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July 1, 2021

Draft paper prepared for the International Conference of Agricultural Economists, August 17–31, 2021

Abstract

While many studies have shown that organic farming may improve the welfare of smallholder farmers in developing countries, its effects on food and nutrition security have barely been analyzed. We use cross-sectional data from Benin to analyze the effect of organic farming on food and nutrition security. We measure food and nutrition insecurity by the FAO dietary diversity score, a score for vitamin A-rich foods, and a food insecurity experience scale. Our preliminary results show that organic farming has no statistical significant effect on food security but that it could improve indicators of dietary diversity and vitamin A rich foods.

Key words: organic farming, food security, dietary diversity, nutrition, farm households, treatment effects.

JEL codes: O13, Q12, Q18.

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1 Introduction

Although substantial interventions supported food security and nutrition in sub-Saharan Africa over the past decades, food insecurity and malnutrition are still prevalent in the region. Particularly, undernourishment rose from 20.8 in 2014 to 22.8% in 2018 in sub-Saharan Africa (FAO, ECA and AUC, 2020), suggesting urgent actions to slow down its prevalence. Given that, many of the undernourished people worldwide are smallholder farmers, agriculture is seen as a mean to improve nutrition of poor rural households, because the majority of the food is produced by smallholders (Herrero et al., 2017) and that more diversified agricultural and food systems may contribute to improve dietary quality and nutrition among smallholders farmers (Koppmair et al., 2017). Hence, promoting sustainable farming systems, closely related to improvement in food production, diversification and fortification could be an important policy intervention. Among sustainability standards, organic farming is increasingly growing interest, since it encourages the use of environmentally friendly practices such as intercropping, crop rotation and diversification, legume cultivation, and the use of organic fertilizers (Meemken et al., 2017; Jouzi et al., 2017) and links smallholder farmers in developing countries to high-value markets (Sellare et al., 2020), but empirical evidence on the effects of organic farming on food security and dietary quality remains scanty. Furthermore, organic farming is supported by at least 172 countries (Meemken et al., 2017), and the majority of organic farmers lives in developing countries: 40% of them live in Asia, 27% in Africa, and 17% in Latin America (FILBS and IFOAM, 2018), suggesting the need to provide evidence on whether organic farming could contribute to supporting and promoting food security in SSA.

Existing economic literature investigates the effects of certified organic farming on household welfare (e.g., Bolwig et al., 2009; Uematsu and Mishra, 2012; Patil et al., 2014; Ayuya et al., 2015; Vellema et al., 2015; Chiputwa and Qaim, 2016; Parvathi and Waibel, 2016; Froehlich et al., 2018; Tran and Goto, 2019; Sellare et al., 2020). The results of these studies are mixed and few of them account for selection bias, which limits the validity of these results for policy implications. Most of these studies analyze the effects of sustainability standards on monetary measures such as income,

consumption, and profitability. However, given that the majority of the world's undernourished are smallholder farmers (Chiputwa and Qaim, 2016; Fanzo, 2018) who often derive their food needs from their own production (Carletto et al., 2015), food and nutrition security could be one of the most important welfare measures of smallholder farmers. Hence, smallholder farmers could be a starting point for agricultural orientated interventions to improve food and nutrition security (Fraval et al., 2019). This is particularly important when analyzing the effects of organic farming, because switching to it could potentially challenge the food and nutrition security of smallholder farmers because organic farming usually gives lower crop yields than conventional farming (e.g., De Ponti et al., 2012; Jouzi et al., 2017) and, thus, could compromise the availability of sufficient self-produced foods in the households. In contrast, it could also be expected that organic households[1] have a more diversified diet than conventional households given that organic farming is usually based on crop rotation and diversified production (Jones et al., 2014). As organic farming promotes the use of sustainable farming practices and crop diversification, it could increase the household's food and nutrition security (Badgley et al., 2007; FAO, 2007; Gracia and De Magistris, 2008; Jouzi et al., 2017) through the consumption of diversified foods that are produced within the farm. However, Sibhatu and Qaim (2018) show that less than 20% of 45 studies found a significant positive relationship between crop diversification and dietary diversity and, thus, it is unclear whether a potentially higher crop diversity of organic farming actually results in a higher dietary diversity of organic households. Finally, if participation in high-value markets positively affects household income, increased possibilities for purchasing nutritious food products could contribute to improved nutrition (Chiputwa and Qaim, 2016).

This study contributes to the existing literature by investigating the causal effect of organic farming on the household's food and nutrition security. We use the FAO household food insecurity experience scale to measure food insecurity and the FAO dietary diversity score and food groups rich in vitamin A to assess the nutrition security status. We extend the HFIES so that it captures smaller variations in food insecurity score. We use a sample of 1255 households in Benin that

[1] In order to avoid long and potentially unclear sentences, we abbreviate households that practice organic farming as "organic households" and households that practice conventional farming as "conventional households."

produce organic or conventional cotton. Our findings show that organic farming leads to improved dietary diversity and more importantly, a diet rich in vitamin A. We do not find, on average, any differential effect of organic farming on food insecurity. Overall, the result may suggest that organic farming is a viable alternative to improve household dietary diets and consumption in vitamin A. In addition, switching to organic farming does not (significantly) jeopardize food security in spite of negative effects on yields. Hence, promoting organic farming is not expected to jeopardize food security of the farm households who switch to organic farming.

The remainder of this article is organized as follows. Section 2 describes the study location, data and the empirical strategy. The results are presented in Section 3. A summary and policies implications conclude the article in section 5.

2 Methodology

2.1 Data collection

Our analysis uses cross-sectional data from a household survey in Benin. The survey locations cover three main cotton growing districts, namely Kandi, Pehunco and Glazoue that were purposely chosen in order to have regions with high importance of cotton farming, agro-ecological diversity, and the presence of organic cotton farming. Cotton production is the main source of livelihoods for most rural households in these districts. Other crops—mostly maize, sorghum, soybean, and groundnut—are cultivated in rotation with cotton for providing food for the household and for maintaining soil fertility. Village-level characteristics (e.g., type of road, type of production system, number of households, number of cotton farming households, number of cotton producers, importance of cotton production, access to water sources, etc.) were collected in all villages in the three districts and serve to select three groups of villages: First, we selected all 25 villages in the three districts that have organic cotton farming in order to be able to select a sufficient number of organic cotton farmers for our survey. Second, we used genetic matching to select a group of 25 villages with only conventional cotton farming that have similar village-level characteristics as

the 25 villages that produce organic cotton. Finally, we used a search algorithm to select a third group of 25 villages that produce only conventional cotton and that together with the two other groups of villages give a representative sample of all cotton growing villages in each of the three districts. The advantage of this sampling strategy is that it allows us to select a sufficiently large number of organic cotton growing households, that we can have conventional cotton farmers in our survey who live in villages without organic cotton production that are similar to villages with organic cotton production, and that our survey is conducted in a representative sample of villages in each of the three districts.

We used stratified random sampling to choose the households for the survey. Our aim was to select approximately 1,400 households for the survey proportionally to the total number of cotton growing households in the respective districts. In order to have a sufficient number of organic cotton growing households in the sample, we intended to choose 70% conventional cotton growing households and 30% organic cotton growing households in each district but this was not possible in Pehunco due to the small number of organic cotton growing households in this district. Based on the total number of organic and conventional cotton growing households in each district, this procedure resulted in sampling intensities of 75%, 100%, and 55% for organic cotton growing households and around 8%, 11%, and 8% for conventional cotton growing households in Kandi, Pehunco, and Glazoue, respectively.

Prior to the survey, a household census was conducted in the 75 selected villages in order to obtain information on the type of cotton production (i.e., whether the household grows conventional or organic cotton), the location, and the mobile phone number for each cotton growing household. This information allowed us to interview almost all households that were selected for the survey. Given that, in Glazoué district, two selected villages, one in the second group and one in the third group had so few cotton farmers, so that the number of cotton growing households rounded to zero; in Kandi district, the inaccessibility of one selected village in the third group with six cotton growing households that could be interviewed; in Pehunco district, one village that was a hamlet of a village in the first group of villages when we implemented the census becomes an independent

village at the time of the household survey; we collected data from cotton growing households located in 73 villages. The few households that could not be interviewed were randomly replaced by other households from the same strata. The survey included 1,361 cotton growing households. We excluded 17 households that produce both organic and conventional cotton, 11 households with missing values in key variables such as household composition, type of cotton production and productive assets, and 78 organic cotton growing households that do not have certification, (i.e., organic cotton growing households that switched to organic production less than three years ago or that did not fulfil all requirements for organic certification) and/or produced both organic and conventional cotton. The final sample consists of 1,255 cotton growing households of which 225 and 1,030 grow organic and conventional cotton, respectively.

The data were collected through face-to-face interviews using the KoBoCollect software from March to May 2018. The gathered data include information on, e.g., household characteristics, household assets, working capital and livestock assets and their monetary values in 2018, the area cultivated with each crop, the number and value of livestock of each species, and household expenditure on air time which we used as indicator of the household's prosperity. The dietary diversity score modules (see FAO, 2011) and the food insecurity experience scale survey module (FIES-SM) (see Cafiero et al., 2018) were also included in the questionnaire: the household head and/or his/her spouse were asked to recall the food consumed in the household over 24 hours 7 days and to answer eight questions about the experience of food insecurity in the past twelve months so that we can calculate the household dietary diversity score and the food insecurity experience scale, respectively.

2.2 Measurement of food and nutrition security

Food security is defined as the situation "when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO, 2009, p. 1). Acknowledging that this definition of food security is widely approved, its measurement is still a challenge due its various dimensions. Some

decades ago, household food consumption expenditure, household food insecurity score (Bhalla et al., 2018), and anthropometric measures (see Rawlins et al., 2014; Smale et al., 2015) were the most widely used for measuring food security. Due to measurement challenges associated with these indicators, further indicators have been proposed.

The household food insecurity experience scale (HFIES) developed by FAO is used as a proxy for measuring food security, i.e., having a sufficient quantity of food to eat. It is built on the methodology of other potential experience measures including the US household food security survey module (HFSSM), the escala latinoamericana Caribena de Seguridad Alimentaria (ELCSA), and the household food insecurity access scale (HFIAS) (Cafiero et al., 2018) and it is a set of eight questions on a severity scale, expressing the experience of food insecurity. It is the first survey instrument to measure people's direct experiences of food insecurity at the individual level that is applied on a global scale (Smith et al., 2017). Secondly, it provides an internal statistical validity of the data set using the Rasch model assumptions (Cafiero et al., 2018). The household head and/or his/her spouse were asked whether they experience the following situations during the last 12 months because of lack of money or other resources:

1. You were worried you would not have enough food to eat.
2. You were unable to eat healthy and nutritious food.
3. You only ate a few different kinds of food.
4. You had to skip a meal
5. You ate less than you thought you should.
6. Your household ran out of food.
7. You were hungry but did not eat.
8. You went without eating for a whole day.

Instead of asking the interviewees for a binary response ("Yes"/"No") for each of the eight potential situations (as done, e.g., by Cafiero et al., 2018; Smith et al., 2017), we extend the HFIES by allowing for four ordered answers: 0 = Never, 1 = Rarely, 2 = Sometimes, and 3 = Often. This allows us to obtain the original HFIES that ranges from 0 to 8 (i.e., the number of answers that are not 0) and to obtain a more detailed HFIES that ranges from 0 to 24 by summing up the answers to the eight questions. Furthermore, we decompose the raw original HFIES (See Smith et al., 2017) in three categories, so that we have: (a) "mild food insecurity" for a raw FIES score greater than zero, (b) "moderate food insecurity" for a raw FIES score greater than three and (c) "severe food insecurity" with a raw FIES score greater than seven.

