (43.5) | (1,412) | (636) | (41.4) | (36.3) | (90) | (173) | (35.2) | (47.3) |
| IV | 721 | 1,439 | 43.7 | 75.0 | 801 | 581 | 51.8 | 40.2 | 79 | 132 | 37.0 | 73.1 |
| | (884) | (1,696) | (32.8) | (43.5) | (1,397) | (705) | (41.5) | (37.1) | (119) | (236) | (34.6) | (44.4) |
| V | 1,219 | 2,160 | 48.2 | 79.4 | 1,380 | 707 | 44.3 | 32.4 | 123 | 233 | 40.4 | 76.9 |
| | (1,421) | (2,418) | (32.7) | (40.6) | (2,138) | (998) | (40.9) | (35.2) | (146) | (337) | (34.2) | (42.3) |

Note: pcy: per capita income; offy: nonfarm income; offysh: nonfarm income share; ofprt: % participation in nonfarm income; offy_m: male nonfarm income; offy_m: female nonfarm income; offy_fsh: female share of nonfarm income; fysh: female share of household income;
† based on 2002 constant prices

**Table 21. Panel data Two-part model estimates of the determinants of nonfarm income**

| VARIABLES | Part 1: APE: RE Probit | Part 1: APE: Pooled Probit | Part 1: APE: FE-LP | Part 2: RE | Part 2: FE |
|---|---|---|---|---|---|
| Intercept | | | 0.677*** | 3.301*** | 2.466*** |
| Female farm manager | 0.043 | 0.043 | –0.028 | –0.012 | –0.310 |
| Age of farm manager | 0.001 | 0.001 | 0.000 | 0.008** | 0.016* |
| Manager’s education level | 0.007** | 0.007** | 0.006 | 0.079*** | 0.041 |
| Number of able workers | –0.015** | –0.014** | –0.021** | 0.041 | 0.089** |
| Dependent proportion | 0.063 | 0.065 | –0.019 | 0.279 | 0.229 |
| Livestock commercialization dummy | 0.045 | 0.041 | 0.058 | 0.115 | 0.204 |
| Non-food cash crop producer dummy | –0.098** | –0.092** | –0.034 | –0.030 | –0.016 |
| Distance to market | 0.010 | 0.010* | 0.001 | –0.012 | –0.016 |
| *Quartiles of cultivated area (Comparison group is lowest quartile)* | | | | | |
| Second | –0.123*** | –0.115*** | –0.107* | 0.011 | –0.075 |
| Third | –0.092** | –0.093*** | –0.027 | 0.109 | –0.153 |
| Highest | –0.030 | –0.032 | 0.023 | 0.144 | –0.108 |
| Fallow dummy | –0.066* | –0.065** | –0.077** | 0.027 | 0.189 |
| Ownership of sowing machine | 0.091*** | 0.085*** | 0.080* | 0.420*** | 0.329* |
| Year effect (2013=1) | 0.202*** | 0.192*** | 0.219*** | 0.160 | 0.261 |
| *Village dummies (comparison village is Gyedi)* | | | | | |
| Akatawia | –0.112 | –0.105* | | –0.192 | |
| Asitey | –0.009 | –0.011 | | –0.212 | |
| Apaa | –0.191*** | –0.177*** | | –0.298 | |
| Gaane | 0.166** | 0.154** | | –0.886*** | |
| Doba | 0.180*** | 0.164*** | | –0.564*** | |
| Zanlerigu | 0.181*** | 0.167*** | | –0.852*** | |
| Shia | 0.238*** | 0.226*** | | –0.445** | |
| Observations | 1,060 | 1,060 | 1,060 | 735 | 735 |
| Households | 569 | 569 | 569 | 472 | 472 |
| R–squared | | | 0.165 | | 0.113 |
| Pseudo $R^2$ | | 0.183 | | | |
| $\sigma_u$ | 0.500 | | 0.367 | 0.353 | 1.177 |
| $\sigma_c$ | | | 0.394 | 1.178 | 1.178 |
| ρ | 0.200 | | 0.465 | 0.0824 | 0.500 |
| Log–likelihood value | –535.3 | –537.7 | | | |

Here and elsewhere in this document *, **, *** represent significance at 10%, 5%, and 1%, respectively. $\sigma_u$ is the estimate of the standard deviation of the overall residuals term $u_{it}$; $\sigma_c$ is the estimate of the standard deviation of residuals within household, $c_i$; $\rho$ is the estimate of the intraclass correlation (the proportion of total variance due to households).

**Table 22. Panel data Two-part model estimates of nonfarm income effect on fertilizer expenditures**

| | PART 1 | | PART 2: log fertilizer expenditure | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | With exogenous nonfarm income | | | | With endogenous nonfarm income | |
| VARIABLES | PP | FE-LP | RE | FE | RE | FE | PDER | OLS |
| Intercept | | 0.497*** | 1.595*** | 2.720*** | 1.605*** | 2.807*** | 1.693*** | 1.644*** |
| Nonfarm income dummy | 0.021 | –0.034 | 0.071 | 0.164 | | | 0.936*** | |
| Real nonfarm income | | | | | 1.6e-04 | 5.2e-5 | | 4.2e-04 |
| Female farm manager | 0.032 | –0.011 | 0.037 | 0.204 | 0.042 | 0.204 | –0.053 | 0.022 |
| Age of farm manager | 7e-05 | –0.002 | –0.004 | –0.002 | –0.004 | –0.002 | –0.007** | –0.005* |
| Manager's education level | 0.003 | –0.010* | 0.009 | 0.041* | 0.008 | 0.045** | 0.002 | 0.003 |
| Number of able workers | 0.012** | 0.003 | 0.025 | –0.013 | 0.027 | –0.014 | 0.023 | 0.031 |
| Dependent proportion | –0.058 | –0.097 | –0.653*** | –0.649** | –0.650*** | –0.612** | –0.827*** | –0.729*** |
| Cultivated area | 0.079*** | 0.017 | 0.283*** | 0.184* | 0.280*** | 0.181* | 0.366*** | 0.290*** |
| Cultivated area squared | –0.007** | | –0.016* | –0.017 | –0.016** | –0.017 | –0.025*** | –0.017** |
| Fallow dummy | –0.008 | –0.024 | –0.027 | –0.123 | –0.025 | –0.123 | 0.014 | –0.019 |
| Unlimited land rights | –0.020 | –0.051 | 0.072 | 0.265* | 0.065 | 0.257* | 0.061 | 0.043 |
| Livestock | 0.050* | 0.054 | –0.128* | –0.055 | –0.125* | –0.049 | –0.213** | –0.144* |
| Commercial vegetables | 0.054* | 0.078* | –0.132* | –0.205* | –0.135* | –0.221* | –0.068 | –0.128* |
| Isolated | 0.004 | 0.009* | 0.014** | 0.016 | 0.015*** | 0.016 | 0.010 | 0.014** |
| Extension dummy | 0.062** | 0.037 | 0.132 | –0.034 | 0.140 | –0.018 | 0.117 | 0.136 |
| Input credit dummy | 0.102** | 0.120* | 0.293*** | 0.511*** | 0.279*** | 0.490** | 0.250** | 0.263** |
| Year effect (2013=1) | 0.079*** | 0.110*** | –0.093 | 0.080 | –0.081 | 0.109 | –0.269*** | –0.147* |
| *Village dummies (comparison village is Gyedi)* | | | | | | | | |
| Akatawia | 0.565*** | | | | | | | |
| Asitey | 0.318*** | | | | | | | |
| Apaa | 0.058 | | | | | | | |
| Gaane | 0.654*** | | | | | | | |
| Doba | 0.597*** | | | | | | | |
| Zanlerigu | 0.009 | | | | | | | |
| Shia | –0.036 | | | | | | | |
| *District dummies (comparison district is Fanteakwa)* | | | | | | | | |
| Krobo | | | 0.316*** | | 0.321*** | | 0.346*** | 0.345*** |
| Navorongo | | | 0.775*** | | 0.800*** | | 0.610*** | 0.831*** |
| Talensi | | | –0.117 | | –0.091 | | –0.326 | –0.081 |
| gres | | | | | | | | 0.224** |
| mgres | | | | | | | | –0.204** |
| Observations | 1,024 | 1,024 | 425 | 425 | 425 | 425 | 425 | 425 |
| Households | 561 | 561 | 299 | 299 | 299 | 299 | 299 | 299 |
| R–squared | | | | 0.244 | | 0.235 | | 0.363 |
| Pseudo $R^2$ | 0.323 | | | | | | | |
| $\chi^2$ stat of independence | | | | | | | 8.437 | |
| *p*-value of $\chi^2$ test | | | | | | | 0.004 | |
| $\sigma_u$ | | 0.385 | 0.649 | 0.649 | 0.652 | 0.652 | 0.642 | |
| $\sigma_c$ | | 0.416 | 0.322 | 0.842 | 0.312 | 0.844 | 0.331 | |
| ρ | | 0.539 | 0.197 | 0.628 | 0.187 | 0.626 | –0.669 | |
| Log–likelihood value | –470.8 | | | | | | –659.4 | |

***Note:*** PP denotes pooled probit; FE-LP is fixed effects linear probability model; PDER is pooled dummy endogenous regression; $\sigma_u$ is the estimate of the standard deviation of the overall residuals term $u_{it}$; $\sigma_c$ is the estimate of the standard deviation of residuals within household, *c*i; $\rho$ is the estimate of the intraclass correlation (the proportion of total variance due to households).

**Table 23. Average partial effects of the determinants of improved seed and hired labour use, Panel**

| | Improved Seed | | Hired Labour | | | |
|---|---|---|---|---|---|---|
| VARIABLES | Pooled Probit | | RE probit | | Pooled Probit | |
| | [1] | [2] | [1] | [2] | [1] | [2] |
| Nonfarm income dummy | 0.026 | | 0.025 | | 0.026 | |
| Nonfarm income level | | 0.000 | | 2.3e-04** | | 2.2e-04** |
| Female farm manager | 0.017 | 0.017 | 0.084** | 0.083** | 0.081** | 0.080** |
| Age of farm manager | 3.0e-04 | 7.9e-05 | –3.9e-04 | –0.001 | –4.0e-04 | –0.001 |
| Manager's education level | 0.004 | 0.003 | 0.008** | 0.006* | 0.007** | 0.005* |
| Number of able workers | 0.003 | 0.003 | 0.001 | 1.7e-04 | 0.001 | –3.7e-04 |
| Dependent proportion | 0.008 | 0.009 | 0.075 | 0.075 | 0.067 | 0.067 |
| Livestock commercialization dummy | –0.035 | –0.035 | –0.014 | –0.016 | –0.016 | –0.018 |
| Commercial vegetable producer | 0.064** | 0.062* | | | | |
| Distance to nearest market | –0.016 | –0.016 | | | | |
| Cultivated area | 0.092*** | 0.091*** | 0.085*** | 0.086*** | 0.085*** | 0.085*** |
| Cultivated area squared | –0.006* | –0.006* | –0.004 | –0.004 | –0.004 | –0.004 |
| Extension dummy | 0.018 | 0.019 | 0.062** | 0.065** | 0.060** | 0.062** |
| Input credit dummy | –0.009 | –0.011 | 0.158** | 0.156** | 0.159*** | 0.157*** |
| Time effect (2013=1) | –0.338*** | –0.333*** | 0.020 | 0.020 | 0.017 | 0.017 |
| *Village dummies (comparison village is Gyedi)* | | | | | | |
| Akatawia | –0.193*** | –0.190*** | –0.123** | –0.115** | –0.119** | –0.111** |
| Asitey | –0.144** | –0.143** | –0.016 | –0.008 | –0.017 | –0.010 |
| Apaa | –0.043 | –0.041 | –0.139** | –0.131** | –0.135** | –0.128** |
| Gaane | –0.043 | –0.034 | –0.215*** | –0.200*** | –0.210*** | –0.194*** |
| Doba | –0.249*** | –0.243*** | –0.248*** | –0.239*** | –0.239*** | –0.230*** |
| Zanlerigu | –0.428*** | –0.419*** | –0.262*** | –0.253*** | –0.250*** | –0.241*** |
| Shia | –0.387*** | –0.380*** | –0.396*** | –0.388*** | –0.378*** | –0.370*** |
| Observations | 914 | 914 | 1,060 | 1,060 | 1,060 | 1,060 |
| Households | 538 | 538 | 569 | 569 | 569 | 569 |
| Pseudo $R^2$ | 0.238 | 0.238 | | | 0.147 | 0.152 |
| $\sigma_c$ | | | 0.357 | 0.365 | | |
| ρ | | | 0.113 | 0.117 | | |
| Log-likelihood value | –482.3 | –482.0 | –574.7 | –571.3 | –575.6 | –572.2 |