The study also uses the household dietary diversity score suggested by FAO (2011) for measuring nutrition security, i.e., having a sufficient nutritional quality of food to eat. Studies showed that dietary diversity is a strong predictor of child nutritional status (Moursi et al., 2008; Gebremedhin et al., 2017; M'Kaibi et al., 2017). It consists of 16 groups of food items and the households were asked to recall the food items consumed by the household members either in a 24 hours or a 3-7 days reference period. We use the household dietary diversity score for the period of 7 days and 24 hours in order to account for short run and long run diverse food. The household dietary diversity module consists in asking the household head and/or his conjoint, whether the following food groups were consumed in the households over the last 24 hours and 7 days (see FAO, 2011):

1. Cereals (bread, maize, sorghum, oats, etc.)
2. White tubers and roots (white potatoes, white yam, white cassava, or other roots)
3. Vitamin A-rich vegetables and tubers (carrots, sweet potatoes, sweet red peppers)
4. Dark green leafy vegetables
5. Other vegetables
6. Vitamin A-rich fruits (mango, papaya, dried peach), and 100% fruit juice made from these
7. Other fruits

8. Organ meat (liver, kidney, heart or other organs or blood-based foods)
9. Flesh meats
10. Eggs
11. Fish and seafood
12. Legumes, nuts and seeds (seed: all other seeds except cereals)
13. Milk and milk products
14. Oils and fats
15. Sweets
16. Spices, condiments, beverages (beverages: coffee, tea, alcoholic beverages).

Based on this classification, a group of 'vegetables' was derived by combining vitamin A-rich vegetables and tubers, dark green leafy vegetables and other vegetables (3, 4, 5). A group of 'fruit' was derived from combining vitamin A-rich fruits and other fruits (6, 7), and a group 'meat' was derived by combining organ meat and flesh meat (8, 9), leading to a total of 12 food groups. The households dietary diversity score is obtained by summing up the number of affirmative responses and then ranges from 0 to 12. We also derive a second indicator for food diversity rich in vitamin A as suggested by FAO (2011). This indicator is obtained by summing up the number of food groups rich in vitamin A (groups 3, 4, 6, 8, 10, 13) consumed by the households in the last seven days and the final score has a range from 0 to 6. Both dietary diversity and diet rich in vitamin A are used for measuring nutrition security with the hypothesis that they may indicate the consumption of important nutrients for a healthy life.

2.3 Theoretical framework

The theory of the agricultural household (Singh et al., 1986) is used as a framework to investigate the effect of organic farming on food and nutrition security. This framework suggests that the

household combines farm resources and household labor to maximize utility over leisure and consumption of goods produced within the farm or purchased on the market. The household decision to produce a given crop or a given variety of crop depends on the production technology and a set of farm (land size, etc.) and household characteristics (age, gender, household composition, etc.), household labor, time allocated to labor and leisure; and a full income constraint (Smale et al., 2015). Following Van Dusen and Taylor (2005) and Smale et al. (2015) application of the household production model to analyse crop diversity and dietary quality respectively, we apply it here to show how household choice could translate into changes in food and nutrition security. Since, farmers in developing countries operate in imperfect market, consumption and production are non-separable, thus family members organize their labor to maximize utility over consumption goods and leisure in an economic environment with market failures (Singh et al., 1986; de Janvry et al., 1991). Given these considerations, households are assumed to maximize the following utility function:

$$Max_{C,R}U = U(X,R,L,Z_h). \tag{1}$$

Each individual household derives utility from consumption of on farm goods (X), and all other purchased goods (R), over leisure (L), given 'a vector of household characteristics such as age, household size, education, etc., (Z_h).

The level of production of crops i (Q_i) depends on the production method (D), a vector of household characteristics (Z_h), farm characteristics (Z_{farm}). The production method is embedded in the production function and is a vector of exogenous household's (Z_h) :

$$Q = Q(D(Z_h),Z_h,Z_{farm}). \tag{2}$$

The househods maximise utility (Equation (1)) is subject to a full income constraint:

$$R_h = p*(Q-C_h) - C(Q,p,Z_{farm}) + I + wHL, \tag{3}$$

where HL is household labor valued at the local market wage w, $C(Q, p, Z_{farm})$ is the cost function, Z_{farm} a vector of farm characteristics and Q a vector of output, p a vector of price of agricultural products and I includes farm income.

Given that the household food and nutrition security depends only on the consumption of food items (i.e., most part of X and purchased food items R) in a direct way and that, X and the consumption of purchased food items R depend on exogenous factors (e.g., price, income, household, farm and market parameters, etc), we derive the set of constrained optimal consumption levels Xc, Rc:

$$X = Xc(p, Ic, D(Z_h), Z_h, Z_{farm}, Z_{market}) \tag{4}$$

$$R = Rc(p, Ic, D(Z_h), Z_h, Z_{farm}, Z_{market}), \tag{5}$$

where Ic represents the full income for the constrained optimal production levels Qc and Z_{market} stands for market characteristics.

Let denote HFIES, HDDS and Vitamin A espectively for the food insecurity experience scale scores, household's dietary diversity, vitamin A rich foods. Our food and nutrition security indicators can be derived as:

$$HFIES = HFIES(XcRc(p, Ic, D(Z_h), Z_h, Z_{farm}, Z_{market}). \tag{6}$$

$$HDDS = HDDS(XcRc(p, Ic, D(Z_h), Z_h, Z_{farm}, Z_{market}). \tag{7}$$

$$VitaminA = VitaminA(XcRc(p, Ic, , D(Z_h), Z_h, Z_{farm}, Z_{market}). \tag{8}$$

2.4 Empirical Strategy

In this section, we present the estimation strategy that we use to investigate the effects of organic farming on rural household food and nutrition security.

Our reduced regression equation is specified as:

$$y_{ik} = \alpha_k + \gamma_k' x_i + \beta_k D_i + \varepsilon_{ik}, \tag{9}$$

where y_{ik} expresses one of our outcome variables, x_i is a vector of exogenous explanatory variables, D_i is a dummy variable that is equal to one if household i does organic farming and zero otherwise, ε_{ik} are the error terms, i indexes households an k the specific outcome variable, representing the food insecurity experience scale, the adjusted food insecurity experience scale, the dietary diversity score and the number of food groups rich in vitamin A.

We purport to isolate the effects of organic farming on food and nutrition security indicators, after controlling for exogenous explanatory variables x_i. Referring to our theoretical framework, the vector of exogenous explanatory variables x_i includes (1) household socioeconomic characteristics Z_h: age, gender, education, household size and dependency ratio, (2) farm characteristics Z_{farm}: experience in agriculture, total land owned and values of productive assets, (3) market characteristics Z_{market}: type of road and distance to closest market, both proxies for prices of products because, prices on farm products also depend on the romoteness and the distance between the household dwelling and the nearest market, (4) exogenous income I: values of household assets instead of observed full income, denoting longer-term income as explained by Smale et al. (2015). x_i additionally accounts for distance to health facility for development level and dummy variables for district to control for district level heterogeneities regarding production systems and food diversities. Standard errors are clustered at the village level using clustered sandwich estimators of type "HC1" in the terminology of MacKinnon and White (1985) (for details see, e.g., Berger et al., 2017). All outcomes variables are used in their linear form, because they have a normal distribution when not log-transforming them.

We aim in this specification at estimating the coefficient β_k and at testing the null hypothesis $H_0 : \beta_k = 0$ versus the alternative hypothesis: $H_0 : \beta_k \neq 0$. In principle $\beta_k = E(y_{ik}|D_i = 1) - E(y_{ik}|D_i = 0)$ should be the average treatment effect (ATE) of organic farming on the outcomes of interest and should be positive and statistically significant. However, as selection into organic farming is not assigned at random, unobserved factors likely influence farmers' decisions to switch to organic farming, and thus β_k would be biased. To obviate this endogeneity concern, we use the three steps approach of IV estimation suggested by Wooldridge (2010, p. 937–942) that takes into account that one of the endogenous regressors, the dummy variable indicating organic farming (D_i), is a binary variable. We conduct a probit regression of the dummy variable indicating organic farming (D_i) on all exogenous explanatory variables x_i and the instrument: exposure to organic farming ($\bar{D}_i$) defined as the proportion of organic households in each village (see, e.g., Sellare et al., 2020). We examine standard model diagnostics for the instrumental variable such as: the relevance of the instrument with the joint F-test for validity in the first stage regression and the exogeneity of the organic farming with the Wu-Haussman test. The validity of the models requires the assumption about the instrument, which means that the instrument has to be correlated to the treatment variable but neither with the error term nor to the outcomes variables. This instrument stands for the awareness of organic farming by the household and also proxies for relevant information about the existence of organic farming, required steps for its adoption, and the intensity of household's exposure to organic farming. The underlying hypothesis is that, the higher this intensity is, the more likely the households are to adopt organic farming. In addition to discussing the validity of the instrument, the falsification tests suggested by Di Falco et al. (2011), indicate that our instrument does not influence none of the food and nutrition security outcomes for the subsample of conventional households (table 7 in the supplemental appendix). Taking this into account, we use the predicted probability as an instrument in classical 2SLS. In this regression analysis, β_k becomes the local average treatment effect.

Sensitivity to omitted variables

We use the approach suggested by Oster (2019) to assess the sensitivity of our analysis to omitted variables. This approach recovers the unobserved association between the treatment variable and the explanatory variables by using the observed association between the treatment variable and the explanatory variables in the regression. In practice, this method suggests that we model the short regression:

$$y_{ik} = \alpha_k^s + \beta_k^s D_i + \varepsilon_{ik}^s, \tag{10}$$

where the superscript s indicates that the parameters and the error term are part of this "short" regression model. Estimating equation (10) would lead to biased estimates if there are important omitted variables in the regression. Let revisit our equation (9) controlling for observed covariates x_i and let denote by W_i a set of unobserved variables that are correlated with both our outcome variables y_{is} and the treatment variable D_i such that

$$y_{ik} = \alpha_k^h + \gamma_k^{h\prime} x_i + \beta_k^h D_i + \psi^{h\prime} W + \varepsilon_{ik}^h, \tag{11}$$

where ψ^h is a vector of parameters and the superscript h indicates that the parameters and the error term are part of this hypothetical regression model. Under the assumption of equal selection of observables and unobservables (Oster, 2019), the biased adjusted estimate of the effect of organic farming on food and nutrition security indicators can be derived as:

$$\hat{\beta}_k^h = \hat{\beta}_k - \delta_k \left[\hat{\beta}_k^s - \hat{\beta}_k\right] \frac{R_k^h - R_k}{R_k - R_k^s}, \tag{12}$$

where—as in Oster (2019)— , R_k^s denotes the R-squared value of the short regression model (10), R_k denotes the R-squared value of the main regression model (9), and R_{kh} denotes the R-squared value of the hypothetical regression model (11) and δ_k is the (assumed) value of the coefficient of proportionality of observable and unobservable. We derive the bias-adjusted estimate of the

treatment effect $\hat{\beta}_k^h$ based on equal selection of observable and unobservable ($\delta_k = 1$) along with some values of R_k^h. We assume $R = 1.25R_k$, $R_k^h = R_k + \left(R_k - R_k^s\right)$ as suggested by Bellows and Miguel (2009) and under the assumption of no omitted variables ($R_k^h = 1$). To claim the robustness of our specification to omitted variables bias, the bounds $\Delta_k = [\hat{\beta}_k^h, \beta]$ should exclude zero, have the same direction of the effect and fall within the confidence interval of β_k estimated by the main model specification (9).

3 Results[2]

3.1 Descriptive statistics

Table 1 reports mean characteristics of organic and conventional households in our sample along with balancing tests.

The majority of the household heads in our empirical analysis is male with significant difference between conventional and organic households. The average educational attainment in those households is quite low and is approximately 1.38 years of primary education. Corroborating with this low level of education, very few farmers can speak, read and understand French. As for literacy, it explains household head's capacity to read and write in the local language. The data then shows that the rate of literacy is about the same in both organic and conventional households. The average household head age is 42.39 years old with significant difference between the two groups. The average household size in the sample is about 7.31 and conventional households have more significantly households asset and productive assets than organic households. Though some studies argued that organic households are land constrained, our data shows no significant difference between organic and conventional households with a mean value of about 13.58 hectares of total land owned. However, conventional households cultivate on average larger land areas with cotton,

[2]The empirical analyses were performed in the statistical software "R" (R Core Team, 2018) and the add-on packages "AER" (Kleiber and Zeileis, 2008), "ggplot2" (Wickham, 2016), "Sandwich" (Zeileis, 2004, 2006; Berger et al., 2017), "xtable" (Dahl et al., 2019)."sampleSelection" (Henningsen and Toomet, 2014), and "Stargazer" (Hlavac, 2018).

Table 1: Descriptive statistics

	All	Convent.	Organic	Diff.	P-value
Household head					
Age	42.39	42.00	44.19	-2.18	0.023
Sex (1=male)	0.93	0.95	0.86	0.09	<0.001
Years of education	1.38	1.35	1.55	-0.20	0.384
Literacy	0.19	0.18	0.24	-0.06	0.065
Experience in cotton farming (years)	15.13	15.19	14.85	0.34	0.620
Household					
Household size	7.31	7.38	6.97	0.41	0.127
Number aged 0-14	3.15	3.19	2.96	0.23	0.173
Number aged 15-35	2.98	3.03	2.78	0.25	0.081
Number aged 36-65	1.10	1.10	1.13	-0.04	0.631
Number aged ≥ 66	0.07	0.06	0.10	-0.03	0.177
Dependency ratio	0.41	0.41	0.41	-0.00	0.866
Land cultivated with cotton (ha)	3.48	3.87	1.66	2.21	<0.001
Total land owned (ha)	13.58	13.90	12.16	1.74	0.354
Other assets (million FCFA)	2.31	2.43	1.79	0.64	0.010
Working Capital (million FCFA)	0.57	0.59	0.48	0.11	0.027
Distance to closest market	3.22	3.22	3.24	-0.03	0.945
Tarred road	0.35	0.30	0.57	-0.27	<0.001
Distance to health facility	4.06	3.88	4.89	-1.01	0.018
Production diversity					
Food crop diversity	4.72	4.78	4.43	0.35	0.011
Cash crop diversity	1.35	1.37	1.26	0.11	0.003
Livestock diversity	1.69	1.67	1.75	-0.08	0.236
Food and nutrition security					
HFIES (HFIESFAO)	2.89	2.83	3.15	-0.31	0.064
HFIES in ordinary scale (HFIES)	4.02	4.00	4.15	-0.15	0.538
Dietary diversity over 24 hours	6.76	6.84	6.40	0.44	<0.001
Diet rich in vitamin A over 24 hours	2.57	2.59	2.46	0.13	0.094
Dietary diversity over 7 days	9.08	9.07	9.16	-0.09	0.451
Diet rich in vitamin A over 7 days	3.94	3.92	4.03	-0.11	0.159
District					<0.001
Kandi	0.56	0.53	0.73	-0.21	
Pehunco	0.24	0.28	0.03	0.25	
Glazoué	0.20	0.19	0.24	-0.05	
Observations	1255	1030	225		

Notes: HFIES = Household Food Insecurity Experienced Scale; P-values of continuous variables are obtained by two-sample t-tests for equality of mean values and P-values of binary variables are obtained by Pearson's χ^2-tests for equal proportions.

more food crops and cash crops than their counterpart conventional households. A primal comparison of our outcome variables shows that conventional households have a significantly higher dietary diversity over 24 hours score and consume significantly more food rich in vitamin A over 24 hours than certified organic households. This trend is the same when we look at the FAO food insecurity experienced scale, but we do not observe any significant difference in terms of our ex-

tended HFIES. There is also no significance difference between certified organic households and conventional households with regards to dietary diversity and vitamin A rich foods over the last 24 hours.

4 Econometric results

4.1 Impact estimates

Both OLS and IV regressions (Table 2 to 3) results are presented for each one of our outcome variables. Statistical test shows that our instrument is highly correlated to the production method. Furthermore, for the FAO food insecurity experienced scale (Table 2), the dietary diversity and vitamin A rich foods in the last 24 hours (Table 3), the Hausman tests indicate that OLS and IV estimates do not differ significantly. That is, OLS estimates are more consistent than IV. Both OLS and IV results show no statistically significant effect of organic farming on the FAO food insecurity scale, adjusted FAO food insecurity scale, dietary diversity and vitamin A rich foods over 24 hours. Our results indicate that organic and conventional households are similar in terms of food insecurity level, and the dietary diversity in the short period (e.i, 24 hours).

In contrast to dietary quality over 24 hours (Table 3), diagnostic tests (e.i, Hausman tests) reject the null hypothesis that organic farming is exogenous in dietary diversity over seven days (Table 4). Thus, IV estimate is more consistent than OLS for the outcome denoting dietary diversity over 7 days and the opposite is observed for vitamin A rich foods over 7 days. IV estimate suggests that organic farming leads to 1.05 points higher dietary diversity score. OLS estimate shows that organic farming leads to 0.28 points higher vitamin A rich foods over 7 days. As for IV estimate, it indicates a gain of about 0.38 points vitamin A rich foods over 7 days. Positive effects of organic certification on nutrition was also reported to some extent in empirical studies using different nutrition indicators (Chiputwa and Qaim, 2016; Meemken et al., 2017)

Two important results can be derived from our analyses. First, organic farming does not affect significantly food insecurity. Secondly, our results show that in the long run, organic farming

affects positively and significantly household dietary quality, which is as expected since organic farming promoters usually encourage crops diversification at the household level, and thus a potentially increase in production diversity could result in high dietary diversity.

4.2 Sensitivity to omitted variable bias

We check if the regression specifications used in this article are robust to omitted variable bias with Oster (2019) approach of coefficient stability. Table 5 presents the bias-adjusted coefficients of the OLS estimates of organic farming calculated with equation (11) for four different values of R_k^h. The bounds of $\Delta_k = [\hat{\beta}_k^h, \beta]$ exclude zero and are within the 99.5% confidence interval of the estimated effects for both the dietary diversity and food rich in vitamin A scores over 7 days. Under the full hypothetical regression with zero omitted variables, the effects are rather still positive but are outside the respective 99.5% confidence intervals. In contrast, the confidence intervals include zero for both indicators measuring food insecurity and dietary quality over 24 hours. That is, there are no significant effects of organic farming on household food insecurity and dietary quality over a period of 24 hours.

4.3 Robustness checks

We conduct further econometric analyses to assess the effect of organic farming on food and nutrition security. In the first alternative specifications (Tables 9, 10, 11), we standardize the raw score of our outcomes variables in order to have a mean of zero and standard deviation of one. This leads to consistent direction of the effects as found in our core findings. Second, our estimates are robust to the model specification when we replace dependency ratio and household size by household composition (Tables 12, 13, 14). Third, though we include district fixed effect in our empirical strategy to control for district level heterogeneities, we also check if our results are not driven by the very high rate of conventional households in Pehunco with respect to organic households (Tables 15, 16, 17). We find that our results are still consistent with our prior findings (See results in section 4.1). Fourth, we use the FAO food insecurity experienced scale to inves-

Table 2: OLS and IV Regression results

	Household food insecurity experienced scales			
	HFIESFAO(OLS)	HFIESFAO(IV)	HFIES(OLS)	HFIES(IV)
	(1)	(2)	(3)	(4)
Organic	0.32 (0.56)	−0.19 (0.68)	0.20 (0.61)	−0.84 (0.56)
Gender (male)	0.12 (0.23)	0.03 (0.27)	0.17 (0.33)	−0.003 (0.39)
Age of household head	−0.02*** (0.01)	−0.02*** (0.01)	−0.03*** (0.01)	−0.03*** (0.01)
Years of education	−0.03 (0.03)	−0.03 (0.03)	−0.03 (0.05)	−0.02 (0.05)
Literacy	0.23 (0.26)	0.24 (0.25)	0.29 (0.39)	0.32 (0.36)
Experience in agriculture	0.03*** (0.01)	0.03*** (0.01)	0.04*** (0.01)	0.04*** (0.01)
Household size	0.05* (0.03)	0.05* (0.03)	0.06 (0.04)	0.06 (0.04)
Dependency ratio	0.41 (0.34)	0.39 (0.33)	0.56 (0.66)	0.54 (0.65)
asinh(Total land owned (ha))	−0.82*** (0.14)	−0.85*** (0.13)	−1.14*** (0.23)	−1.19*** (0.22)
Distance to closest market	−0.05** (0.03)	−0.06** (0.03)	−0.10*** (0.03)	−0.10*** (0.03)
Tarred road	−0.13 (0.52)	−0.06 (0.57)	−0.23 (0.67)	−0.10 (0.76)
Distance to health facility	0.05* (0.03)	0.06** (0.03)	0.08** (0.03)	0.10*** (0.03)
log(Household assets (million FCFA))	−0.05 (0.10)	−0.07 (0.10)	−0.08 (0.13)	−0.11 (0.14)
log(Working Capital (million FCFA))	0.17* (0.10)	0.17* (0.10)	0.26* (0.14)	0.26* (0.14)
Arronangaradebou	−0.06 (0.53)	−0.14 (0.57)	0.23 (0.74)	0.07 (0.79)
Arronbensekou	0.68 (0.58)	0.55 (0.65)	1.36 (0.85)	1.08 (0.94)
Arrondonwari	−0.16 (0.41)	−0.07 (0.40)	0.15 (0.65)	0.34 (0.64)
Arrongnemasson	1.33*** (0.22)	1.23*** (0.20)	2.31*** (0.29)	2.09*** (0.22)
Arronkand2	1.85*** (0.37)	1.68*** (0.43)	4.46*** (0.41)	4.11*** (0.47)
ArronKandi1	1.57*** (0.36)	1.42*** (0.37)	2.67*** (0.51)	2.37*** (0.50)
Arronkandi3	1.38*** (0.44)	1.25** (0.48)	1.53** (0.63)	1.25* (0.67)
Arronkassakou	−0.58 (0.50)	−0.73 (0.55)	0.53 (0.69)	0.23 (0.75)
Arronpehunco	1.19*** (0.22)	1.09*** (0.21)	2.08*** (0.29)	1.89*** (0.24)
Arronsaah	−1.12*** (0.22)	−1.22*** (0.21)	−1.42*** (0.35)	−1.63*** (0.32)
Arronsam	−1.31*** (0.27)	−1.40*** (0.26)	−1.46*** (0.44)	−1.65*** (0.42)
Arronsonsoro	−0.09 (0.34)	−0.11 (0.35)	0.26 (0.53)	0.22 (0.54)
Arrontobre	0.96*** (0.25)	0.84*** (0.24)	1.36*** (0.31)	1.14*** (0.26)
Constant	3.60*** (1.03)	4.05*** (0.95)	4.68*** (1.65)	5.57*** (1.53)
Observations	1255	1255	1255	1255
R squared.	0.15	0.15	0.16	0.14
Weak instruments		500.67***		500.67***
Wu-Hausman test		3.36*		6.45**