**Table 24. Average partial effects: Panel data Two-part model estimates of market participation with nonfarm income effect**

| | Maize | | | | Rice | | | |
|---|---|---|---|---|---|---|---|---|
| | Part 1:RE Probit | | Part 2: GEE | | Part 1: Pooled Probit | | Part 2: QMLE | |
| VARIABLES | [1] | [2] | [1] | [2] | [1] | [2] | [1] | [2] |
| Nonfarm income dummy | –0.029 | | 0.010 | | –0.068 | | 0.047 | |
| Real nonfarm income | | 1.9e–06 | | 4.6e-05 | | –1.3e-04 | | 1.0e-04 |
| Female farm manager | –0.024 | –0.026 | 0.010 | 0.009 | –0.040 | –0.039 | –0.089** | –0.090** |
| Age of farm manager | –0.002** | –0.002** | 0.001 | 0.001 | –0.001 | –0.001 | 0.001 | 0.001 |
| Manager's education level | –0.001 | –0.001 | –2.3e-04 | –0.001 | 0.002 | 0.003 | 0.001 | –3.5e-04 |
| Dependent proportion | –0.028 | –0.027 | 0.012 | 0.013 | 0.054 | 0.052 | 0.042 | 0.046 |
| Farm size (log) | 0.015 | 0.016 | 0.020 | 0.018 | 0.094*** | 0.099*** | 0.010 | 0.008 |
| Available calories per capita | 0.098*** | 0.099*** | 0.047*** | 0.047*** | 0.066*** | 0.067*** | 0.093*** | 0.093*** |
| Distance to market | –0.000 | –0.000 | –0.003* | –0.003 | 0.002 | 0.001 | –0.004 | –0.004 |
| Nonfood cash cropper | 0.079*** | 0.082*** | 0.052* | 0.050* | 0.141*** | 0.152*** | 0.037 | 0.036 |
| Livestock (in TLU) | –0.007 | –0.009 | 0.018 | 0.019 | –0.130*** | –0.129*** | –0.001 | 4.7e-04 |
| Mobile phone dummy | 0.036 | 0.036 | | | 0.026 | 0.024 | | |
| Bicycle dummy | 0.043 | 0.042 | | | | | | |
| Time effect (2013=1) | –0.054* | –0.064** | –0.068*** | –0.067*** | 0.132** | 0.128** | 0.065* | 0.073** |
| *Village dummies (comparison village is Gyedi)* | | | | | | | | |
| Akatawia | 0.082 | 0.085 | | | | | | |
| Asitey | 0.041 | 0.042 | | | | | | |
| Apaa | –0.025 | –0.019 | | | | | | |
| Gaane | –0.329*** | –0.338*** | | | | | | |
| Doba | –0.438*** | –0.444*** | | | –0.580*** | –0.577*** | –0.095** | –0.104** |
| Zanlerigu | –0.630*** | –0.636*** | | | –0.655*** | –0.662*** | –0.230** | –0.225** |
| Shia | –0.281*** | –0.299*** | | | –0.571*** | –0.572*** | –0.142*** | –0.137*** |
| *District dummies (comparison district is Fanteakwa)* | | | | | | | | |
| Krobo | | | –0.076*** | –0.075*** | | | | |
| Navorongo | | | –0.189*** | –0.186*** | | | | |
| Talensi | | | –0.308*** | –0.305*** | | | | |
| Observations | 716 | 716 | 465 | 465 | 397 | 397 | 168 | 168 |
| Households | 472 | 472 | 300 | 300 | 245 | 245 | 120 | 120 |
| Working correlation | | | 0.017 | 0.004 | | | | |
| $\sigma_c$ | 0.669 | 0.628 | | | | | | |
| $\rho$ | 0.309* | 0.283* | | | | | | |
| Pseudo $R^2$ | | | | | 0.446 | 0.445 | | |
| Log–likelihood value | –171.8 | –172.6 | | | –149.8 | –150.1 | | |

The standard errors of the coefficients are robust to nonspherical errors; the average partial effects, APE, from the QMLE were obtained using 250 and 150 bootstrap replications for the maize and rice output market participation models respectively; $\sigma_c$ is the estimate of the standard deviation of residuals within household, *ci*; $\rho$ is the estimate of the intraclass correlation (the proportion of total variance due to households).

**Table 25. Partial effects of nonfood cash crop production with nonfarm income effect**

| VARIABLES | [1] | | [2] | |
|---|---|---|---|---|
| | Pooled probit | FELP | Pooled probit | FELP |
| Intercept | | 0.518*** | | 0.493*** |
| Nonfarm income dummy | –0.033 | –0.040 | | |
| Real nonfarm income | | | 2.2e-05 | 6.2e-05 |
| Female farm manager | –0.043** | 3.6e-04 | –0.045** | 0.005 |
| Age of farm manager | –3.8e-04 | 0.003 | –4.3e-04 | 0.002 |
| Manager's education level | –0.008*** | 0.003 | –0.008*** | 0.002 |
| Number of males | 0.012* | 0.022** | 0.012** | 0.023** |
| Number of females | 0.005 | –0.027*** | 0.005 | –0.027** |
| Dependent proportion | –0.020 | 0.097 | –0.026 | 0.100 |
| Livestock (in TLU) | –0.002 | 0.010 | –0.002 | 0.009 |
| Extension dummy | 0.066*** | 0.118*** | 0.066*** | 0.119*** |
| Input credit dummy | 0.025 | –0.029 | 0.027 | –0.027 |
| Distance from village center | 0.003 | 0.006 | 0.003 | 0.006 |
| Total land endowment | 0.011** | 0.053*** | 0.011** | 0.052*** |
| Previous two seasons produced calories per capita | 5.3e-05** | –6.1e-05* | 5.4e-05** | –6.2e-05* |
| Time effect (2013=1) | –0.407*** | –0.456*** | –0.416*** | –0.468*** |
| *Village dummies (comparison village is Gyedi)* | | | | |
| Akatawia | –0.190*** | | –0.181*** | |
| Asitey | –0.220*** | | –0.220*** | |
| Apaa | –0.018 | | –0.016 | |
| Gaane | –0.705*** | | –0.711*** | |
| Doba | –0.174*** | | –0.179*** | |
| Zanlerigu | –0.274*** | | –0.282*** | |
| Shia | –0.423*** | | –0.431*** | |
| Observations | 1,054 | | 1,054 | |
| Households | 569 | | 569 | |
| Pseudo $R^2$ | 0.559 | | 0.556 | |
| $\sigma_u$ | | 0.350 | | 0.350 |
| $\sigma_c$ | | 0.326 | | 0.329 |
| $\rho$ | | 0.465 | | 0.469 |
| Log–likelihood value | –283.7 | | –287.6 | |

FELP is a fixed effects linear probability model. The standard errors used for inference are robust to data clustering; $\sigma_u$ is the estimate of the standard deviation of the overall residuals term $u_{it}$; $\sigma_c$ is the estimate of the standard deviation of residuals within household, $c$i; $\rho$ is the estimate of the intraclass correlation (the proportion of total variance due to households)

**Table 26. Panel data estimates of the determinants of total cultivated area with nonfarm income effect**

| | [1] | | | [2] | | |
|---|---|---|---|---|---|---|
| VARIABLES | FE | RE | OLS | FE | RE | OLS |
| Intercept | 0.360** | 0.330*** | 0.652*** | 0.393** | 0.329*** | 0.337*** |
| Nonfarm income dummy | 0.047 | 0.003 | –0.014 | | | |
| Real nonfarm income | | | | 0.000 | 1.0e-04 | 0.001* |
| Female farm manager | –0.142* | –0.127*** | –0.154*** | –0.143* | –0.126*** | –0.128*** |
| Age of farm manager | 0.000 | –0.001 | –0.002 | 0.000 | –0.001 | –0.002 |
| Manager's education level | –0.002 | –0.002 | –0.008* | –0.002 | –0.003 | –0.011** |
| Number of able workers | 0.017 | 0.015 | 0.022* | 0.016 | 0.014 | 0.013 |
| Dependent proportion | 0.051 | 0.059 | 0.026 | 0.051 | 0.060 | 0.071 |
| Livestock (in TLU) | 0.020** | 0.022** | 0.013 | 0.020** | 0.021** | 0.018* |
| Hectares of uncultivated land (log) | 0.058*** | 0.068*** | 0.068*** | 0.058*** | 0.067*** | 0.065*** |
| Fallow dummy | –0.078* | –0.063* | –0.003 | –0.082* | –0.061* | –0.041 |
| Nonfood cash cropper | 0.295*** | 0.285*** | 0.319*** | 0.292*** | 0.284*** | 0.281*** |
| Unlimited land rights | –0.045 | –0.001 | 0.006 | –0.044 | –0.002 | 0.005 |
| Extension dummy | 0.048 | 0.052 | 0.054 | 0.050 | 0.054 | 0.052 |
| Input credit dummy | 0.067 | 0.091 | 0.097 | 0.062 | 0.089 | 0.094 |
| Time effect (2013=1) | 0.182*** | 0.184*** | 0.057 | 0.191*** | 0.182*** | 0.147*** |
| *Village dummies (comparison village is Gyedi)* | | | | | | |
| Akatawia | | –0.079 | –0.012 | | –0.071 | –0.017 |
| Asitey | | –0.393*** | –0.390*** | | –0.388*** | –0.360*** |
| Apaa | | –0.148** | –0.030 | | –0.139** | –0.072 |
| Gaane | | –0.188** | –0.323*** | | –0.180** | –0.152* |
| Doba | | –0.157** | –0.281*** | | –0.151** | –0.136* |
| Zanlerigu | | –0.390*** | –0.537*** | | –0.386*** | –0.377*** |
| Shia | | –0.188** | –0.357*** | | –0.185** | –0.184** |
| Correction term | | | –0.399** | | | –0.050* |
| Time averaged correction term | | | 0.003 | | | –0.016 |
| Observations | 1,060 | 1,060 | 1,060 | 1,060 | 1,060 | 1,060 |
| Households | 569 | 569 | | 569 | 569 | |
| R–squared | 0.150 | | 0.301 | 0.148 | | 0.300 |
| $\sigma_u$ | 0.454 | 0.454 | | 0.454 | 0.454 | |
| $\sigma_c$ | 0.428 | 0.193 | | 0.426 | 0.192 | |
| $P$ | 0.471 | 0.154 | | 0.468 | 0.152 | |

The RE & OLS estimates include time-averages of three explanatory variables; The OLS estimates follow apply endogeneity corrections suggested by Valla & Verbeek (see Vella and Verbeek, 1998; Vella and Verbeek, 1999). Inference is based on standard errors that a robust to nonspherical errors; $\sigma_u$ is the estimate of the standard deviation of the overall residuals term $u_{it}$; $\sigma_c$ is the estimate of the standard deviation of residuals within household, $c$i; $\rho$ is the estimate of the intraclass correlation (the proportion of total variance due to households).

**Table 27. Panel data estimates of the determinants of composite welfare with nonfarm income effect**

| | [1] | | | [2] | | |
|---|---|---|---|---|---|---|
| VARIABLES | FE | RE | OLS | FE | RE | OLS |
| Intercept | 13.405*** | 7.300*** | 10.535** | 15.367*** | 11.344*** | 12.094*** |
| Nonfarm income dummy | 2.890*** | 3.870*** | 3.036*** | | | |
| Real nonfarm income level | | | | 0.014*** | 0.014*** | 0.017*** |
| Female farm manager | –0.742 | –0.597 | –0.745 | –0.261 | –0.072 | 0.193 |
| Age of farm manager | –0.144*** | –0.113** | –0.145*** | –0.157*** | –0.156*** | –0.149*** |
| Manager’s education level | 0.175 | 0.189 | 0.124 | 0.093 | 0.082 | 0.082 |
| Number of males | 0.284 | 0.108 | 0.267 | 0.270 | 0.199 | 0.230 |
| Number of females | 0.102 | 0.314 | 0.384* | 0.121 | 0.320 | 0.319 |
| Dependent proportion | 0.451 | 0.071 | –0.924 | 0.520 | –0.513 | –0.813 |
| Hectares of land (log) | 2.198** | 3.926*** | 3.034*** | 1.747* | 2.432*** | 2.480*** |
| Livestock (in TLU) | 0.585** | 0.649*** | 0.577*** | 0.568** | 0.579*** | 0.577*** |
| Village group membership | 2.274* | 2.647** | 3.189*** | 1.816 | 2.736*** | 2.904*** |
| Distance from village center | –0.073 | –0.106 | –0.135 | –0.053 | –0.091 | –0.103 |
| Time effect (2013 = 1) | 7.808*** | 7.031*** | 6.547*** | 8.077*** | 8.096*** | 8.261*** |
| *Village dummies (comparison village is Gyedi)* | | | | | | |
| Akatawia | | –8.998*** | –8.872*** | | –8.430*** | –8.053*** |
| Asitey | | –2.647 | –2.596 | | –2.229 | –2.202 |
| Apaa | | –6.299*** | –6.880*** | | –6.449*** | –5.896*** |
| Gaane | | –12.151*** | –12.415*** | | –10.875*** | –11.135*** |
| Doba | | –7.214*** | –9.303*** | | –8.185*** | –8.487*** |
| Zanlerigu | | –9.668*** | –10.937*** | | –9.760*** | –9.949*** |
| Shia | | –10.832*** | –11.466*** | | –10.343*** | –10.767*** |
| Correction term | | | –3.153 | | | –0.470 |
| Time averaged correction term | | | 2.680 | | | 0.986 |
| Observations | 1,059 | 1,059 | 1,059 | 1,059 | 1,059 | 1,054 |
| Households | 569 | 569 | 569 | 569 | 569 | 569 |
| R–squared | 0.299 | | 0.374 | 0.332 | | 0.418 |
| $\sigma_u$ | 10.20 | 10.79 | | 9.952 | 9.952 | |
| $\sigma_c$ | 11.14 | 5.329 | | 10.47 | 4.055 | |
| $P$ | 0.544 | 0.196 | | 0.526 | 0.142 | |

The OLS estimates apply endogeneity corrections suggested by Valla & Verbeek (see Vella and Verbeek, 1998; Vella and Verbeek, 1999). Inferential standard errors are robust to general forms of conditional variance misspecification or data clustering; $\sigma_u$ is the estimate of the standard deviation of the overall residuals term $u_{it}$; $\sigma_c$ is the estimate of the standard deviation of residuals within household, $c_i$; $\rho$ is the estimate of the intraclass correlation (the proportion of total variance due to households).

**Table 28. Panel data estimates of the probability of food insecurity with nonfarm income effect**

| VARIABLES | [1a]: PP | [1b]: PBP | [1c]: FELP | [2a]: PP | [2b]:CMP | [2c]: FELP |
|---|---|---|---|---|---|---|
| Intercept | | | 0.737*** | | | 0.762*** |
| Nonfarm income dummy | 0.010 | 0.405*** | 0.018 | | | |
| Real nonfarm income | | | | –2.3e-04*** | –0.001*** | –2.5e-04** |
| Female farm manager | –0.023 | –0.040 | –0.059 | –0.023 | –0.021 | –0.070 |
| Age of farm manager | –0.003*** | –0.003*** | –0.006*** | –0.003*** | –0.003*** | –0.006*** |
| Manager's education level | –0.003 | –0.006** | –0.002 | –0.001 | 0.002 | –1.6e04 |
| Dependent proportion | –0.060 | –0.088* | –0.002 | –0.057 | –0.057 | –0.006 |
| *Quartiles of land endowment (Comparison group is lowest quartile)* | | | | | | |
| Second | –0.047 | –0.022 | –0.014 | –0.046 | –0.042 | –0.006 |
| Third | –0.122*** | –0.071** | –0.105 | –0.118*** | –0.109*** | –0.103 |
| Highest | –0.026 | –0.003 | 0.041 | –0.017 | –0.004 | 0.052 |
| Livestock (TLU) | –0.011** | –0.009** | –0.012 | –0.010** | –0.010** | –0.011 |
| Village group membership | –0.086** | –0.078** | –0.072 | –0.081** | –0.068* | –0.064 |
| Distance from village center | –0.003 | –0.004 | –0.003 | –0.003 | –0.003 | –0.004 |
| Nonfood cash cropper | 0.090** | 0.102*** | 0.089 | 0.091** | 0.089** | 0.091 |
| Calories harvested per hectare (log) | –0.015 | –0.006 | –0.012 | –0.015 | –0.016 | –0.016 |
| Time effect (2013 = 1) | 0.085** | –0.009 | 0.078* | 0.094*** | 0.099*** | 0.092** |
| *Village dummies (comparison village is Gyedi)* | | | | | | |
| Akatawia | 0.344*** | 0.377*** | | 0.335*** | 0.325*** | |
| Asitey | 0.118*** | 0.141*** | | 0.121*** | 0.128*** | |
| Apaa | 0.066** | 0.146*** | | 0.060** | 0.054* | |
| Gaane | 0.399*** | 0.280*** | | 0.395*** | 0.387*** | |
| Doba | 0.536*** | 0.375*** | | 0.539*** | 0.535*** | |
| Zanlerigu | 0.560*** | 0.399*** | | 0.563*** | 0.558*** | |
| Shia | 0.585*** | 0.397*** | | 0.592*** | 0.590*** | |
| Observations | 1,059 | 1,059 | 1,059 | 1,059 | 1,059 | 1,059 |
| Households | 569 | | 569 | 569 | | 569 |
| Pseudo $R^2$ | 0.208 | | | 0.215 | | |
| Log–likelihood value | –549.8 | –1091 | | –545.0 | –5912 | |
| ρ | | –0.823*** | 0.453 | | 0.234* | 0.454 |
| $\sigma_u$ | | | 0.430 | | | 0.428 |
| $\sigma_c$ | | | 0.391 | | | 0.390 |

PP: Pooled Probit; PBP: Pooled Bivariate Probit; FELP: Fixed Effects Linear Probability model; CMP: Simultaneous estimation of Probit and endogenous censored explanatory variable; Inferential standard errors are robust to general forms of conditional variance misspecification or data clustering; *, **, *** represent significance at 10%, 5%, and 1%, respectively; $\sigma_u$ is the estimate of the standard deviation of the overall residuals term $u_{it}$; $\sigma_c$ is the estimate of the standard deviation of residuals within household, $c_i$; $\rho$ is the estimate of the intraclass correlation—the proportion of total variance due to households in the case of the fixed effects LPM—or the correlation between the structural equation and the reduced form equation in the case of the simultaneous maximum likelihood equation estimates.

**Table 29. Two-Part model estimates of the determinants of nonfarm income, Afrint 3**

| | Part 1 | | | Part 2 | | |
|---|---|---|---|---|---|---|
| | Probit APE | Bivariate Probit APE | | OLS of log nonfarm income | | |
| VARIABLES | All | Male | Female | All | Male | Female |
| Intercept | | | | 6.267*** | 6.052*** | 6.235*** |
| Female farm manager | 0.052* | | | –0.286** | | |
| Age of farm manager | –0.000 | 0.001 | –0.002 | 0.001 | 0.003 | 0.005 |
| Manager's education level | –0.001 | 0.009** | –0.009** | 0.043*** | 0.061*** | 0.021 |
| Number of able workers | 0.003 | –0.001 | 0.026*** | 0.043* | 0.031 | 0.016 |
| Dependent proportion | 0.089* | –0.086 | 0.194** | 0.113 | 0.471 | –0.291 |
| Livestock commercialisation dummy | 0.025 | 0.029 | 0.005 | –0.065 | –0.113 | 0.072 |
| Non-food cash crop producer dummy | 0.000 | –0.001 | 0.007 | 0.051 | 0.045 | 0.056 |
| Distance to market | 0.007* | 0.003 | –0.001 | –0.006 | –0.002 | 0.001 |
| *Quartiles of cultivated area (Comparison group is lowest quartile)* | | | | | | |
| Second | –0.033 | 0.125** | –0.005 | 0.110 | –0.033 | 0.114 |
| Third | –0.043 | 0.144*** | –0.031 | 0.414*** | 0.297 | 0.308** |
| Highest | –0.076* | 0.120** | –0.092 | 0.244 | 0.009 | 0.274* |
| Fallow dummy | –0.018 | –0.025 | –0.004 | –0.151 | –0.160 | –0.078 |
| Credit access dummy | 0.060** | –0.014 | 0.139*** | 0.347*** | 0.129 | 0.398*** |
| Ownership of sowing machine | 0.016 | 0.078* | 0.096** | 0.393*** | 0.305* | 0.059 |
| *Village dummies (comparison village is Gyedi)* | | | | | | |
| Akatawia | –0.094 | 0.052 | 0.011 | | | |
| Asitey | 0.070 | 0.200** | –0.169* | | | |
| Apaa | –0.058 | 0.092 | –0.132 | | | |
| Gaane | 0.138** | 0.540*** | 0.265*** | | | |
| Doba | 0.113 | 0.376*** | 0.246*** | | | |
| Zanlerigu | 0.150** | 0.546*** | 0.005 | | | |
| Shia | 0.159** | 0.502*** | 0.212** | | | |
| *District dummies (comparison district is Fanteakwa)* | | | | | | |
| Krobo | | | | –0.034 | –0.049 | –0.208 |
| Navorongo | | | | –0.261 | –0.752*** | –0.956*** |
| Talensi | | | | –0.332 | –0.780** | –0.972*** |
| Observations | 538 | 538 | 538 | 470 | 343 | 352 |
| R–squared | | | | 0.197 | 0.199 | 0.260 |
| Pseudo $R^2$ | 0.187 | | | | | |
| ρ | | –0.199** | | | | |
| Log–likelihood value | –166.0 | –579.9 | | | | |