*p<0.1; **p<0.05; ***p<0.01

Table 3: OLS and IV Regression results

	Dietary quality for last 24H			
	Dietary Diversity(OLS)	Dietary Diversity(IV)	vitamin A-rich foods(OLS)	vitamin A-rich foods(IV)
	(1)	(2)	(3)	(4)
Organic	−0.38* (0.20)	−0.31* (0.18)	−0.10 (0.10)	−0.13 (0.20)
Gender (male)	−0.18 (0.22)	−0.17 (0.23)	0.11 (0.09)	0.11 (0.11)
Age of household head	0.01 (0.01)	0.01 (0.01)	0.004 (0.01)	0.004 (0.01)
Years of education	0.05** (0.02)	0.05** (0.02)	0.04*** (0.01)	0.04*** (0.01)
Literacy	0.27 (0.23)	0.26 (0.23)	0.06 (0.09)	0.06 (0.08)
Experience in agriculture	−0.02** (0.01)	−0.02** (0.01)	−0.01 (0.01)	−0.01 (0.01)
Household size	0.03 (0.02)	0.03 (0.02)	0.004 (0.02)	0.004 (0.02)
Dependency ratio	−0.16 (0.25)	−0.15 (0.25)	−0.004 (0.14)	−0.004 (0.13)
asinh(Total land owned (ha))	0.32** (0.15)	0.33** (0.15)	0.18** (0.07)	0.18** (0.07)
Distance to closest market	0.09*** (0.02)	0.09*** (0.02)	0.04** (0.02)	0.04** (0.02)
Tarred road	−0.22 (0.13)	−0.23 (0.16)	−0.13 (0.24)	−0.13 (0.26)
Distance to health facility	−0.09*** (0.02)	−0.09*** (0.02)	−0.07*** (0.01)	−0.07*** (0.01)
log(Household assets (million FCFA))	0.09 (0.07)	0.09 (0.07)	0.11** (0.05)	0.11** (0.04)
log(Working Capital (million FCFA))	−0.10** (0.05)	−0.10** (0.05)	−0.03 (0.02)	−0.03 (0.02)
Arronangaradebou	0.48** (0.21)	0.49** (0.23)	−0.19 (0.24)	−0.20 (0.26)
Arronbensekou	−0.21 (0.25)	−0.19 (0.28)	−0.66*** (0.25)	−0.66** (0.29)
Arrondonwari	0.93*** (0.23)	0.91*** (0.21)	0.23 (0.18)	0.23 (0.15)
Arrongnemasson	−0.72*** (0.08)	−0.70*** (0.08)	−0.91*** (0.05)	−0.91*** (0.06)
Arronkand2	1.79*** (0.17)	1.82*** (0.18)	0.62*** (0.10)	0.61*** (0.15)
ArronKandi1	−0.15 (0.16)	−0.13 (0.18)	−0.31*** (0.09)	−0.32** (0.13)
Arronkandi3	0.73*** (0.23)	0.75*** (0.24)	0.41*** (0.12)	0.40*** (0.15)
Arronkassakou	1.18*** (0.19)	1.20*** (0.22)	0.54*** (0.17)	0.53** (0.21)
Arronpehunco	0.18* (0.11)	0.19** (0.10)	−0.41*** (0.05)	−0.42*** (0.06)
Arronsaah	−0.16 (0.16)	−0.14 (0.17)	−0.49*** (0.09)	−0.50*** (0.10)
Arronsam	1.43*** (0.20)	1.44*** (0.21)	−0.05 (0.11)	−0.06 (0.12)
Arronsonsoro	0.96*** (0.20)	0.96*** (0.20)	−0.06 (0.13)	−0.07 (0.14)
Arrontobre	0.43*** (0.12)	0.45*** (0.13)	−0.06 (0.07)	−0.07 (0.08)
Constant	5.52*** (0.86)	5.46*** (0.81)	0.91* (0.48)	0.94** (0.45)
Observations	1255	1255	1255	1255
R squared.	0.12	0.12	0.15	0.15
Weak instruments		500.67***		500.67***
Wu-Hausman test		0.08		0.04

*p<0.1; **p<0.05; ***p<0.01

Table 4: OLS and IV Regression results

	Dietary quality for last 7 days			
	Dietary Diversity(OLS)	Dietary Diversity(IV)	vitamin A-rich foods(OLS)	vitamin A-rich foods(IV)
	(1)	(2)	(3)	(4)
Organic	0.12 (0.25)	0.42* (0.22)	0.18*** (0.05)	−0.12 (0.19)
Gender (male)	−0.11 (0.17)	−0.06 (0.17)	0.07 (0.15)	0.02 (0.18)
Age of household head	0.003 (0.01)	0.003 (0.01)	0.01 (0.01)	0.01 (0.01)
Years of education	0.05* (0.03)	0.05* (0.03)	0.03 (0.02)	0.03 (0.02)
Literacy	0.29 (0.20)	0.29 (0.19)	0.09 (0.09)	0.09 (0.09)
Experience in agriculture	−0.02* (0.01)	−0.02** (0.01)	−0.01*** (0.005)	−0.01*** (0.01)
Household size	0.03** (0.01)	0.03** (0.01)	0.01 (0.01)	0.01 (0.01)
Dependency ratio	−0.20 (0.22)	−0.19 (0.23)	−0.16 (0.11)	−0.17 (0.11)
asinh(Total land owned (ha))	0.10 (0.16)	0.12 (0.15)	0.14* (0.07)	0.12* (0.06)
Distance to closest market	0.03* (0.02)	0.04** (0.02)	0.02 (0.02)	0.02 (0.02)
Tarred road	−0.45** (0.20)	−0.49** (0.22)	−0.16 (0.26)	−0.13 (0.25)
Distance to health facility	−0.02 (0.02)	−0.03* (0.02)	−0.04*** (0.01)	−0.03*** (0.01)
log(Household assets (million FCFA))	0.06 (0.05)	0.07* (0.04)	0.12*** (0.02)	0.11*** (0.02)
log(Working Capital (million FCFA))	0.03 (0.05)	0.03 (0.05)	0.01 (0.02)	0.01 (0.02)
Arronangaradebou	−1.09*** (0.28)	−1.05*** (0.30)	−1.20*** (0.25)	−1.24*** (0.24)
Arronbensekou	−1.42*** (0.30)	−1.34*** (0.33)	−1.26*** (0.28)	−1.34*** (0.29)
Arrondonwari	−0.27 (0.32)	−0.32 (0.31)	−0.57*** (0.19)	−0.52*** (0.17)
Arrongnemasson	−0.56*** (0.09)	−0.50*** (0.07)	−0.98*** (0.06)	−1.04*** (0.04)
Arronkand2	0.88*** (0.22)	0.98*** (0.21)	0.56*** (0.09)	0.46*** (0.10)
ArronKandi1	−1.42*** (0.17)	−1.34*** (0.19)	−0.81*** (0.10)	−0.89*** (0.11)
Arronkandi3	−0.21 (0.28)	−0.13 (0.29)	−0.24 (0.15)	−0.32** (0.15)
Arronkassakou	−0.64** (0.25)	−0.55** (0.27)	−0.43** (0.17)	−0.52*** (0.17)
Arronpehunco	−0.26** (0.11)	−0.20* (0.11)	−0.66*** (0.06)	−0.71*** (0.04)
Arronsaah	−2.01*** (0.15)	−1.95*** (0.15)	−1.92*** (0.11)	−1.98*** (0.10)
Arronsam	−1.42*** (0.21)	−1.36*** (0.21)	−1.38*** (0.13)	−1.44*** (0.11)
Arronsonsoro	−0.58** (0.25)	−0.57** (0.25)	−0.99*** (0.15)	−1.01*** (0.14)
Arrontobre	−0.41*** (0.11)	−0.34*** (0.10)	−0.55*** (0.06)	−0.61*** (0.06)
Constant	8.14*** (0.67)	7.88*** (0.56)	2.30*** (0.24)	2.55*** (0.27)
Observations	1255	1255	1255	1255
R squared.	0.16	0.16	0.23	0.22
Weak instruments		500.67***		500.67***
Wu-Hausman test		2.11		4.33**

*p<0.1; **p<0.05; ***p<0.01

Table 5: Sensitivity analysis

Outcomes	1.25R	R+(R-Rs)	1	Confidence Interval
HFIESFAO	[0.33;0.32]	[0.34;0.32]	[0.48;0.32]	[-0.03;0.68]
HFIESAS	[0.21;0.20]	[0.25;0.20]	[0.48;0.20]	[-0.32;0.72]
Dietary Diversity 24 hours	[-0.38;-0.37]	[-0.38;-0.32]	[-0.38;0.077]	[-0.69;-0.077]
Diet rich in vitamin A 24 hours	[-0.096;-0.061]	[-0.096;-0.061]	[-0.096;0.11]	[-0.29;0.097]
Dietary Diversity 7 days	[0.12;0.12]	[0.12;0.14]	[0.12;0.26]	[-0.15;0.38]
Diet rich in vitamin A 7 days	[0.18;0.24]	[0.18;0.24]	[0.18;0.42]	[-0.0019;0.36]

tigate the effect of organic farming on mid and moderate food insecure households.[3]The results also show no significant effect of organic farming on mid and moderate food insecure households as with our FAO household food insecurity experienced scale indicators. Fifth, we estimate equation 9 by endogenous treatment effect model that assumes a normal distribution of the error term and is estimated using a non-linear maximization of the log-likelihood function using an iterative method. Reportedly, our treatment regression estimates are consistent with our IV estimates (table 19). Specifically, organic farming only affects both dietary quality indicators namely dietary diversity and vitamin A rich foods over a period of 7 days hours with about 1.06 and 0.33 gains respectively.

5 Concluding remarks

Our study adds to the very few existing studies on the micro-level effect of sustainability standards (Schleifer and Sun, 2020; Meemken et al., 2017; Chiputwa and Qaim, 2016) on food and nutrition security and particularly documents the first contribution to literature of the organic farming effect on rural household food and nutrition security. Using FAO food insecurity experience scale and extended HFIES, FAO household dietary diversity score and food groups rich in vitamin A over 24 hours and 7 days, we investigate the effects of organic farming on household food and nutrition security. Our hypothesis is that organic farming could produce healthy and diversified foods which in turn can improve household food insecurity to some extent and more dietary diversity. First,

[3]Given that we only have 47 households that fall within the category of severely food insecure households, of whom 10 are organic households, our regression analysis could not estimate the effect of organic farming among severely food insecure households.

Gender (male)	−0.46	−0.45	−0.52	−0.52	−0.53	−0.48
Age of household head	0.01	0.01	0.01	0.01	0.01	0.01
Years of education	0.01	0.01	0.01	0.004	0.01	0.01
Literacy	0.25	0.26	0.27	0.28	0.26	0.28
Experience in agriculture	0.01	0.01	0.01	0.01	0.01	0.01
Household size	−0.002	0.004	0.001	0.0005	0.001	−0.004
Dependency ratio	0.05	0.05	0.01	0.02	0.03	−0.03
asinh(Total land owned (ha))	−0.39	−0.40	−0.37	−0.38	−0.36	−0.38
Distance to closest market	−0.01	−0.01	−0.02	−0.02	−0.02	−0.01
Tarred road	−0.10	−0.11	−0.09	−0.08	−0.11	−0.04
log(Household assets (million FCFA))	0.04	0.05	0.05	0.05	0.05	0.05
log(Working Capital (million FCFA))	−0.003	0.002	0.004	−0.01	−0.001	0.001
Distance to health facility	0.05	0.05	0.05	0.05	0.05	0.04
Arronangaradebou	0.45	0.43	0.47	0.45	0.47	0.39
Arronbensekou	0.16	0.15	0.15	0.11	0.15	−0.01
Arrondonwari	−0.38	−0.39	−0.32	−0.32	−0.29	−0.34
Arrongnemasson	−4.74	−4.70	−4.78	−4.74	−4.82	−4.48
Arronkand2	−4.75	−4.71	−4.85	−4.81	−4.74	−4.53
ArronKandi1	−4.50	−4.54	−4.65	−4.65	−4.67	−4.52
Arronkandi3	−4.89	−4.85	−4.90	−4.90	−4.82	−4.62
Arronkassakou	−4.96	−4.97	−5.02	−5.05	−4.99	−4.75
Arronpehunco	−0.61	−0.63	−0.58	−0.59	−0.60	−0.66
Arronsaah	−4.69	−4.65	−4.71	−4.72	−4.67	−4.52
Arronsam	−4.74	−4.74	−4.88	−4.93	−4.74	−4.83
Arronsonsoro	−0.27	−0.28	−0.22	−0.24	−0.20	−0.32
Arrontobre	−0.44	−0.46	−0.40	−0.39	−0.43	−0.36
Share of Organic household	0.12	0.12	0.11	0.11	0.11	0.11
Organic	−0.19	−0.19	−0.30	−0.17	0.46	−0.35
Gender (male)	−0.46	−0.45	−0.52	−0.52	−0.53	−0.48
Age of household head	0.01	0.01	0.01	0.01	0.01	0.01
Years of education	0.01	0.01	0.01	0.004	0.01	0.01
Literacy	0.25	0.26	0.27	0.28	0.26	0.28
Experience in agriculture	0.01	0.01	0.01	0.01	0.01	0.01
Household size	−0.002	0.004	0.001	0.0005	0.001	−0.004
Dependency ratio	0.05	0.05	0.01	0.02	0.03	−0.03
asinh(Total land owned (ha))	−0.39	−0.40	−0.37	−0.38	−0.36	−0.38
Distance to closest market	−0.01	−0.01	−0.02	−0.02	−0.02	−0.01
Tarred road	−0.10	−0.11	−0.09	−0.08	−0.11	−0.04
log(Household assets (million FCFA))	0.04	0.05	0.05	0.05	0.05	0.05
log(Working Capital (million FCFA))	−0.003	0.002	0.004	−0.01	−0.001	0.001
Distance to health facility	0.05	0.05	0.05	0.05	0.05	0.04
Arronangaradebou	0.45	0.43	0.47	0.45	0.47	0.39
Arronbensekou	0.16	0.15	0.15	0.11	0.15	−0.01
Arrondonwari	−0.38	−0.39	−0.32	−0.32	−0.29	−0.34
Arrongnemasson	−4.74	−4.70	−4.78	−4.74	−4.82	−4.48
Arronkand2	−4.75	−4.71	−4.85	−4.81	−4.74	−4.53
ArronKandi1	−4.50	−4.54	−4.65	−4.65	−4.67	−4.52
Arronkandi3	−4.89	−4.85	−4.90	−4.90	−4.82	−4.62
Arronkassakou	−4.96	−4.97	−5.02	−5.05	−4.99	−4.75
Arronpehunco	−0.61	−0.63	−0.58	−0.59	−0.60	−0.66
Arronsaah	−4.69	−4.65	−4.71	−4.72	−4.67	−4.52
Arronsam	−4.74	−4.74	−4.88	−4.93	−4.74	−4.83

we do not observe any significant effect of organic farming on both indicators measuring food insecurity, that is food insecurity experienced scales. Second, organic households depict only significant positive returns of about 1.05 and 0.28 on the dietary diversity score and vitamin A rich foods over 7 days respectively. The results thus imply that the effects of organic farming on dietary quality is observed in the long run. From a behavioral perspective, the results suggest that policies that promote organic farming would help to sustain rural household food and nutrition security.