**Table 30. Two-part model estimates of purchased input expenditures with exogenous nonfarm income effect, Afrint 3**

| | Part 1: Probit APE | | | | | Part 2: OLS of log expenditure | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| VARIABLES | [1] | [2] | [3] | [4] | [5] | [1] | [2] | [3] | [4] | [5] |
| Intercept | | | | | | 1.707*** | 1.691*** | 1.649*** | 1.691*** | 1.719*** |
| Nonfarm income dummy | 0.020 | | | | | 0.017 | | | | |
| Nonfarm income level | | –0.000 | | | | | 0.000 | | | |
| Male nonfarm income dummy | | | 0.013 | | | | | 0.094 | | |
| Female nonfarm income dummy | | | 0.023 | | | | | 0.102 | | |
| Nonfarm income level: male | | | | | –0.000 | | | | 0.000 | |
| Nonfarm income level: female | | | | | 0.000 | | | | 0.000 | |
| Has male & female nonfarm income earners | | | | 0.023 | | | | | | 0.203** |
| Female farm manager | –0.029 | –0.028 | –0.031 | –0.025 | –0.037 | 0.077 | 0.078 | 0.082 | 0.076 | 0.103 |
| Age of farm manager | 0.014*** | 0.014*** | 0.013*** | 0.013*** | 0.013*** | –0.002 | –0.002 | –0.002 | –0.002 | –0.002 |
| Age of farm manager squared/100 | –0.013*** | –0.013*** | –0.013*** | –0.013*** | –0.012*** | | | | | |
| Manager's education level | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | –0.006 | –0.007 | –0.005 | –0.007 | –0.006 |
| Number of able workers | 0.002 | 0.002 | 0.001 | 0.001 | 0.001 | 0.014 | 0.014 | 0.010 | 0.013 | 0.009 |
| Dependent proportion | –0.011 | –0.010 | –0.014 | –0.011 | –0.012 | 0.533*** | 0.534*** | 0.507*** | 0.534*** | 0.518*** |
| Livestock commercialisation dummy | 0.132*** | 0.131*** | 0.132*** | 0.133*** | 0.131*** | –0.168** | –0.162* | –0.174** | –0.162* | –0.168** |
| Commercial vegetable producer dummy | 0.094*** | 0.092*** | 0.093*** | 0.092*** | 0.096*** | | | | | |
| Distance to market | –0.005*** | –0.005** | –0.005** | –0.005** | –0.005** | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 |
| Cultivated area | 0.034* | 0.033* | 0.033* | 0.032* | 0.031* | 0.500*** | 0.498*** | 0.504*** | 0.498*** | 0.498*** |
| Cultivated area squared | –0.002 | –0.002 | –0.002 | –0.002 | –0.002 | –0.036*** | –0.036*** | –0.037*** | –0.036*** | –0.036*** |
| Extension dummy | –0.021 | –0.019 | –0.023 | –0.021 | –0.023 | 0.378*** | 0.374*** | 0.370*** | 0.373*** | 0.369*** |
| Input credit dummy | 0.154*** | 0.155*** | 0.154*** | 0.156*** | 0.155*** | 0.529*** | 0.532*** | 0.532*** | 0.532*** | 0.531*** |
| Fallow dummy | 0.013 | 0.010 | 0.014 | 0.012 | 0.013 | 0.197** | 0.207** | 0.193** | 0.207** | 0.186** |
| Unlimited land rights | –0.068** | –0.067** | –0.066** | –0.065** | –0.067** | | | | | |
| *Village dummies (comparison village is Gyedi)* | | | | | | | | | | |
| Akatawia | 0.373*** | 0.372*** | 0.358*** | 0.353*** | 0.375*** | | | | | |
| Asitey | 0.343*** | 0.343*** | 0.331*** | 0.328*** | 0.345*** | | | | | |
| Apaa | 0.001 | –0.003 | –0.001 | –0.004 | –0.005 | | | | | |
| Gaane | 0.374*** | 0.374*** | 0.357*** | 0.353*** | 0.377*** | | | | | |
| Doba | 0.297*** | 0.297*** | 0.277*** | 0.272*** | 0.296*** | | | | | |
| Zanlerigu | –0.286*** | –0.284*** | –0.305*** | –0.310*** | –0.275*** | | | | | |
| Shia | –0.496*** | –0.494*** | –0.521*** | –0.525*** | –0.489*** | | | | | |
| *District dummies (comparison district is Fanteakwa)* | | | | | | | | | | |
| Krobo | | | | | | 1.028*** | 1.037*** | 1.018*** | 1.038*** | 1.023*** |
| Navorongo | | | | | | 1.783*** | 1.791*** | 1.709*** | 1.792*** | 1.670*** |
| Talensi | | | | | | 0.402** | 0.414** | 0.331 | 0.415** | 0.297 |
| Observations | 538 | 538 | 538 | 538 | 538 | 360 | 360 | 360 | 360 | 360 |
| R–squared | | | | | | 0.571 | 0.572 | 0.573 | 0.572 | 0.576 |
| Pseudo $R^2$ | 0.604 | 0.604 | 0.605 | 0.605 | 0.607 | | | | | |
| Log–likelihood value | –131.2 | –131.3 | –130.9 | –131.0 | –130.5 | | | | | |

**Table 31. Two-part model of purchased input expenditures with endogenous nonfarm income effect, Afrint 3**

| | Part 1: APE | Part 2: Coef of log expenditure | | | |
|---|---|---|---|---|---|
| VARIABLES | | [1]: DER | [2]: Vella | [4]: DER | [5]: Vella |
| Intercept | | 1.005*** | 1.343*** | 1.830*** | 1.698*** |
| Nonfarm income dummy | | 1.155*** | | | |
| Nonfarm income level | | | 0.000* | | |
| Male nonfarm income dummy | –0.188* | | | | |
| Nonfarm income level: male | | | | 0.000 | |
| Nonfarm income level: female | | | | 0.000** | |
| M & F nonfarm income earners | | | | | 0.954*** |
| Female farm manager | –0.077* | 0.004 | 0.066 | 0.028 | 0.196 |
| Age of farm manager | –0.000 | –0.002 | 0.000 | 0.000 | –0.001 |
| Manager's education level | 0.006* | –0.003 | –0.023* | –0.014 | –0.005 |
| Number of able workers | 0.001 | 0.003 | –0.005 | –0.011 | –0.011 |
| Dependent proportion | –0.033 | 0.310 | 0.480*** | 0.440** | 0.452** |
| Livestock commercialisation dummy | 0.147*** | –0.238** | –0.120 | –0.154* | –0.177** |
| Commercial vegetable producer dummy | 0.082*** | | | | |
| Distance to market | –0.004** | 0.004 | 0.007 | 0.007 | 0.007 |
| Cultivated area | 0.031* | 0.489*** | 0.483*** | 0.492*** | 0.506*** |
| Cultivated area squared | –0.002 | –0.033*** | –0.036*** | –0.037*** | –0.039*** |
| Fallow dummy | 0.010 | 0.213** | 0.349*** | 0.262** | 0.145 |
| Unlimited land rights | –0.072** | | | | |
| Extension dummy | –0.005 | 0.363*** | 0.370*** | 0.363*** | 0.339*** |
| Input credit dummy | 0.150*** | 0.589*** | 0.507*** | 0.498*** | 0.502*** |
| *Village dummies (comparison village is Gyedi)* | | | | | |
| Akatawia | 0.430*** | | | | |
| Asitey | 0.393*** | | | | |
| Apaa | 0.009 | | | | |
| Gaane | 0.459*** | | | | |
| Doba | 0.377*** | | | | |
| Zanlerigu | –0.109 | | | | |
| Shia | –0.330*** | | | | |
| *District dummies (comparison district is Fanteakwa)* | | | | | |
| Krobo | | 0.909*** | 1.143*** | 1.101*** | 1.003*** |
| Navorongo | | 1.518*** | 1.816*** | 1.612*** | 1.243*** |
| Talensi | | 0.124 | 0.515** | 0.340 | –0.107 |
| Endogeneity correction term 1 | | | –0.231* | | |
| Endogeneity correction term male | | | | 0.019 | |
| Endogeneity correction term: female | | | | 0.107** | |
| Observations | 538 | 360 | 360 | 360 | 360 |
| R–squared | | | 0.575 | 0.577 | |
| rho | 0.690* | –0.792*** | | | –0.568*** |
| Log–likelihood value | –407.3 | –518.6 | | | –560.8 |

BP denotes estimates from a bivariate Probit models; DER denotes estimates from a Binary Endogenous regression; Vella denotes the two step approach by Vella (1993)

**Table 32. Average partial effects of the determinants of improved seed and hired labour use, Afrint 3**

| Variable | Improved Seed | | | | Hired Labour | | |
|---|---|---|---|---|---|---|---|
| | [1]: Probit | [3]: Probit | [5i] Probit | [5ii] BIProbit | [1] Probit | [3] Probit | [5] Probit |
| Nonfarm income dummy | –0.043 | | | | 0.096* | | |
| Male nonfarm income dummy | | 0.016 | | | | –0.046 | |
| Female nonfarm income dummy | | –0.058 | | | | 0.036 | |
| Has male & female nonfarm income earners | | | –0.020 | 0.380*** | | | –0.058 |
| Female farm manager | 0.021 | 0.039 | 0.013 | 0.045 | 0.058 | 0.037 | 0.055 |
| Age of farm manager | 0.002 | 0.001 | 0.002 | 0.002 | 0.001 | 0.002 | 0.001 |
| Manager's education level | 0.008** | 0.008** | 0.008** | 0.007 | 0.005 | 0.005 | 0.005 |
| Number of able workers | –0.001 | 0.001 | –0.000 | –0.013 | –0.008 | –0.010 | –0.007 |
| Dependent proportion | –0.050 | –0.045 | –0.055 | –0.094 | –0.001 | –0.013 | 0.000 |
| Livestock commercialisation dummy | –0.026 | –0.030 | –0.031 | –0.035 | 0.122*** | 0.127*** | 0.126*** |
| Commercial vegetable producer dummy | –0.024 | –0.014 | –0.016 | –0.003 | 0.111** | 0.103** | 0.107** |
| Distance to market | –0.002 | –0.002 | –0.002 | –0.003 | | | |
| Cultivated area | 0.184*** | 0.185*** | 0.190*** | 0.159** | 0.054*** | 0.054*** | 0.055*** |
| Cultivated area squared | –0.026** | –0.027** | –0.027*** | –0.027** | | | |
| Extension dummy | 0.100*** | 0.108*** | 0.100*** | 0.080** | 0.064 | 0.060 | 0.067* |
| Input credit dummy | 0.078 | 0.079 | 0.080 | 0.053 | 0.251*** | 0.240*** | 0.240*** |
| Exchange labour availability | | | | | –0.082* | –0.078* | –0.083* |
| Household labour shortage | | | | | 0.200*** | 0.203*** | 0.204*** |
| *Location dummy (comparison location is Upper East)* | | | | | | | |
| Krobo Area | 0.217*** | 0.211*** | 0.215*** | 0.352*** | | | |
| Fanteakwa | 0.614*** | 0.607*** | 0.611*** | 0.629*** | | | |
| *Village dummies (comparison village is Gyedi)* | | | | | | | |
| Akatawia | | | | | –0.056 | –0.069 | –0.052 |
| Asitey | | | | | 0.028 | 0.034 | 0.033 |
| Apaa | | | | | –0.039 | –0.041 | –0.039 |
| Gaane | | | | | –0.084 | –0.072 | –0.034 |
| Doba | | | | | –0.063 | –0.058 | –0.018 |
| Zanlerigu | | | | | 0.019 | 0.039 | 0.054 |
| Shia | | | | | –0.221** | –0.210* | –0.171 |
| Observations | 481 | 481 | 481 | 481 | 538 | 538 | 538 |
| Pseudo $R^2$ | 0.361 | 0.364 | 0.360 | | 0.197 | 0.199 | 0.198 |
| Log–likelihood value | –190.7 | –189.8 | –191.2 | –423.7 | –266.2 | –265.8 | –265.9 |
| ρ | | | | –0.899* | | | |

ρ is the estimate of the correlation between the errors from the primary equation of interest and the suspected endogenous binary variable equation, and is essentially the exogeneity test.

**Table 33. Average partial effects: TPM model for maize market participation with nonfarm income effect, Afrint 3**

| | Part 1: Probit | | | | Part 2: QMLE | | | |
|---|---|---|---|---|---|---|---|---|
| VARIABLES | [1] | [2] | [3] | [4] | [1] | [2] | [3] | [4] |
| Nonfarm income dummy | –0.004 | | | | –0.034 | | | |
| Nonfarm income level | | 0.012 | | | | –0.008 | | |
| Male nonfarm income dummy | | | 0.050 | | | | –0.012 | |
| Female nonfarm income dummy | | | 0.087*** | | | | –0.027 | |
| Nonfarm income level: male | | | | 0.018 | | | | –0.009 |
| Nonfarm income level: female | | | | 0.038 | | | | –0.006 |
| Female farm manager | –0.045 | –0.044 | –0.055 | –0.043 | 0.000 | –0.006 | –0.001 | –0.008 |
| Age of farm manager | 0.010 | 0.010 | 0.010 | 0.010 | 0.001 | 0.001 | 0.001 | 0.001 |
| Age of farm manager squared | –0.013** | –0.013** | –0.013** | –0.012** | | | | |
| Manager's education level | –0.003 | –0.003 | –0.002 | –0.003 | 0.001 | 0.001 | 0.001 | 0.001 |
| Dependent proportion | 0.009 | 0.004 | 0.003 | –0.006 | 0.017 | 0.014 | 0.015 | 0.014 |
| Farm size (log) | 0.071*** | 0.072*** | 0.074*** | 0.074*** | 0.029 | 0.033* | 0.031* | 0.033* |
| Per capita calories available (log) | 0.134*** | 0.131*** | 0.134*** | 0.129*** | 0.052*** | 0.053*** | 0.050*** | 0.054*** |
| Distance to market | –0.001 | –0.002 | –0.001 | –0.002 | –0.001 | –0.001 | –0.001 | –0.001 |
| Nonfood cash cropper | 0.063* | 0.061* | 0.064** | 0.052 | 0.004 | 0.006 | 0.009 | 0.006 |
| Livestock commercialisation | –0.024 | –0.025 | –0.026 | –0.028 | –0.004 | –0.006 | –0.004 | –0.006 |
| Mobile phone ownership | 0.059 | 0.050 | 0.044 | 0.039 | | | | |
| *Location dummies (Comparison location is Upper East)* | | | | | | | | |
| Akatawia | 0.480*** | 0.486*** | 0.548*** | 0.486*** | 0.018 | 0.023 | 0.014 | 0.022 |
| Asitey | 0.278*** | 0.277*** | 0.351*** | 0.268*** | 0.123*** | 0.131*** | 0.112** | 0.131*** |
| Gyedi | 0.231*** | 0.236*** | 0.308*** | 0.240*** | 0.301*** | 0.310*** | 0.292*** | 0.308*** |
| Apaa | 0.316*** | 0.310*** | 0.384*** | 0.314*** | 0.179*** | 0.190*** | 0.168*** | 0.191*** |
| Observations | 419 | 419 | 419 | 419 | 241 | 241 | 241 | 241 |
| Pseudo $R^2$ | 0.564 | 0.566 | 0.574 | 0.571 | | | | |
| Log–likelihood value | –124.6 | –123.9 | –121.7 | –122.5 | | | | |

**Table 34. Average partial effects: TPM model for rice market participation with nonfarm income effect, Afrint 3**

| | Part 1: Probit | | | | Part 2: QMLE | | | |
|---|---|---|---|---|---|---|---|---|
| VARIABLES | [1] | [2] | [3] | [4] | [1] | [2] | [3] | [4] |
| Nonfarm income dummy | –0.119* | | | | 0.174** | | | |
| Nonfarm income level | | –0.022 | | | | 0.010 | | |
| Male nonfarm income dummy | | | –0.048 | | | | 0.159*** | |
| Female nonfarm income dummy | | | –0.052 | | | | 0.084 | |
| Nonfarm income level: male | | | | –0.021 | | | | 0.015 |
| Nonfarm income level: female | | | | –0.020 | | | | –0.008 |
| Female farm manager | 0.035 | 0.021 | 0.016 | 0.024 | 0.058 | 0.075 | 0.116* | 0.078 |
| Age of farm manager | –0.002 | –0.002 | –0.002 | –0.002 | –0.001 | –0.001 | –0.001 | –0.001 |
| Manager's education level | 0.006 | 0.008 | 0.006 | 0.008 | 0.009** | 0.009** | 0.008** | 0.009** |
| Dependent proportion | 0.063 | 0.062 | 0.061 | 0.064 | 0.036 | 0.044 | 0.024 | 0.040 |
| Farm size (log) | 0.057 | 0.062 | 0.062 | 0.061 | 0.022 | 0.021 | 0.013 | 0.021 |
| Calories available (log) | 0.118*** | 0.114*** | 0.117*** | 0.116*** | 0.070* | 0.062 | 0.091** | 0.061 |
| Distance to market | 0.006 | 0.007 | 0.006 | 0.007 | –0.003 | –0.003 | –0.002 | –0.003 |
| Nonfood cash cropper | 0.100* | 0.120** | 0.112** | 0.120** | 0.147*** | 0.122** | 0.112** | 0.124** |
| Livestock commercialisation | –0.123** | –0.128*** | –0.129*** | –0.126*** | –0.050 | –0.048 | –0.044 | –0.047 |
| Mobile phone ownership | –0.043 | –0.035 | –0.046 | –0.038 | | | | |
| Gaane village dummy | 0.545*** | 0.538*** | 0.555*** | 0.540*** | 0.179*** | 0.187*** | 0.140*** | 0.187*** |
| Observations | 212 | 212 | 212 | 212 | 105 | 105 | 105 | 105 |
| Pseudo $R^2$ | 0.494 | 0.491 | 0.491 | 0.490 | | | | |
| Log–likelihood value | –74.42 | –74.79 | –74.78 | –74.94 | | | | |

**Table 35. Probit Average partial effects for nonfood cash crop participation with nonfarm income effect, Afrint 3**

| VARIABLES | [1] | [2] | [3] | [4] |
|---|---|---|---|---|
| Nonfarm income dummy | –0.008 | | | |
| Nonfarm income level | | –0.012 | | |
| Male nonfarm income dummy | | | –0.059** | |
| Female nonfarm income dummy | | | 0.059** | |
| Nonfarm income level: male | | | | –0.015 |
| Nonfarm income level: female | | | | 0.022 |
| Female farm manager | –0.098*** | –0.105*** | –0.137*** | –0.110*** |
| Age of farm manager | 0.019*** | 0.020*** | 0.018*** | 0.020*** |
| Age of farm manager squared/100 | –0.016*** | –0.016*** | –0.015** | –0.016*** |
| Manager's education level | –0.001 | –0.001 | –0.000 | –0.000 |
| Number of able workers | 0.007 | 0.008 | 0.005 | 0.007 |
| Dependent proportion | 0.070 | 0.075 | 0.059 | 0.066 |
| Livestock (in TLU) | –0.012 | –0.012 | –0.013 | –0.013 |
| Extension dummy | –0.038 | –0.035 | –0.048* | –0.049* |
| Input credit dummy | –0.042 | –0.047 | –0.045 | –0.042 |
| Distance to market | –0.001 | –0.001 | –0.002 | –0.002 |
| Land endowment (log) | 0.073*** | 0.071*** | 0.073*** | 0.071*** |
| Calories available (log) | –0.004 | –0.002 | 0.002 | 0.002 |
| *Location dummies (Comparison location is Upper East)* | | | | |
| Akatawia | 0.129*** | 0.129*** | 0.106** | 0.117*** |
| Asitey | 0.149*** | 0.157*** | 0.161*** | 0.144*** |
| Gyedi | 0.499*** | 0.517*** | 0.486*** | 0.489*** |
| Apaa | 0.424*** | 0.433*** | 0.421*** | 0.422*** |
| Observations | 538 | 538 | 538 | 538 |
| Pseudo $R^2$ | 0.458 | 0.465 | 0.476 | 0.466 |
| Log–likelihood value | –142.3 | –140.6 | –137.7 | –140.2 |

**Table 36. Estimates of nonfarm income effect on total cultivated area, Afrint 3**

| | [1] OLS | [1] DER | [2] OLS | [2] VV | [3] OLS | [3a] DER | [3b] DER | [4] OLS | [4] VV | [5] OLS | [5] DER |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Intercept | 0.973*** | 1.180*** | 0.862*** | 0.854*** | 0.858*** | 0.915*** | 0.988*** | 0.859*** | 0.810*** | 0.849*** | 0.912*** |
| Nonfarm income dummy | –0.161* | –0.461*** | | | | | | | | | |
| Nonfarm income level | | | –2.3e-06 | 5.0e-6 | | | | | | | |
| Male nonfarm income dummy | | | | | 0.022 | –0.145 | | | | | |
| Female nonfarm income dummy | | | | | –0.029 | | –0.361* | | | | |
| Nonfarm income level: male | | | | | | | | –8.2e-06 | –2.9e-05 | | |
| Nonfarm income level: female | | | | | | | | 1.7e-05 | –4.5e-05 | | |
| Has male & female nonfarm income earners | | | | | | | | | | 0.088 | –0.560*** |
| Female farm manager | –0.346*** | –0.325*** | –0.357*** | –0.355*** | –0.341*** | –0.404*** | –0.272*** | –0.367*** | –0.361** | –0.342*** | –0.449*** |
| Age of farm manager | –0.000 | –0.000 | –0.000 | –0.000 | –0.000 | –0.000 | –0.001 | –0.000 | –0.000 | –0.000 | –0.001 |
| Manager’s education level | –0.004 | –0.004 | –0.003 | –0.004 | –0.004 | –0.003 | –0.005 | –0.003 | –0.001 | –0.004 | –0.003 |
| Number of able workers | 0.039*** | 0.041*** | 0.038*** | 0.038** | 0.039*** | 0.038*** | 0.049*** | 0.037*** | 0.044*** | 0.036*** | 0.048*** |
| Dependent proportion | 0.225** | 0.254** | 0.208* | 0.209* | 0.217** | 0.194* | 0.293** | 0.205* | 0.221* | 0.206* | 0.235** |
| Livestock commercialisation dummy | 0.125** | 0.137*** | 0.119** | 0.121* | 0.120** | 0.122** | 0.130** | 0.118** | 0.112* | 0.119** | 0.126** |
| Hectares of extra land (log) | 0.221*** | 0.215*** | 0.225*** | 0.224*** | 0.223*** | 0.229*** | 0.212*** | 0.225*** | 0.228*** | 0.223*** | 0.233*** |
| Fallow dummy | –0.120* | –0.128** | –0.119* | –0.115 | –0.117* | –0.122* | –0.108* | –0.119* | –0.134* | –0.116* | –0.094 |
| Unlimited land rights | 0.021 | 0.023 | 0.019 | 0.019 | 0.018 | 0.021 | 0.016 | 0.020 | 0.015 | 0.023 | 0.003 |
| Extension dummy | 0.252*** | 0.247*** | 0.253*** | 0.253*** | 0.256*** | 0.252*** | 0.254*** | 0.248*** | 0.250*** | 0.250*** | 0.259*** |
| Input credit dummy | 0.089 | 0.083 | 0.089 | 0.089 | 0.090 | 0.088 | 0.096 | 0.092 | 0.098 | 0.097 | 0.119 |
| *Village dummies (comparison village is Gyedi)* | | | | | | | | | | | |
| Akatawia | –0.075 | –0.057 | –0.071 | –0.069 | –0.068 | –0.056 | –0.055 | –0.070 | –0.076 | –0.083 | –0.062 |
| Asitey | –0.383*** | –0.362*** | –0.399*** | –0.396*** | –0.405*** | –0.381*** | –0.410*** | –0.396*** | –0.411*** | –0.395*** | –0.363*** |
| Apaa | –0.246** | –0.243** | –0.239** | –0.239** | –0.241** | –0.233** | –0.251** | –0.236** | –0.239** | –0.236** | –0.257** |
| Gaane | –0.481*** | –0.410*** | –0.515*** | –0.514*** | –0.515*** | –0.453*** | –0.386*** | –0.509*** | –0.461*** | –0.569*** | –0.219* |
| Doba | –0.511*** | –0.452*** | –0.537*** | –0.537*** | –0.533*** | –0.479*** | –0.406*** | –0.536*** | –0.489*** | –0.579*** | –0.228* |
| Zanlerigu | –0.591*** | –0.523*** | –0.623*** | –0.624*** | –0.631*** | –0.557*** | –0.563*** | –0.614*** | –0.588*** | –0.653*** | –0.379*** |
| Shia | –0.470*** | –0.402*** | –0.502*** | –0.504*** | –0.502*** | –0.433*** | –0.413*** | –0.497*** | –0.455*** | –0.550*** | –0.257** |
| Endogeneity correction term | | | | –0.004 | | | | | | | |
| Endogeneity correction term male | | | | | | | | | –0.007 | | |
| Endogeneity correction term: female | | | | | | | | | –0.036 | | |
| Observations | 538 | 538 | 538 | 538 | 538 | 538 | 538 | 538 | 538 | 538 | 538 |
| R–squared | 0.371 | | 0.366 | 0.366 | 0.366 | | | 0.367 | 0.368 | 0.368 | |
| ρ | | 0.305** | | | | 0.180 | 0.353* | | | | 0.631*** |
| Log–likelihood value | | –611.3 | | | | –721.8 | –725.1 | | | | –709.7 |