Furthermore, as our study relies on cross-sectional data, which is not sufficient to solve endogeneity problems in our empirical analyses, we cannot claim that we investigate the causal effect of organic farming on food and nutrition security. We then advise future studies to use our results as a starting contribution to the literature in the field of the food and nutrition security implications associated to organic standards. Given this limitation, we recommend further studies to use panel data to estimate the causal effects of organic farming on food and nutrition security.

Acknowledgment

We gratefully acknowledge the financial support provided by the Ministry of Foreign Affairs of Denmark (Grant: 14-02KU). The authors would like to thank Michael Carter for his comments and suggestions on the identification strategy of this article. Of course, the authors take full responsibility for any remaining errors.

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Supplemental appendix

A Additional Tables

Additional tables are presented on the following pages.

A.1 Di Falco et al. (2011) falsification test

Table 7: OLS Regression results

	Food and nutrition security indicators					
	HFIESFAO	HFIES	HDDS24H	VitA 24H	HDDS7D	VitA 7D
	(1)	(2)	(3)	(4)	(5)	(6)
Share of Organic household	−0.01 (0.02)	−0.01 (0.02)	0.01 (0.01)	0.003 (0.01)	0.01 (0.02)	−0.01 (0.01)
Gender (male)	0.28 (0.25)	0.41 (0.35)	−0.01 (0.28)	0.16 (0.13)	0.01 (0.21)	0.10 (0.20)
Age of household head	−0.02*** (0.01)	−0.03** (0.01)	0.01 (0.01)	0.01 (0.01)	0.002 (0.01)	0.01 (0.01)
Years of education	−0.04 (0.03)	−0.06 (0.06)	0.06** (0.03)	0.04** (0.02)	0.07*** (0.02)	0.03* (0.02)
Literacy	0.21 (0.21)	0.34 (0.28)	0.32 (0.29)	0.09 (0.10)	0.26 (0.29)	0.14 (0.11)
Experience in agriculture	0.03*** (0.01)	0.04** (0.02)	−0.02 (0.01)	−0.01* (0.01)	−0.01 (0.01)	−0.01** (0.005)
Household size	0.03 (0.03)	0.05 (0.05)	0.03 (0.03)	−0.01 (0.02)	0.03* (0.02)	−0.0003 (0.01)
Dependency ratio	0.27 (0.35)	0.40 (0.68)	−0.14 (0.33)	0.11 (0.19)	−0.23 (0.21)	−0.19 (0.16)
asinh(Total land owned (ha))	−0.78*** (0.16)	−1.09*** (0.27)	0.31* (0.17)	0.20** (0.10)	0.05 (0.18)	0.15* (0.09)
Distance to closest market	−0.07** (0.03)	−0.11*** (0.04)	0.11*** (0.02)	0.05** (0.02)	0.04** (0.02)	0.03* (0.02)
Tarred road	0.06 (0.32)	0.14 (0.44)	−0.11 (0.23)	−0.14 (0.32)	−0.45* (0.23)	−0.16 (0.31)
Distance to health facility	0.07** (0.04)	0.12** (0.05)	−0.09*** (0.03)	−0.07*** (0.02)	−0.02 (0.02)	−0.04*** (0.01)
log(Household assets (million FCFA))	−0.10 (0.11)	−0.16 (0.17)	0.07 (0.09)	0.11** (0.05)	0.08* (0.05)	0.11*** (0.02)
log(Working Capital (million FCFA))	0.15 (0.11)	0.24 (0.17)	−0.12** (0.06)	−0.04 (0.03)	0.004 (0.05)	0.01 (0.03)
Arronangaradebou	−0.74* (0.39)	−0.78 (0.62)	0.33 (0.32)	−0.23 (0.35)	−1.06*** (0.30)	−1.20*** (0.27)
Arronbensekou	0.35 (0.40)	0.86 (0.64)	−0.36 (0.37)	−0.81** (0.37)	−1.28*** (0.39)	−1.43*** (0.34)
Arrondonwari	−0.71* (0.38)	−0.30 (0.63)	0.96*** (0.28)	0.32 (0.25)	−0.51* (0.28)	−0.40** (0.20)
Arrongnemasson	0.91*** (0.12)	1.81*** (0.15)	−0.66*** (0.07)	−0.88*** (0.07)	−0.51*** (0.10)	−1.00*** (0.05)
Arronkand2	1.45*** (0.25)	4.04*** (0.32)	1.88*** (0.22)	0.73*** (0.19)	0.88*** (0.20)	0.54*** (0.13)
ArronKandi1	1.18*** (0.30)	2.16*** (0.45)	−0.06 (0.20)	−0.27 (0.16)	−1.32*** (0.21)	−0.80*** (0.12)
Arronkandi3	1.04*** (0.32)	1.08** (0.50)	0.78*** (0.27)	0.46** (0.18)	−0.15 (0.31)	−0.26* (0.15)
Arronkassakou	−0.95** (0.38)	0.03 (0.58)	1.24*** (0.28)	0.59** (0.26)	−0.57* (0.30)	−0.42** (0.19)
Arronpehunco	0.78*** (0.13)	1.63*** (0.16)	0.25** (0.10)	−0.39*** (0.07)	−0.20 (0.14)	−0.70*** (0.06)
Arronsaah	−1.46*** (0.19)	−1.84*** (0.32)	−0.11 (0.19)	−0.47*** (0.11)	−1.95*** (0.15)	−1.90*** (0.09)
Arronsam	−1.57*** (0.24)	−1.80*** (0.41)	1.49*** (0.22)	−0.03 (0.13)	−1.32*** (0.23)	−1.38*** (0.12)
Arronsonsoro	−0.48* (0.24)	−0.23 (0.41)	1.05*** (0.23)	−0.01 (0.16)	−0.48** (0.24)	−0.94*** (0.15)
Arrontobre	0.48*** (0.18)	0.74*** (0.24)	0.56*** (0.12)	−0.01 (0.07)	−0.28*** (0.10)	−0.52*** (0.07)
Constant	4.64*** (1.15)	6.07*** (1.79)	5.79*** (0.75)	0.88* (0.49)	8.07*** (0.47)	2.43*** (0.36)
Observations	1030	1030	1030	1030	1030	1030
R squared.	0.14	0.15	0.12	0.15	0.17	0.24

*p<0.1; **p<0.05; ***p<0.01

A.2 Selection model : Probit estimation of organic farming adoption

Table 8: Probit regression results for adoption of organic farming

	Organic Organic Farming (Yes/No)
Gender (male)	−0.04 (1.24)
Age of household head	0.0004 (0.01)
Years of education	0.0002 (0.01)
Literacy	0.02 (0.55)
Experience in agriculture	0.0004 (0.02)
Household size	0.0001 (0.002)
Dependency ratio	0.001 (0.03)
asinh(Total land owned (ha))	−0.02 (0.65)
Distance to closest market	−0.001 (0.03)
Tarred road	−0.004 (0.15)
log(Household assets (million FCFA))	0.002 (0.09)
log(Working Capital (million FCFA))	−0.0003 (0.01)
Distance to health facility	0.002 (0.08)
Share of Organic household	0.01 (0.20)
Arronangaradebou	0.03 (1.04)
Arronbensekou	0.01 (0.26)
Arrondonwari	−0.01 (0.47)
Arrongnemasson	−0.03 (1.08)
Arronkand2	−0.02 (0.88)
ArronKandi1	−0.02 (0.92)
Arronkandi3	−0.02 (0.93)
Arronkassakou	−0.03 (1.03)
Arronpehunco	−0.02 (0.69)
Arronsaah	−0.03 (0.96)
Arronsam	−0.03 (0.99)
Arronsonsoro	−0.01 (0.35)
Arrontobre	−0.01 (0.53)
Observations	1,255
Log Likelihood	-311.16
Akaike Inf. Crit.	678.32
Note:	*p<0.1; **p<0.05; ***p<0.01

A.3 OLS and IV estimation with standardized dependent variables

Table 9: OLS and IV Regression results

	Standardised Household food insecurity experienced scales			
	Dietary Diversity(OLS)	Dietary Diversity(IV)	vitamin A-rich foods(OLS)	vitamin A-rich foods(IV)
	(1)	(2)	(3)	(4)
Organic	0.14 (0.25)	−0.08 (0.30)	0.06 (0.18)	−0.25 (0.17)
Gender (male)	0.05 (0.10)	0.01 (0.12)	0.05 (0.10)	−0.001 (0.12)
Age of household head	−0.01*** (0.003)	−0.01*** (0.003)	−0.01*** (0.004)	−0.01*** (0.003)
Years of education	−0.01 (0.01)	−0.01 (0.01)	−0.01 (0.01)	−0.01 (0.01)
Literacy	0.10 (0.11)	0.11 (0.11)	0.09 (0.12)	0.10 (0.11)
Experience in agriculture	0.01*** (0.004)	0.01*** (0.005)	0.01*** (0.004)	0.01*** (0.004)
Household size	0.02* (0.01)	0.02* (0.01)	0.02 (0.01)	0.02 (0.01)
Dependency ratio	0.18 (0.15)	0.17 (0.15)	0.17 (0.20)	0.16 (0.19)
asinh(Total land owned (ha))	−0.36*** (0.06)	−0.37*** (0.06)	−0.34*** (0.07)	−0.36*** (0.07)
Distance to closest market	−0.02** (0.01)	−0.03** (0.01)	−0.03*** (0.01)	−0.03*** (0.01)
Tarred road	−0.05 (0.23)	−0.03 (0.25)	−0.07 (0.20)	−0.03 (0.23)
Distance to health facility	0.02* (0.01)	0.03** (0.01)	0.02** (0.01)	0.03*** (0.01)
log(Household assets (million FCFA))	−0.02 (0.04)	−0.03 (0.05)	−0.02 (0.04)	−0.03 (0.04)
log(Working Capital (million FCFA))	0.08* (0.04)	0.07* (0.04)	0.08* (0.04)	0.08* (0.04)
Arronangaradebou	−0.03 (0.23)	−0.06 (0.25)	0.07 (0.22)	0.02 (0.24)
Arronbensekou	0.30 (0.25)	0.24 (0.28)	0.41 (0.25)	0.32 (0.28)
Arrondonwari	−0.07 (0.18)	−0.03 (0.18)	0.04 (0.19)	0.10 (0.19)
Arrongnemasson	0.58*** (0.09)	0.54*** (0.09)	0.69*** (0.09)	0.63*** (0.07)
Arronkand2	0.81*** (0.16)	0.74*** (0.19)	1.33*** (0.12)	1.23*** (0.14)
ArronKandi1	0.68*** (0.16)	0.62*** (0.16)	0.80*** (0.15)	0.71*** (0.15)
Arronkandi3	0.60*** (0.19)	0.54** (0.21)	0.46** (0.19)	0.37* (0.20)
Arronkassakou	−0.25 (0.22)	−0.32 (0.24)	0.16 (0.21)	0.07 (0.22)
Arronpehunco	0.52*** (0.09)	0.48*** (0.09)	0.62*** (0.09)	0.57*** (0.07)
Arronsaah	−0.49*** (0.10)	−0.53*** (0.09)	−0.43*** (0.10)	−0.49*** (0.09)
Arronsam	−0.57*** (0.12)	−0.61*** (0.11)	−0.44*** (0.13)	−0.49*** (0.13)
Arronsonsoro	−0.04 (0.15)	−0.05 (0.15)	0.08 (0.16)	0.07 (0.16)
Arrontobre	0.42*** (0.11)	0.37*** (0.10)	0.41*** (0.09)	0.34*** (0.08)
Constant	0.31 (0.45)	0.51 (0.42)	0.20 (0.49)	0.46 (0.46)
Observations	1255	1255	1255	1255
R squared.	0.15	0.15	0.16	0.14
Weak instruments		500.67***		500.67***
Wu-Hausman test		3.36*		6.45**