DER denotes dummy endogenous regression; VV is an OLS estimates with correction suggested by Vella, 1993; ρ is the estimate of the correlation between the errors from the primary equation of interest and the suspected endogenous binary variable equation, and is essentially the exogeneity test

**Table 37. Determinants of composite welfare with nonfarm income effect, Afrint 3**

| VARIABLES | [1] OLS | [1] DER | [2] OLS | [2] VV | [3] OLS | [3] DER 1 | [3] DER 2 | [4] OLS | [4] VV | [5] OLS | [5] DER |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Intercept | 19.657*** | 30.133*** | 18.426*** | 20.751*** | 19.013*** | 24.503*** | 10.743** | 18.573*** | 17.387*** | 20.827*** | 21.805*** |
| Nonfarm income dummy | 2.208 | –11.361 | | | | | | | | | |
| Nonfarm income level | | | 0.002*** | –4.1e-04 | | | | | | | |
| Male nonfarm income dummy | | | | | 3.240*** | –18.423*** | | | | | |
| Female nonfarm income dummy | | | | | 2.117* | | 17.010*** | | | | |
| Nonfarm income level: male | | | | | | | | 0.002*** | 0.001 | | |
| Nonfarm income level: female | | | | | | | | 0.001** | –0.001 | | |
| Has male & female nonfarm income earners | | | | | | | | | | 3.938*** | –16.363*** |
| Female farm manager | 1.451 | 2.148 | 2.257* | 1.577 | 2.183 | 2.864** | 0.912 | 2.492* | 1.827 | 2.209 | 2.369* |
| Age of farm manager | –0.037 | –0.042 | –0.036 | –0.039 | –0.036 | –0.031 | –0.006 | –0.036 | –0.045 | –0.035 | –0.055 |
| Manager's education level | 0.908*** | 0.888*** | 0.764*** | 0.943*** | 0.896*** | 1.106*** | 1.025*** | 0.759*** | 0.881*** | 0.894*** | 0.990*** |
| Number of males | 0.286 | 0.330 | 0.317 | 0.295 | 0.263 | 0.597 | 0.174 | 0.333 | 0.381 | 0.249 | 0.618 |
| Number of females | 1.002** | 0.998** | 0.877** | 1.065** | 0.969** | 0.772 | 0.615 | 0.873** | 1.036** | 0.936** | 1.177** |
| Dependent proportion | 2.150 | 3.524 | 2.973 | 2.416 | 2.268 | 1.162 | –0.113 | 2.955 | 2.711 | 2.447 | 2.034 |
| Land endowment (log) | 1.695** | 1.205 | 1.748** | 1.425 | 1.672** | 2.656** | 2.672*** | 1.783** | 1.665** | 1.597** | 2.097** |
| Livestock (in TLU) | 0.701*** | 0.731*** | 0.639*** | 0.727*** | 0.716*** | 0.645*** | 0.659*** | 0.641*** | 0.681*** | 0.721*** | 0.660*** |
| Village group membership | 2.785 | 3.238* | 2.550 | 3.318* | 2.636 | 3.394* | 1.554 | 2.523 | 3.127* | 2.605 | 4.039** |
| Distance to market | –0.159 | –0.122 | –0.148 | –0.157 | –0.153 | –0.118 | –0.112 | –0.151 | –0.170 | –0.139 | –0.206 |
| *Village dummies (comparison village is Gyedi)* | | | | | | | | | | | |
| Akatawia | –10.867*** | –11.346*** | –9.310*** | –10.099*** | –11.158*** | –10.207*** | –12.306*** | –9.343*** | –9.695*** | –11.476*** | –8.415*** |
| Asitey | –3.951 | –2.796 | –2.756 | –3.643 | –4.066* | 0.598 | –0.891 | –2.849 | –3.242 | –3.595 | –4.061 |
| Apaa | –6.755*** | –7.569*** | –5.803** | –5.785** | –6.813*** | –4.804* | –4.554 | –5.892** | –5.796** | –6.888*** | –6.321** |
| Gaane | –15.867*** | –13.482*** | –13.910*** | –14.574*** | –17.670*** | –5.255* | –19.814*** | –14.043*** | –12.432*** | –17.838*** | –5.125* |
| Doba | –10.155*** | –8.180*** | –8.418*** | –9.203*** | –11.539*** | –1.823 | –13.534*** | –8.464*** | –7.214** | –11.676*** | –1.565 |
| Zanlerigu | –15.609*** | –13.274*** | –14.079*** | –14.612*** | –16.962*** | –4.183 | –14.961*** | –14.254*** | –13.126*** | –16.685*** | –8.517** |
| Shia | –14.955*** | –12.519*** | –13.000*** | –13.578*** | –16.534*** | –4.820 | –17.781*** | –13.173*** | –12.016*** | –16.549*** | –5.768* |
| Correction term 1 | | | | 1.233 | | | | | | | |
| Correction term 2 | | | | | | | | | –0.731 | | |
| Correction term 3 | | | | | | | | | –0.502 | | |
| Observations | 539 | 539 | 539 | 539 | 539 | 539 | 539 | 539 | 539 | 539 | 539 |
| R–squared | 0.317 | | 0.367 | 0.367 | 0.326 | | | 0.368 | 0.369 | 0.327 | |
| ρ | | 0.580* | | | | 0.840*** | –0.641** | | | | 0.807*** |
| Log–likelihood value | | –2291 | | | | –2407 | –2416 | | | | –2391 |

DER denotes dummy endogenous regression; VV is an OLS estimates with correction suggested by Vella, 1993; ρ is the estimate of the correlation between the errors from the primary equation of interest and the suspected endogenous binary variable equation, and is essentially the exogeneity test.

**Table 38. Average partial effects of the probability of food insecurity with nonfarm participation effect, Afrint 3**

| VARIABLES | [1a] Probit | [1b] BIProbit | [2] Probit | [3a] Probit | [3b] BIProbit | [3c] BIProbit | [4] Probit | [5a] Probit | [5b] BIProbit |
|---|---|---|---|---|---|---|---|---|---|
| Nonfarm income dummy | –0.061 | 0.390*** | | | | | | | |
| Nonfarm income level | | | –0.040** | | | | | | |
| Male nonfarm income dummy | | | | –0.051 | –0.514*** | | | | |
| Female nonfarm income dummy | | | | 0.065 | | 0.383*** | | | |
| Nonfarm income level: male | | | | | | | –0.066*** | | |
| Nonfarm income level: female | | | | | | | –0.061* | | |
| Has male & female nonfarm income earners | | | | | | | | 0.056 | 0.047 |
| Female farm manager | –0.092* | –0.124*** | –0.106** | –0.129** | –0.257*** | –0.178*** | –0.109** | –0.089* | –0.087 |
| Age of farm manager | –0.002* | –0.002* | –0.002* | –0.002* | –0.001 | –0.001 | –0.002* | –0.002* | –0.002* |
| Manager's education level | –0.008* | –0.007* | –0.006 | –0.008* | –0.006 | –0.005 | –0.005 | –0.008* | –0.009** |
| Dependent proportion | –0.061 | –0.119 | –0.048 | –0.086 | –0.144** | –0.126* | –0.037 | –0.070 | –0.076 |
| *Quartiles of land endowment (Comparison group is lowest quartile)* | | | | | | | | | |
| Second | –0.043 | –0.001 | –0.033 | –0.038 | –0.009 | –0.035 | –0.023 | –0.042 | –0.040 |
| Third | 0.028 | 0.048 | 0.035 | 0.031 | 0.022 | 0.028 | 0.041 | 0.024 | 0.029 |
| Highest | –0.099* | –0.030 | –0.090 | –0.092 | –0.041 | –0.080 | –0.081 | –0.097* | –0.095 |
| Livestock (TLU) | –0.017** | –0.015** | –0.015** | –0.017** | –0.015** | –0.016** | –0.016** | –0.017** | –0.017** |
| Village group membership | –0.058 | –0.073 | –0.048 | –0.063 | –0.013 | –0.076 | –0.035 | –0.061 | –0.061 |
| Distance to markets | –0.001 | –0.004 | –0.002 | –0.002 | –0.000 | –0.001 | –0.002 | –0.002 | –0.002 |
| Nonfood cash cropper | 0.148*** | 0.196*** | 0.154*** | 0.153*** | 0.006 | 0.136*** | 0.156*** | 0.157*** | 0.155*** |
| Calories per hectare (log) | –0.016 | 0.006 | –0.020 | –0.011 | 0.001 | 0.016 | –0.021 | –0.011 | –0.011 |
| *District dummies (comparison district is Fanteakwa)* | | | | | | | | | |
| Krobo | 0.319*** | 0.285*** | 0.329*** | 0.322*** | 0.195*** | 0.308*** | 0.336*** | 0.334*** | 0.336*** |
| Navorongo | 0.362*** | 0.215*** | 0.351*** | 0.343*** | 0.382*** | 0.180* | 0.356*** | 0.328*** | 0.331** |
| Talensi | 0.435*** | 0.293*** | 0.424*** | 0.434*** | 0.468*** | 0.316*** | 0.418*** | 0.413*** | 0.414*** |
| Observations | 539 | 538 | 539 | 539 | 538 | 538 | 539 | 539 | 538 |
| ρ | | –0.865*** | | | 0.987** | –0.704* | | | 0.015 |
| Pseudo $R^2$ | 0.150 | | 0.162 | 0.153 | | | 0.175 | 0.150 | |
| Log–likelihood value | –288.1 | –500.1 | –284.0 | –287.0 | –587.5 | –565.9 | –279.8 | –288.0 | –559.3 |

ρ is the estimate of the correlation between the errors from the primary equation of interest and the suspected endogenous binary variable equation, and is essentially the exogeneity test.