*p<0.1; **p<0.05; ***p<0.01

Table 10: OLS and IV Regression results

	Standardised Dietary quality for last 24 hours			
	Dietary Diversity(OLS)	Dietary Diversity(IV)	vitamin A-rich foods(OLS)	vitamin A-rich foods(IV)
	(1)	(2)	(3)	(4)
Organic	−0.20* (0.10)	−0.16* (0.09)	−0.08 (0.08)	−0.10 (0.16)
Gender (male)	−0.09 (0.12)	−0.09 (0.12)	0.09 (0.07)	0.09 (0.09)
Age of household head	0.003 (0.005)	0.003 (0.005)	0.004 (0.01)	0.004 (0.01)
Years of education	0.03** (0.01)	0.03** (0.01)	0.03*** (0.01)	0.03*** (0.01)
Literacy	0.14 (0.12)	0.14 (0.12)	0.05 (0.07)	0.05 (0.07)
Experience in agriculture	−0.01** (0.01)	−0.01** (0.01)	−0.01 (0.01)	−0.01 (0.005)
Household size	0.01 (0.01)	0.01 (0.01)	0.004 (0.01)	0.004 (0.01)
Dependency ratio	−0.08 (0.13)	−0.08 (0.13)	−0.003 (0.11)	−0.004 (0.11)
asinh(Total land owned (ha))	0.17** (0.08)	0.17** (0.07)	0.15** (0.06)	0.15** (0.06)
Distance to closest market	0.05*** (0.01)	0.05*** (0.01)	0.03** (0.02)	0.03** (0.02)
Tarred road	−0.11 (0.07)	−0.12 (0.08)	−0.10 (0.19)	−0.10 (0.21)
Distance to health facility	−0.05*** (0.01)	−0.05*** (0.01)	−0.06*** (0.01)	−0.06*** (0.01)
log(Household assets (million FCFA))	0.05 (0.04)	0.05 (0.04)	0.09** (0.04)	0.09** (0.04)
log(Working Capital (million FCFA))	−0.05** (0.02)	−0.05** (0.02)	−0.03 (0.02)	−0.03 (0.02)
Arronangaradebou	0.24** (0.11)	0.25** (0.12)	−0.16 (0.20)	−0.16 (0.21)
Arronbensekou	−0.11 (0.13)	−0.10 (0.15)	−0.53*** (0.20)	−0.53** (0.23)
Arrondonwari	0.48*** (0.12)	0.47*** (0.11)	0.18 (0.14)	0.19 (0.12)
Arrongnemasson	−0.37*** (0.04)	−0.36*** (0.04)	−0.73*** (0.04)	−0.73*** (0.05)
Arronkand2	0.92*** (0.09)	0.93*** (0.09)	0.50*** (0.08)	0.49*** (0.12)
ArronKandi1	−0.08 (0.08)	−0.07 (0.09)	−0.25*** (0.08)	−0.26** (0.11)
Arronkandi3	0.38*** (0.12)	0.39*** (0.13)	0.33*** (0.09)	0.32*** (0.12)
Arronkassakou	0.61*** (0.10)	0.62*** (0.11)	0.43*** (0.13)	0.43** (0.17)
Arronpehunco	0.09* (0.05)	0.10** (0.05)	−0.33*** (0.04)	−0.33*** (0.05)
Arronsaah	−0.08 (0.08)	−0.07 (0.09)	−0.40*** (0.08)	−0.40*** (0.08)
Arronsam	0.74*** (0.10)	0.74*** (0.11)	−0.04 (0.09)	−0.05 (0.09)
Arronsonsoro	0.49*** (0.10)	0.49*** (0.10)	−0.05 (0.11)	−0.05 (0.11)
Arrontobre	0.22*** (0.06)	0.23*** (0.07)	−0.05 (0.05)	−0.05 (0.06)
Constant	−0.64 (0.44)	−0.67 (0.42)	−1.34*** (0.38)	−1.32*** (0.36)
Observations	1255	1255	1255	1255
R squared.	0.12	0.12	0.15	0.15
Weak instruments		500.67***		500.67***
Wu-Hausman test		0.08		0.04

*p<0.1; **p<0.05; ***p<0.01

Table 11: OLS and IV Regression results

	Standardised Dietary quality for last 7 days			
	Dietary Diversity(OLS)	Dietary Diversity(IV)	vitamin A-rich foods(OLS)	vitamin A-rich foods(IV)
	(1)	(2)	(3)	(4)
Organic	0.07 (0.15)	0.25* (0.13)	0.15*** (0.04)	−0.10 (0.16)
Gender (male)	−0.06 (0.10)	−0.03 (0.10)	0.06 (0.12)	0.02 (0.14)
Age of household head	0.002 (0.01)	0.002 (0.01)	0.01 (0.004)	0.01 (0.004)
Years of education	0.03* (0.02)	0.03* (0.02)	0.02 (0.01)	0.02 (0.01)
Literacy	0.17 (0.12)	0.17 (0.11)	0.07 (0.07)	0.08 (0.07)
Experience in agriculture	−0.01* (0.01)	−0.01** (0.01)	−0.01*** (0.004)	−0.01*** (0.004)
Household size	0.02** (0.01)	0.02** (0.01)	0.01 (0.01)	0.01 (0.005)
Dependency ratio	−0.12 (0.13)	−0.11 (0.13)	−0.13 (0.09)	−0.14 (0.09)
asinh(Total land owned (ha))	0.06 (0.09)	0.07 (0.09)	0.11* (0.06)	0.10* (0.05)
Distance to closest market	0.02* (0.01)	0.02** (0.01)	0.02 (0.01)	0.01 (0.01)
Tarred road	−0.26** (0.11)	−0.29** (0.13)	−0.13 (0.21)	−0.10 (0.21)
Distance to health facility	−0.01 (0.01)	−0.02* (0.01)	−0.03*** (0.01)	−0.03*** (0.01)
log(Household assets (million FCFA))	0.04 (0.03)	0.04* (0.02)	0.10*** (0.02)	0.09*** (0.02)
log(Working Capital (million FCFA))	0.02 (0.03)	0.02 (0.03)	0.01 (0.02)	0.01 (0.02)
Arronangaradebou	−0.64*** (0.16)	−0.61*** (0.17)	−0.98*** (0.20)	−1.01*** (0.20)
Arronbensekou	−0.83*** (0.18)	−0.78*** (0.19)	−1.03*** (0.23)	−1.10*** (0.23)
Arrondonwari	−0.16 (0.19)	−0.19 (0.18)	−0.47*** (0.15)	−0.42*** (0.14)
Arrongnemasson	−0.33*** (0.05)	−0.29*** (0.04)	−0.80*** (0.05)	−0.85*** (0.03)
Arronkand2	0.52*** (0.13)	0.58*** (0.12)	0.46*** (0.07)	0.38*** (0.08)
ArronKandi1	−0.83*** (0.10)	−0.78*** (0.11)	−0.66*** (0.08)	−0.73*** (0.09)
Arronkandi3	−0.12 (0.16)	−0.08 (0.17)	−0.20 (0.12)	−0.26** (0.12)
Arronkassakou	−0.37** (0.15)	−0.32** (0.16)	−0.35** (0.14)	−0.42*** (0.14)
Arronpehunco	−0.15** (0.06)	−0.12* (0.06)	−0.54*** (0.05)	−0.58*** (0.03)
Arronsaah	−1.18*** (0.09)	−1.14*** (0.09)	−1.57*** (0.09)	−1.62*** (0.08)
Arronsam	−0.83*** (0.12)	−0.80*** (0.12)	−1.13*** (0.10)	−1.17*** (0.09)
Arronsonsoro	−0.34** (0.14)	−0.33** (0.14)	−0.81*** (0.12)	−0.82*** (0.12)
Arrontobre	−0.24*** (0.06)	−0.20*** (0.06)	−0.45*** (0.05)	−0.50*** (0.05)
Constant	−0.55 (0.39)	−0.71** (0.33)	−1.34*** (0.20)	−1.13*** (0.22)
Observations	1255	1255	1255	1255
R squared.	0.16	0.16	0.23	0.22
Weak instruments		500.67***		500.67***
Wu-Hausman test		2.11		4.33**
Note:				*p<0.1; **p<0.05; ***p<0.01

A.4 OLS and IV estimation with household members categories

Table 12: IV Regression results

	Household food Insecurity experienced scale			
	HFIESFAO(OLS)	HFIESFAO(IV)	HFIES(OLS)	HFIES(IV)
	(1)	(2)	(3)	(4)
Organic	0.33 (0.57)	−0.19 (0.68)	0.20 (0.61)	−0.86 (0.55)
Gender (male)	0.12 (0.23)	0.04 (0.26)	0.18 (0.32)	0.003 (0.38)
Age of household head	−0.02** (0.01)	−0.02** (0.01)	−0.03** (0.02)	−0.03** (0.02)
Years of education	−0.03 (0.03)	−0.03 (0.03)	−0.03 (0.05)	−0.02 (0.05)
Literacy	0.23 (0.26)	0.24 (0.25)	0.29 (0.39)	0.32 (0.36)
Experience in agriculture	0.03*** (0.01)	0.03*** (0.01)	0.04*** (0.01)	0.04*** (0.02)
Number aged 0-14	0.07* (0.04)	0.07* (0.04)	0.09 (0.06)	0.09 (0.05)
Number aged 15-35	0.04 (0.04)	0.04 (0.04)	0.06 (0.05)	0.07 (0.05)
Number aged 36-65	0.02 (0.12)	0.02 (0.12)	0.01 (0.19)	0.01 (0.20)
Number aged $\geq$ 66	0.13 (0.37)	0.14 (0.37)	0.31 (0.56)	0.34 (0.56)
asinh(Total land owned (ha))	−0.82*** (0.14)	−0.85*** (0.13)	−1.14*** (0.24)	−1.20*** (0.22)
Distance to closest market	−0.05* (0.03)	−0.06** (0.03)	−0.10*** (0.03)	−0.10*** (0.03)
Tarred road	−0.12 (0.52)	−0.06 (0.57)	−0.23 (0.68)	−0.10 (0.77)
Distance to health facility	0.05* (0.03)	0.06** (0.03)	0.08** (0.04)	0.10*** (0.04)
log(Household assets (million FCFA))	−0.05 (0.10)	−0.07 (0.10)	−0.08 (0.13)	−0.12 (0.14)
log(Working Capital (million FCFA))	0.17* (0.10)	0.17* (0.10)	0.26* (0.14)	0.26* (0.14)
Arronangaradebou	−0.07 (0.52)	−0.14 (0.56)	0.23 (0.73)	0.08 (0.80)
Arronbensekou	0.68 (0.60)	0.54 (0.67)	1.34 (0.88)	1.06 (0.98)
Arrondonwari	−0.17 (0.41)	−0.08 (0.40)	0.13 (0.65)	0.32 (0.64)
Arrongnemasson	1.31*** (0.17)	1.20*** (0.16)	2.26*** (0.24)	2.03*** (0.19)
Arronkand2	1.83*** (0.35)	1.66*** (0.44)	4.42*** (0.42)	4.06*** (0.54)
ArronKandi1	1.57*** (0.33)	1.42*** (0.36)	2.67*** (0.49)	2.37*** (0.50)
Arronkandi3	1.37*** (0.45)	1.24** (0.49)	1.51** (0.64)	1.24* (0.69)
Arronkassakou	−0.60 (0.49)	−0.76 (0.54)	0.47 (0.69)	0.17 (0.75)
Arronpehunco	1.16*** (0.17)	1.06*** (0.18)	2.04*** (0.24)	1.84*** (0.22)
Arronsaah	−1.12*** (0.23)	−1.21*** (0.21)	−1.40*** (0.35)	−1.60*** (0.32)
Arronsam	−1.30*** (0.25)	−1.39*** (0.25)	−1.44*** (0.44)	−1.63*** (0.44)
Arronsonsoro	−0.10 (0.34)	−0.12 (0.34)	0.26 (0.52)	0.22 (0.53)
Arrontobre	0.94*** (0.22)	0.83*** (0.22)	1.33*** (0.29)	1.10*** (0.26)
Constant	3.81*** (1.09)	4.27*** (1.01)	4.99*** (1.80)	5.91*** (1.66)
Observations	1255	1255	1255	1255
R squared.	0.15	0.15	0.16	0.14
Weak instruments		502.42***		502.42***
Wu-Hausman test		3.36*		6.59**