**Table 39. Ordered probit model estimates from of the probability of food security (1), Afrint 3**

| | [1] | | | | | [3a] | | | | | [3b] | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *APE* | | | | | *APE* | | | | | *APE* | | | |
| VARIABLES | Coef | *fsec=1* | *fsec=2* | *fsec=3* | *fsec=4* | Coef | *fsec=1* | *fsec=2* | *fsec=3* | *fsec=4* | Coef | *fsec=1* | *fsec=2* | *fsec=3* | *fsec=4* |
| Nonfarm income dummy | 0.171 | –0.052 | –0.004 | 0.002 | 0.055 | | | | | | | | | | |
| Male nonfarm income dummy | | | | | | 0.209 | –0.064 | –0.005 | 0.002 | 0.067 | | | | | |
| Female nonfarm income dummy | | | | | | | | | | | –0.270** | 0.082 | 0.007 | –0.003 | –0.086 |
| Female farm manager | 0.185 | –0.056 | –0.005 | 0.002 | 0.059 | 0.274* | –0.083 | –0.007 | 0.003 | 0.087 | 0.266** | –0.081 | –0.007 | 0.003 | 0.085 |
| Age of farm manager | 0.010*** | –0.003 | –2.5e-04 | 1.0e-04 | 0.003 | 0.010*** | –0.003 | –2.5e-04 | 1.0e-04 | 0.003 | 0.009*** | –0.003 | –2.4e-04 | 9e-05 | 0.003 |
| Manager's education level | 0.022* | –0.007 | –0.001 | 2.3e-04 | 0.007 | 0.021* | –0.007 | –0.001 | 2.2e-04 | 0.007 | 0.021* | –0.006 | –0.001 | 2e-04 | 0.007 |
| Dependent proportion | 0.068 | –0.021 | –0.002 | 0.001 | 0.022 | 0.114 | –0.035 | –0.003 | 0.001 | 0.036 | 0.141 | –0.043 | –0.004 | 0.001 | 0.045 |
| *Quartiles of land endowment (Comparison group is lowest quartile)* | | | | | | | | | | | | | | | |
| Second | 0.203 | –0.063 | –0.005 | 0.003 | 0.065 | 0.188 | –0.058 | –0.005 | 0.002 | 0.060 | 0.193 | –0.060 | –0.005 | 0.002 | 0.062 |
| Third | 0.018 | –0.006 | –2.6e-04 | 3.7e-04 | 0.006 | 0.001 | –4.4e-04 | –2e-05 | 2.8e-05 | 4e-04 | 0.004 | –0.001 | –5.4e-05 | 7e-05 | 0.001 |
| Highest | 0.332** | –0.101 | –0.010 | 0.003 | 0.108 | 0.313* | –0.095 | –0.009 | 0.002 | 0.102 | 0.309* | –0.093 | –0.009 | 0.002 | 0.100 |
| Livestock (TLU) | 0.053*** | –0.016 | –0.001 | 0.001 | 0.017 | 0.053*** | –0.016 | –0.001 | 0.001 | 0.017 | 0.054*** | –0.016 | –0.001 | 0.001 | 0.017 |
| Village group membership | 0.196 | –0.060 | –0.005 | 0.002 | 0.063 | 0.197 | –0.060 | –0.005 | 0.002 | 0.063 | 0.230 | –0.070 | –0.006 | 0.002 | 0.073 |
| Distance to markets | –3.7e-05 | 1.1e-05 | 9.3e-07 | –3.8e-07 | –1.2e-05 | 4.4e-04 | –1.3e-04 | –1.1e-05 | 4.7e-06 | 1e-04 | 9.1e-04 | –2.8e-04 | –2.3e-05 | 9e-06 | 3e-04 |
| Nonfood cash cropper | –0.302** | 0.092 | 0.008 | –0.003 | –0.097 | –0.310** | 0.094 | 0.008 | –0.003 | –0.099 | –0.329** | 0.100 | 0.008 | –0.003 | –0.105 |
| Calories per hectare (log) | 0.091 | –0.028 | –0.002 | 0.001 | 0.029 | 0.087 | –0.027 | –0.002 | 0.001 | 0.028 | 0.063 | –0.019 | –0.002 | 0.001 | 0.020 |
| *District dummies (comparison district is Fanteakwa)* | | | | | | | | | | | | | | | |
| Krobo | –1.227*** | 0.259 | 0.097 | 0.060 | –0.416 | –1.233*** | 0.255 | 0.098 | 0.062 | –0.414 | –1.201*** | 0.266 | 0.093 | 0.054 | –0.413 |
| Navorongo | –1.607*** | 0.394 | 0.104 | 0.048 | –0.546 | –1.646*** | 0.401 | 0.105 | 0.049 | –0.555 | –1.459*** | 0.358 | 0.098 | 0.046 | –0.502 |
| Talensi | –1.728*** | 0.440 | 0.102 | 0.041 | –0.583 | –1.779*** | 0.451 | 0.102 | 0.042 | –0.594 | –1.634*** | 0.423 | 0.096 | 0.038 | –0.557 |
| cut_1_1 | –0.310 | | | | | –0.341 | | | | | –0.701 | | | | |
| cut_1_2 | 0.117 | | | | | 0.086 | | | | | –0.274 | | | | |
| cut_1_3 | 0.480 | | | | | 0.450 | | | | | 0.091 | | | | |
| Observations | 539 | | | | | 539 | | | | | 539 | | | | |
| Pseudo $R^2$ | 0.111 | | | | | 0.112 | | | | | 0.114 | | | | |
| Log–likelihood value | –599.2 | | | | | –598.5 | | | | | –597.4 | | | | |

**Table 40. Ordered probit model estimates from of the probability of food security (2), Afrint 3**

| | [5] | | | | | [2] | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | *APE* | | | | | *APE* | | | |
| VARIABLES | Coef | *fsec=1* | *fsec=2* | *fsec=3* | *fsec=4* | Coef | *fsec=1* | *fsec=2* | *fsec=3* | *fsec=4* |
| Has male & female nonfarm income earners | –0.211* | 0.064 | 0.005 | –0.002 | –0.067 | | | | | |
| Nonfarm income level | | | | | | 0.129*** | –0.039 | –0.003 | 0.001 | 0.040 |
| Female farm manager | 0.166 | –0.050 | –0.004 | 0.002 | 0.053 | 0.242* | –0.073 | –0.006 | 0.003 | 0.076 |
| Age of farm manager | 0.010*** | –0.003 | –2.5e-04 | 9.6e-05 | 0.003 | 0.010*** | –0.003 | –2.5e-04 | 1.2e-04 | 0.003 |
| Manager's education level | 0.023* | –0.007 | –0.001 | 2.3e-04 | 0.007 | 0.014 | –0.004 | –3.5e-04 | 1.6e-04 | 0.004 |
| Dependent proportion | 0.091 | –0.028 | –0.002 | 0.001 | 0.029 | 0.060 | –0.018 | –0.001 | 0.001 | 0.019 |
| *Quartiles of land endowment (Comparison group is lowest quartile)* | | | | | | | | | | |
| Second | 0.203 | –0.063 | –0.005 | 0.003 | 0.065 | 0.176 | –0.054 | –0.004 | 0.002 | 0.056 |
| Third | 0.032 | –0.010 | –4.9e-04 | 0.001 | 0.010 | –0.001 | 4.6e-04 | 2.1e-05 | –3.0e-05 | –4.5e-04 |
| Highest | 0.331** | –0.100 | –0.010 | 0.003 | 0.108 | 0.310* | –0.093 | –0.009 | 0.003 | 0.099 |
| Livestock (TLU) | 0.053*** | –0.016 | –0.001 | 0.001 | 0.017 | 0.050*** | –0.015 | –0.001 | 0.001 | 0.016 |
| Village group membership | 0.218 | –0.066 | –0.006 | 0.002 | 0.070 | 0.156 | –0.047 | –0.004 | 0.002 | 0.049 |
| Distance to markets | 0.001 | –1.8e-04 | –1.5e-05 | 5.9e-06 | 2e-04 | 0.001 | –3.8e-04 | –3.1e-05 | 1.4e-05 | 3.9e-04 |
| Nonfood cash cropper | –0.332*** | 0.101 | 0.009 | –0.003 | –0.106 | –0.323** | 0.097 | 0.008 | –0.004 | –0.101 |
| Calories per hectare (log) | 0.070 | –0.021 | –0.002 | 0.001 | 0.022 | 0.100 | –0.030 | –0.002 | 0.001 | 0.031 |
| *District dummies (comparison district is Fanteakwa)* | | | | | | | | | | |
| Krobo | –1.203*** | 0.271 | 0.093 | 0.053 | –0.417 | –1.238*** | 0.264 | 0.096 | 0.057 | –0.417 |
| Navorongo | –1.442*** | 0.356 | 0.098 | 0.046 | –0.499 | –1.569*** | 0.380 | 0.101 | 0.047 | –0.528 |
| Talensi | –1.598*** | 0.414 | 0.096 | 0.038 | –0.548 | –1.697*** | 0.427 | 0.100 | 0.040 | –0.566 |
| cut_1_1 | –0.566 | | | | | –0.276 | | | | |
| cut_1_2 | –0.140 | | | | | 0.159 | | | | |
| cut_1_3 | 0.224 | | | | | 0.530 | | | | |
| Observations | 539 | | | | | 539 | | | | |
| Pseudo $R^2$ | 0.112 | | | | | 0.121 | | | | |
| Log–likelihood value | –598.4 | | | | | –592.3 | | | | |

**Table 41. Ordered probit model estimates from of the probability of food security (3), Afrint 3**

| | [4a] | | | | | [4b] | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | APE | | | | | APE | | | |
| VARIABLES | Coef | *fsec=1* | *fsec=2* | *fsec=3* | *fsec=4* | Coef | *fsec=1* | *fsec=2* | *fsec=3* | *fsec=4* |
| Nonfarm income level: M | 0.145*** | –0.044 | –0.004 | 0.002 | 0.046 | | | | | |
| Nonfarm income level: F | | | | | | 0.103 | –0.031 | –0.003 | 0.001 | 0.033 |
| Female farm manager | 0.275** | –0.083 | –0.007 | 0.003 | 0.087 | 0.182 | –0.056 | –0.005 | 0.002 | 0.058 |
| Age of farm manager | 0.010*** | –0.003 | –2.6e-04 | 1e-04 | 0.003 | 0.010*** | –0.003 | –2.5e-04 | 1e-04 | 0.003 |
| Manager's education level | 0.015 | –0.004 | –3.7e-04 | 2e-04 | 0.005 | 0.021* | –0.006 | –0.001 | 2e-04 | 0.007 |
| Dependent proportion | 0.074 | –0.022 | –0.002 | 0.001 | 0.023 | 0.077 | –0.024 | –0.002 | 0.001 | 0.025 |
| *Quartiles of land endowment (Comparison group is lowest quartile)* | | | | | | | | | | |
| Second | 0.176 | –0.054 | –0.004 | 0.002 | 0.056 | 0.173 | –0.054 | –0.004 | 0.002 | 0.056 |
| Third | 0.001 | –2.2e-04 | –1.0e-05 | 1e-05 | 2e-04 | 0.002 | –7.2e-04 | –3.5e-05 | 4e-05 | 7e-04 |
| Highest | 0.312* | –0.094 | –0.009 | 0.003 | 0.101 | 0.297* | –0.090 | –0.009 | 0.002 | 0.097 |
| Livestock (TLU) | 0.053*** | –0.016 | –0.001 | 0.001 | 0.017 | 0.052*** | –0.016 | –0.001 | 0.001 | 0.016 |
| Village group membership | 0.179 | –0.054 | –0.005 | 0.002 | 0.057 | 0.184 | –0.056 | –0.005 | 0.002 | 0.059 |
| Distance to markets | 0.001 | –2.0e-04 | –1.7e-05 | 7e-06 | 2e-04 | 0.001 | –3.5e-04 | –2.9e-05 | 1e-05 | 4e-04 |
| Nonfood cash cropper | –0.312** | 0.094 | 0.008 | –0.003 | –0.099 | –0.327** | 0.100 | 0.008 | –0.003 | –0.104 |
| Calories per hectare (log) | 0.087 | –0.026 | –0.002 | 0.001 | 0.027 | 0.090 | –0.027 | –0.002 | 0.001 | 0.029 |
| *District dummies (comparison district is Fanteakwa)* | | | | | | | | | | |
| Krobo | –1.214*** | 0.259 | 0.095 | 0.057 | –0.410 | –1.225*** | 0.265 | 0.096 | 0.058 | –0.419 |
| Navorongo | –1.565*** | 0.382 | 0.101 | 0.046 | –0.529 | –1.561*** | 0.385 | 0.102 | 0.047 | –0.534 |
| Talensi | –1.701*** | 0.432 | 0.099 | 0.038 | –0.569 | –1.674*** | 0.427 | 0.101 | 0.041 | –0.569 |
| cut_1_1 | –0.363 | | | | | –0.404 | | | | |
| cut_1_2 | 0.073 | | | | | 0.023 | | | | |
| cut_1_3 | 0.443 | | | | | 0.386 | | | | |
| Observations | 539 | | | | | 539 | | | | |
| Pseudo $R^2$ | 0.120 | | | | | 0.111 | | | | |
| Log–likelihood value | –592.9 | | | | | –599.0 | | | | |

**Table 42. Ordered probit with endogenous nonfarm income and participation (1), Afrint 3**

| | [2] | | | | | [3b] | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | *APE* | | | | | *APE* | | | |
| VARIABLES | Coef | *fsec=1* | *fsec=2* | *fsec=3* | *fsec=4* | Coef | *fsec=1* | *fsec=2* | *fsec=3* | *fsec=4* |
| Nonfarm income level | –0.128 | 0.040 | 0.003 | –0.001 | –0.042 | | | | | |
| F nonfarm income dummy | | | | | | –0.947*** | 0.280 | 0.019 | –0.008 | –0.291 |
| Female farm manager | 0.139 | –0.043 | –0.003 | 0.001 | 0.045 | 0.427*** | –0.126 | –0.008 | 0.004 | 0.131 |
| Age of farm manager | 0.009** | –0.003 | –2.1e-04 | 8e-05 | 0.003 | 0.007** | –0.002 | –1e-04 | 6e-05 | 0.002 |
| Manager's education level | 0.028** | –0.009 | –0.001 | 2e-04 | 0.009 | 0.018 | –0.005 | –3e-04 | 2e-04 | 0.005 |
| Dependent proportion | 0.121 | –0.038 | –0.003 | 0.001 | 0.039 | 0.243 | –0.072 | –0.005 | 0.002 | 0.074 |
| *Quartiles of land endowment (Comparison group is lowest quartile)* | | | | | | | | | | |
| Second | 0.201 | –0.062 | –0.005 | 0.002 | 0.065 | 0.190 | –0.056 | –0.004 | 0.002 | 0.058 |
| Third | 0.012 | –0.004 | –2.8e-04 | 1e-04 | 0.004 | –0.007 | 0.002 | 1e-04 | –6.5e-05 | –0.002 |
| Highest | 0.301* | –0.094 | –0.007 | 0.003 | 0.098 | 0.294* | –0.087 | –0.006 | 0.003 | 0.090 |
| Livestock (TLU) | 0.048*** | –0.015 | –0.001 | 4e-04 | 0.016 | 0.054*** | –0.016 | –0.001 | 5e-04 | 0.017 |
| Group membership | 0.240 | –0.075 | –0.006 | 0.002 | 0.078 | 0.265* | –0.078 | –0.005 | 0.002 | 0.081 |
| Distance to markets | 0.001 | –2.1e-04 | –1.6e-05 | 6e-06 | 2e-04 | 0.001 | –2e-04 | –1.2e-05 | 5e-06 | 2e-04 |
| Nonfood cash cropper | –0.294** | 0.091 | 0.007 | –0.003 | –0.096 | –0.325*** | 0.096 | 0.006 | –0.003 | –0.100 |
| Calories per hectare (log) | 0.071 | –0.022 | –0.002 | 0.001 | 0.023 | 0.010 | –0.003 | –2.0e-04 | 9e-05 | 0.003 |
| *District dummies (comparison district is Fanteakwa)* | | | | | | | | | | |
| Krobo | –1.134*** | 0.353 | 0.027 | –0.010 | –0.369 | –1.081*** | 0.320 | 0.021 | –0.009 | –0.331 |
| Navorongo | –1.482*** | 0.461 | 0.035 | –0.013 | –0.482 | –1.088*** | 0.322 | 0.021 | –0.009 | –0.334 |
| Talensi | –1.582*** | 0.492 | 0.037 | –0.014 | –0.515 | –1.383*** | 0.409 | 0.027 | –0.012 | –0.424 |
| cut_1_1 | –0.603 | | | | | –1.260** | | | | |
| cut_1_2 | –0.208 | | | | | –0.851 | | | | |
| cut_1_3 | 0.130 | | | | | –0.502 | | | | |
| Observations | 539 | | | | | 539 | | | | |
| ρ | 0.464** | | | | | 0.460** | | | | |
| Log–likelihood value | –1614 | | | | | –876.3 | | | | |

**Table 43. Ordered probit with endogenous nonfarm income and participation (2), Afrint 3**

| | [4a] | | | | | [4b] | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | APE | | | | | APE | | | |
| VARIABLES | Coef | *fsec=1* | *fsec=2* | *fsec=3* | *fsec=4* | Coef | *fsec=1* | *fsec=2* | *fsec=3* | *fsec=4* |
| Nonfarm income level: M | –0.141 | 0.044 | 0.003 | –0.001 | –0.046 | | | | | |
| Nonfarm income level: F | | | | | | –0.500** | 0.154 | 0.011 | –0.004 | –0.160 |
| Female farm manager | 0.107 | –0.033 | –0.003 | 0.001 | 0.035 | 0.263** | –0.081 | –0.006 | 0.002 | 0.084 |
| Age of farm manager | 0.009** | –0.003 | –2.2e-04 | 8e-05 | 0.003 | 0.008** | –0.003 | –1.8e-04 | 8e-05 | 0.003 |
| Manager's education level | 0.028* | –0.009 | –0.001 | 2e-04 | 0.009 | 0.025** | –0.008 | –0.001 | 2.2e-04 | 0.008 |
| Dependent proportion | 0.123 | –0.038 | –0.003 | 0.001 | 0.040 | 0.143 | –0.044 | –0.003 | 0.001 | 0.046 |
| *Quartiles of land endowment (Comparison group is lowest quartile)* | | | | | | | | | | |
| Second | 0.192 | –0.060 | –0.005 | 0.002 | 0.062 | 0.246* | –0.076 | –0.005 | 0.002 | 0.079 |
| Third | 0.019 | –0.006 | –4.6e-04 | 2e-04 | 0.006 | 0.045 | –0.014 | –0.001 | 4.0e-04 | 0.014 |
| Highest | 0.309* | –0.096 | –0.007 | 0.003 | 0.101 | 0.369** | –0.113 | –0.008 | 0.003 | 0.118 |
| Livestock (TLU) | 0.047*** | –0.015 | –0.001 | 4e-04 | 0.015 | 0.051*** | –0.016 | –0.001 | 4.5e-04 | 0.016 |
| Group membership | 0.213 | –0.066 | –0.005 | 0.002 | 0.069 | 0.270* | –0.083 | –0.006 | 0.002 | 0.086 |
| Distance to markets | 0.001 | –4.0e-04 | –3.1e-05 | 1e-05 | 4e-04 | –0.001 | 3e-04 | 2e-05 | –7.7e-06 | –2.8e-04 |
| Nonfood cash cropper | –0.303** | 0.094 | 0.007 | –0.003 | –0.098 | –0.298** | 0.091 | 0.006 | –0.003 | –0.095 |
| Calories per hectare (log) | 0.081 | –0.025 | –0.002 | 0.001 | 0.026 | 0.037 | –0.011 | –0.001 | 3.3e-04 | 0.012 |
| *District dummies (comparison district is Fanteakwa)* | | | | | | | | | | |
| Krobo | –1.125*** | 0.349 | 0.027 | –0.010 | –0.366 | –1.084*** | 0.333 | 0.023 | –0.010 | –0.346 |
| Navorongo | –1.456*** | 0.451 | 0.035 | –0.013 | –0.473 | –1.469*** | 0.451 | 0.031 | –0.013 | –0.469 |
| Talensi | –1.558*** | 0.483 | 0.038 | –0.014 | –0.506 | –1.653*** | 0.508 | 0.035 | –0.015 | –0.528 |
| cut_1_1 | –0.484 | | | | | –0.794 | | | | |
| cut_1_2 | –0.082 | | | | | –0.403 | | | | |
| cut_1_3 | 0.261 | | | | | –0.070 | | | | |
| Observations | 539 | | | | | 539 | | | | |
| ρ | 0.421* | | | | | 0.457*** | | | | |
| Log–likelihood value | –1514 | | | | | –1164 | | | | |

**Table 44. Summary of regression results of farm-nonfarm linkages and welfare effects**

| Dependent variable | Explanatory variables (Nonfarm income indicators): Nonfarm income dummy | | Level of nonfarm income | | Male nonfarm Income dummy | Female nonfarm Income dummy | Male nonfarm income level | Female nonfarm income level | Dummy for male & female income earner |
|---|---|---|---|---|---|---|---|---|---|
| | Panel | Afrint3 | Panel | Afrint3 | Afrin 3 Only | | | | |
| Purchased input use (binary) | No | No | No | No | **Yes (–)** | No | No | No | No |
| Expenditure on purchased inputs | **Yes (+)** | **Yes (+)** | No | **Yes (+)** | No | No | No | **Yes (+)** | **Yes (+)** |
| Adoption of improved seed (binary) | No | No | No | No | No | No | No | No | **Yes (+)** |
| Hired labour use (binary) | No | Yes(+) | No | No | No | No | No | No | No |
| Maize output market participation (binary) | No | No | No | No | No | Yes (+) | No | No | No |
| Share of maize output sold by sellers | No | No | No | No | No | No | No | No | No |
| Rice output market participation (binary) | No | Yes (–) | No | No | No | No | No | No | No |
| Share of rice output sold by sellers | No | Yes (+) | No | No | Yes (+) | No | No | No | No |
| Participation in nonfood cash crops (binary) | No | No | No | No | Yes (–) | Yes (+) | No | No | No |
| Total cultivated area | No | **Yes (–)** | **Yes (+)** | No | No | **Yes (–)** | No | No | **Yes (–)** |
| Composite welfare index | Yes (+) | No | Yes (+) | Yes (+) | **Yes (–)** | Yes (+) | Yes (+) | Yes (+) | **Yes (–)** |
| Food insecurity (binary) | **Yes (+)** | **Yes (+)** | Yes (–) | Yes (–) | **Yes (–)** | **Yes (+)** | Yes (–) | Yes (–) | No |
| Food security (ordered) | n.a | No | n.a | Yes (+) | No | Yes (–) | Yes (+) | **Yes (–)** | Yes (–) |

Note: results in bold font indicates those observed only after accounting for endogeneity of nonfarm income