*p<0.1; **p<0.05; ***p<0.01

Table 13: IV Regression results

	Dietary quality for last 24 hours			
	Dietary Diversity(OLS)	Dietary Diversity(IV)	vitamin A-rich foods(OLS)	vitamin A-rich foods(IV)
	(1)	(2)	(3)	(4)
Organic	−0.38* (0.20)	−0.33* (0.19)	−0.10 (0.10)	−0.14 (0.20)
Gender (male)	−0.19 (0.23)	−0.18 (0.23)	0.12 (0.09)	0.11 (0.11)
Age of household head	0.005 (0.01)	0.005 (0.01)	0.004 (0.01)	0.004 (0.01)
Years of education	0.06** (0.02)	0.05** (0.02)	0.04*** (0.01)	0.04*** (0.01)
Literacy	0.27 (0.23)	0.26 (0.23)	0.05 (0.08)	0.05 (0.08)
Experience in agriculture	−0.02** (0.01)	−0.02** (0.01)	−0.01 (0.01)	−0.01 (0.01)
Number aged 0-14	0.02 (0.02)	0.02 (0.02)	0.003 (0.02)	0.003 (0.02)
Number aged 15-35	0.01 (0.03)	0.01 (0.03)	0.01 (0.02)	0.01 (0.02)
Number aged 36-65	0.07 (0.06)	0.07 (0.06)	−0.01 (0.03)	−0.01 (0.03)
Number aged $\geq$ 66	0.04 (0.20)	0.04 (0.20)	0.11 (0.13)	0.11 (0.13)
asinh(Total land owned (ha))	0.33** (0.15)	0.33** (0.15)	0.18** (0.07)	0.18** (0.07)
Distance to closest market	0.09*** (0.02)	0.09*** (0.02)	0.04** (0.02)	0.04** (0.02)
Tarred road	−0.21 (0.14)	−0.22 (0.16)	−0.13 (0.24)	−0.12 (0.25)
Distance to health facility	−0.09*** (0.02)	−0.09*** (0.02)	−0.07*** (0.01)	−0.07*** (0.01)
log(Household assets (million FCFA))	0.10 (0.07)	0.10 (0.07)	0.11** (0.05)	0.11** (0.04)
log(Working Capital (million FCFA))	−0.10** (0.05)	−0.10** (0.05)	−0.03 (0.02)	−0.03 (0.02)
Arronangaradebou	0.48** (0.22)	0.49** (0.24)	−0.19 (0.25)	−0.19 (0.26)
Arronbensekou	−0.21 (0.27)	−0.19 (0.31)	−0.67*** (0.25)	−0.68** (0.29)
Arrondonwari	0.94*** (0.25)	0.93*** (0.22)	0.23 (0.18)	0.23 (0.15)
Arrongnemasson	−0.68*** (0.10)	−0.66*** (0.10)	−0.91*** (0.05)	−0.92*** (0.07)
Arronkand2	1.87*** (0.21)	1.89*** (0.23)	0.63*** (0.12)	0.62*** (0.17)
ArronKandi1	−0.13 (0.16)	−0.12 (0.19)	−0.31*** (0.10)	−0.32** (0.13)
Arronkandi3	0.73*** (0.23)	0.75*** (0.26)	0.40*** (0.12)	0.39** (0.15)
Arronkassakou	1.21*** (0.20)	1.22*** (0.24)	0.53*** (0.17)	0.52** (0.21)
Arronpehunco	0.21* (0.12)	0.22* (0.11)	−0.41*** (0.06)	−0.41*** (0.07)
Arronsaah	−0.17 (0.15)	−0.16 (0.16)	−0.48*** (0.09)	−0.49*** (0.10)
Arronsam	1.44*** (0.20)	1.45*** (0.21)	−0.05 (0.11)	−0.06 (0.12)
Arronsonsoro	0.96*** (0.21)	0.97*** (0.21)	−0.06 (0.13)	−0.06 (0.14)
Arrontobre	0.46*** (0.13)	0.47*** (0.15)	−0.06 (0.07)	−0.07 (0.08)
Constant	5.44*** (0.91)	5.39*** (0.86)	0.89* (0.45)	0.92** (0.41)
Observations	1255	1255	1255	1255
R squared.	0.12	0.12	0.15	0.15
Weak instruments		502.42***		502.42***
Wu-Hausman test		0.05		0.06

*p<0.1; **p<0.05; ***p<0.01

Table 14: IV Regression results

	Dietary quality for last seven days			
	Dietary Diversity(OLS)	Dietary Diversity(IV)	vitamin A-rich foods(OLS)	vitamin A-rich foods(IV)
	(1)	(2)	(3)	(4)
Organic	0.12 (0.25)	0.41* (0.22)	0.18*** (0.05)	−0.13 (0.19)
Gender (male)	−0.12 (0.17)	−0.07 (0.18)	0.07 (0.14)	0.02 (0.17)
Age of household head	0.002 (0.01)	0.002 (0.01)	0.01* (0.01)	0.01* (0.01)
Years of education	0.05** (0.03)	0.05* (0.03)	0.03 (0.02)	0.03 (0.02)
Literacy	0.29 (0.20)	0.29 (0.19)	0.09 (0.09)	0.10 (0.09)
Experience in agriculture	−0.02* (0.01)	−0.02** (0.01)	−0.01*** (0.005)	−0.01** (0.01)
Number aged 0-14	0.02 (0.02)	0.02 (0.02)	0.004 (0.01)	0.003 (0.01)
Number aged 15-35	0.03 (0.03)	0.03 (0.03)	0.004 (0.01)	0.01 (0.01)
Number aged 36-65	0.07* (0.04)	0.07* (0.04)	0.01 (0.04)	0.01 (0.03)
Number aged $\geq$ 66	−0.04 (0.12)	−0.05 (0.12)	−0.11 (0.09)	−0.11 (0.09)
asinh(Total land owned (ha))	0.11 (0.16)	0.12 (0.15)	0.14* (0.07)	0.12* (0.06)
Distance to closest market	0.03* (0.02)	0.04** (0.02)	0.02 (0.02)	0.02 (0.02)
Tarred road	−0.45** (0.20)	−0.48** (0.22)	−0.16 (0.26)	−0.13 (0.25)
Distance to health facility	−0.02 (0.01)	−0.03* (0.01)	−0.04*** (0.01)	−0.03*** (0.01)
log(Household assets (million FCFA))	0.06 (0.05)	0.07* (0.04)	0.13*** (0.02)	0.11*** (0.02)
log(Working Capital (million FCFA))	0.03 (0.05)	0.03 (0.05)	0.01 (0.02)	0.01 (0.02)
Arronangaradebou	−1.09*** (0.28)	−1.05*** (0.30)	−1.20*** (0.25)	−1.25*** (0.24)
Arronbensekou	−1.40*** (0.31)	−1.33*** (0.34)	−1.26*** (0.29)	−1.34*** (0.29)
Arrondonwari	−0.26 (0.32)	−0.31 (0.31)	−0.57*** (0.19)	−0.51*** (0.17)
Arrongnemasson	−0.53*** (0.10)	−0.47*** (0.10)	−0.95*** (0.06)	−1.02*** (0.05)
Arronkand2	0.92*** (0.25)	1.02*** (0.24)	0.57*** (0.11)	0.47*** (0.12)
ArronKandi1	−1.42*** (0.18)	−1.34*** (0.19)	−0.81*** (0.11)	−0.90*** (0.12)
Arronkandi3	−0.20 (0.28)	−0.13 (0.28)	−0.25* (0.15)	−0.33** (0.15)
Arronkassakou	−0.61** (0.26)	−0.53* (0.29)	−0.41** (0.17)	−0.50*** (0.18)
Arronpehunco	−0.23** (0.12)	−0.18 (0.12)	−0.65*** (0.07)	−0.70*** (0.05)
Arronsaah	−2.02*** (0.15)	−1.97*** (0.15)	−1.93*** (0.11)	−1.99*** (0.09)
Arronsam	−1.42*** (0.21)	−1.37*** (0.21)	−1.40*** (0.13)	−1.45*** (0.12)
Arronsonsoro	−0.58** (0.25)	−0.57** (0.25)	−1.00*** (0.15)	−1.01*** (0.14)
Arrontobre	−0.39*** (0.12)	−0.32*** (0.11)	−0.54*** (0.07)	−0.61*** (0.07)
Constant	8.06*** (0.65)	7.81*** (0.56)	2.14*** (0.21)	2.41*** (0.24)
Observations	1255	1255	1255	1255
R squared.	0.16	0.16	0.23	0.22
Weak instruments		502.42***		502.42***
Wu-Hausman test		1.89		4.55**

*p<0.1; **p<0.05; ***p<0.01

A.5 OLS and IV excluding data from the district of Pehunco

Table 15: OLS and IV Regression results

	Household food insecurity experienced scales			
	HFIESFAO(OLS)	HFIESFAO(IV)	HFIES(OLS)	HFIES(IV)
	(1)	(2)	(3)	(4)
Organic	0.32 (0.56)	−0.19 (0.68)	0.20 (0.61)	−0.84 (0.56)
Gender (male)	0.12 (0.23)	0.03 (0.27)	0.17 (0.33)	−0.003 (0.39)
Age of household head	−0.02*** (0.01)	−0.02*** (0.01)	−0.03*** (0.01)	−0.03*** (0.01)
Years of education	−0.03 (0.03)	−0.03 (0.03)	−0.03 (0.05)	−0.02 (0.05)
Literacy	0.23 (0.26)	0.24 (0.25)	0.29 (0.39)	0.32 (0.36)
Experience in agriculture	0.03*** (0.01)	0.03*** (0.01)	0.04*** (0.01)	0.04*** (0.01)
Household size	0.05* (0.03)	0.05* (0.03)	0.06 (0.04)	0.06 (0.04)
Dependency ratio	0.41 (0.34)	0.39 (0.33)	0.56 (0.66)	0.54 (0.65)
asinh(Total land owned (ha))	−0.82*** (0.14)	−0.85*** (0.13)	−1.14*** (0.23)	−1.19*** (0.22)
Distance to closest market	−0.05** (0.03)	−0.06** (0.03)	−0.10*** (0.03)	−0.10*** (0.03)
Tarred road	−0.13 (0.52)	−0.06 (0.57)	−0.23 (0.67)	−0.10 (0.76)
Distance to health facility	0.05* (0.03)	0.06** (0.03)	0.08** (0.03)	0.10*** (0.03)
log(Household assets (million FCFA))	−0.05 (0.10)	−0.07 (0.10)	−0.08 (0.13)	−0.11 (0.14)
log(Working Capital (million FCFA))	0.17* (0.10)	0.17* (0.10)	0.26* (0.14)	0.26* (0.14)
Arronangaradebou	−0.06 (0.53)	−0.14 (0.57)	0.23 (0.74)	0.07 (0.79)
Arronbensekou	0.68 (0.58)	0.55 (0.65)	1.36 (0.85)	1.08 (0.94)
Arrondonwari	−0.16 (0.41)	−0.07 (0.40)	0.15 (0.65)	0.34 (0.64)
Arrongnemasson	1.33*** (0.22)	1.23*** (0.20)	2.31*** (0.29)	2.09*** (0.22)
Arronkand2	1.85*** (0.37)	1.68*** (0.43)	4.46*** (0.41)	4.11*** (0.47)
ArronKandi1	1.57*** (0.36)	1.42*** (0.37)	2.67*** (0.51)	2.37*** (0.50)
Arronkandi3	1.38*** (0.44)	1.25** (0.48)	1.53** (0.63)	1.25* (0.67)
Arronkassakou	−0.58 (0.50)	−0.73 (0.55)	0.53 (0.69)	0.23 (0.75)
Arronpehunco	1.19*** (0.22)	1.09*** (0.21)	2.08*** (0.29)	1.89*** (0.24)
Arronsaah	−1.12*** (0.22)	−1.22*** (0.21)	−1.42*** (0.35)	−1.63*** (0.32)
Arronsam	−1.31*** (0.27)	−1.40*** (0.26)	−1.46*** (0.44)	−1.65*** (0.42)
Arronsonsoro	−0.09 (0.34)	−0.11 (0.35)	0.26 (0.53)	0.22 (0.54)
Arrontobre	0.96*** (0.25)	0.84*** (0.24)	1.36*** (0.31)	1.14*** (0.26)
Constant	3.60*** (1.03)	4.05*** (0.95)	4.68*** (1.65)	5.57*** (1.53)
Observations	1255	1255	1255	1255
R squared.	0.15	0.15	0.16	0.14
Weak instruments		500.67***		500.67***
Wu-Hausman test		3.36*		6.45**

*p<0.1; **p<0.05; ***p<0.01

Table 16: OLS and IV Regression results

	Dietary quality for last 24 hours			
	Dietary Diversity(OLS)	Dietary Diversity(IV)	vitamin A-rich foods(OLS)	vitamin A-rich foods(IV)
	(1)	(2)	(3)	(4)
Organic	−0.38* (0.20)	−0.31* (0.18)	−0.10 (0.10)	−0.13 (0.20)
Gender (male)	−0.18 (0.22)	−0.17 (0.23)	0.11 (0.09)	0.11 (0.11)
Age of household head	0.01 (0.01)	0.01 (0.01)	0.004 (0.01)	0.004 (0.01)
Years of education	0.05** (0.02)	0.05** (0.02)	0.04*** (0.01)	0.04*** (0.01)
Literacy	0.27 (0.23)	0.26 (0.23)	0.06 (0.09)	0.06 (0.08)
Experience in agriculture	−0.02** (0.01)	−0.02** (0.01)	−0.01 (0.01)	−0.01 (0.01)
Household size	0.03 (0.02)	0.03 (0.02)	0.004 (0.02)	0.004 (0.02)
Dependency ratio	−0.16 (0.25)	−0.15 (0.25)	−0.004 (0.14)	−0.004 (0.13)
asinh(Total land owned (ha))	0.32** (0.15)	0.33** (0.15)	0.18** (0.07)	0.18** (0.07)
Distance to closest market	0.09*** (0.02)	0.09*** (0.02)	0.04** (0.02)	0.04** (0.02)
Tarred road	−0.22 (0.13)	−0.23 (0.16)	−0.13 (0.24)	−0.13 (0.26)
Distance to health facility	−0.09*** (0.02)	−0.09*** (0.02)	−0.07*** (0.01)	−0.07*** (0.01)
log(Household assets (million FCFA))	0.09 (0.07)	0.09 (0.07)	0.11** (0.05)	0.11** (0.04)
log(Working Capital (million FCFA))	−0.10** (0.05)	−0.10** (0.05)	−0.03 (0.02)	−0.03 (0.02)
Arronangaradebou	0.48** (0.21)	0.49** (0.23)	−0.19 (0.24)	−0.20 (0.26)
Arronbensekou	−0.21 (0.25)	−0.19 (0.28)	−0.66*** (0.25)	−0.66** (0.29)
Arrondonwari	0.93*** (0.23)	0.91*** (0.21)	0.23 (0.18)	0.23 (0.15)
Arrongnemasson	−0.72*** (0.08)	−0.70*** (0.08)	−0.91*** (0.05)	−0.91*** (0.06)
Arronkand2	1.79*** (0.17)	1.82*** (0.18)	0.62*** (0.10)	0.61*** (0.15)
ArronKandi1	−0.15 (0.16)	−0.13 (0.18)	−0.31*** (0.09)	−0.32** (0.13)
Arronkandi3	0.73*** (0.23)	0.75*** (0.24)	0.41*** (0.12)	0.40*** (0.15)
Arronkassakou	1.18*** (0.19)	1.20*** (0.22)	0.54*** (0.17)	0.53** (0.21)
Arronpehunco	0.18* (0.11)	0.19** (0.10)	−0.41*** (0.05)	−0.42*** (0.06)
Arronsaah	−0.16 (0.16)	−0.14 (0.17)	−0.49*** (0.09)	−0.50*** (0.10)
Arronsam	1.43*** (0.20)	1.44*** (0.21)	−0.05 (0.11)	−0.06 (0.12)
Arronsonsoro	0.96*** (0.20)	0.96*** (0.20)	−0.06 (0.13)	−0.07 (0.14)
Arrontobre	0.43*** (0.12)	0.45*** (0.13)	−0.06 (0.07)	−0.07 (0.08)
Constant	5.52*** (0.86)	5.46*** (0.81)	0.91* (0.48)	0.94** (0.45)
Observations	1255	1255	1255	1255
R squared.	0.12	0.12	0.15	0.15
Weak instruments		500.67***		500.67***
Wu-Hausman test		0.08		0.04

*p<0.1; **p<0.05; ***p<0.01

Table 17: OLS and IV Regression results

	Dietary quality for last 7 days			
	Dietary Diversity(OLS)	Dietary Diversity(IV)	vitamin A-rich foods(OLS)	vitamin A-rich foods(IV)
	(1)	(2)	(3)	(4)
Organic	0.12 (0.25)	0.42* (0.22)	0.18*** (0.05)	−0.12 (0.19)
Gender (male)	−0.11 (0.17)	−0.06 (0.17)	0.07 (0.15)	0.02 (0.18)
Age of household head	0.003 (0.01)	0.003 (0.01)	0.01 (0.01)	0.01 (0.01)
Years of education	0.05* (0.03)	0.05* (0.03)	0.03 (0.02)	0.03 (0.02)
Literacy	0.29 (0.20)	0.29 (0.19)	0.09 (0.09)	0.09 (0.09)
Experience in agriculture	−0.02* (0.01)	−0.02** (0.01)	−0.01*** (0.005)	−0.01*** (0.01)
Household size	0.03** (0.01)	0.03** (0.01)	0.01 (0.01)	0.01 (0.01)
Dependency ratio	−0.20 (0.22)	−0.19 (0.23)	−0.16 (0.11)	−0.17 (0.11)
asinh(Total land owned (ha))	0.10 (0.16)	0.12 (0.15)	0.14* (0.07)	0.12* (0.06)
Distance to closest market	0.03* (0.02)	0.04** (0.02)	0.02 (0.02)	0.02 (0.02)
Tarred road	−0.45** (0.20)	−0.49** (0.22)	−0.16 (0.26)	−0.13 (0.25)
Distance to health facility	−0.02 (0.02)	−0.03* (0.02)	−0.04*** (0.01)	−0.03*** (0.01)
log(Household assets (million FCFA))	0.06 (0.05)	0.07* (0.04)	0.12*** (0.02)	0.11*** (0.02)
log(Working Capital (million FCFA))	0.03 (0.05)	0.03 (0.05)	0.01 (0.02)	0.01 (0.02)
Arronangaradebou	−1.09*** (0.28)	−1.05*** (0.30)	−1.20*** (0.25)	−1.24*** (0.24)
Arronbensekou	−1.42*** (0.30)	−1.34*** (0.33)	−1.26*** (0.28)	−1.34*** (0.29)
Arrondonwari	−0.27 (0.32)	−0.32 (0.31)	−0.57*** (0.19)	−0.52*** (0.17)
Arrongnemasson	−0.56*** (0.09)	−0.50*** (0.07)	−0.98*** (0.06)	−1.04*** (0.04)
Arronkand2	0.88*** (0.22)	0.98*** (0.21)	0.56*** (0.09)	0.46*** (0.10)
ArronKandi1	−1.42*** (0.17)	−1.34*** (0.19)	−0.81*** (0.10)	−0.89*** (0.11)
Arronkandi3	−0.21 (0.28)	−0.13 (0.29)	−0.24 (0.15)	−0.32** (0.15)
Arronkassakou	−0.64** (0.25)	−0.55** (0.27)	−0.43** (0.17)	−0.52*** (0.17)
Arronpehunco	−0.26** (0.11)	−0.20* (0.11)	−0.66*** (0.06)	−0.71*** (0.04)
Arronsaah	−2.01*** (0.15)	−1.95*** (0.15)	−1.92*** (0.11)	−1.98*** (0.10)
Arronsam	−1.42*** (0.21)	−1.36*** (0.21)	−1.38*** (0.13)	−1.44*** (0.11)
Arronsonsoro	−0.58** (0.25)	−0.57** (0.25)	−0.99*** (0.15)	−1.01*** (0.14)
Arrontobre	−0.41*** (0.11)	−0.34*** (0.10)	−0.55*** (0.06)	−0.61*** (0.06)
Constant	8.14*** (0.67)	7.88*** (0.56)	2.30*** (0.24)	2.55*** (0.27)
Observations	1255	1255	1255	1255
R squared.	0.16	0.16	0.23	0.22
Weak instruments		500.67***		500.67***
Wu-Hausman test		2.11		4.33**

*p<0.1; **p<0.05; ***p<0.01

A.6 Treatment heterogeneity for OLS and IV for Food insecurity experienced scale

Table 18: OLS and IV Regression results

	Treatment heterogeneity with of FAO HFIES			
	Mild(OLS)	Mild(IV)	Moderate(OLS)	Moderate(IV)
	(1)	(2)	(3)	(4)
Organic	0.38 (0.59)	0.34 (0.87)	0.45* (0.24)	0.08 (0.16)
Gender (male)	0.50 (0.32)	0.49 (0.32)	0.28 (0.26)	0.15 (0.33)
Age of household head	−0.02** (0.01)	−0.02** (0.01)	−0.03*** (0.01)	−0.02** (0.01)
Years of education	0.01 (0.03)	0.01 (0.03)	0.01 (0.02)	0.01 (0.02)
Literacy	0.01 (0.22)	0.01 (0.22)	0.08 (0.18)	−0.13 (0.22)
Experience in agriculture	0.02* (0.01)	0.02* (0.01)	0.02* (0.01)	0.02* (0.01)
Household size	0.05*** (0.02)	0.05*** (0.02)	0.06** (0.03)	0.06*** (0.02)
Dependency ratio	0.02 (0.37)	0.02 (0.35)	−0.35 (0.25)	−0.31 (0.25)
asinh(Total land owned (ha))	−0.53*** (0.12)	−0.54*** (0.14)	−0.21 (0.13)	−0.19 (0.17)
Distance to closest market	−0.04* (0.02)	−0.04* (0.02)	−0.01 (0.02)	0.01 (0.02)
Tarred road	−0.33 (0.36)	−0.33 (0.38)	−0.58*** (0.16)	−0.47*** (0.11)
Distance to health facility	0.03 (0.03)	0.03 (0.03)	−0.01 (0.02)	−0.01 (0.03)
log(Household assets (million FCFA))	−0.10 (0.11)	−0.10 (0.10)	−0.05 (0.08)	−0.08 (0.05)
log(Working Capital (million FCFA))	0.05 (0.07)	0.05 (0.07)	0.08* (0.04)	0.06 (0.04)
Arronangaradebou	−0.26 (0.32)	−0.26 (0.33)	−0.70*** (0.25)	−0.56*** (0.18)
Arronbensekou	0.18 (0.42)	0.17 (0.47)	−0.30 (0.24)	−0.06 (0.16)
Arrondonwari	−0.78*** (0.25)	−0.78*** (0.26)	−0.87*** (0.31)	−0.46** (0.18)
Arrongnemasson	0.75*** (0.14)	0.74*** (0.17)	−0.48*** (0.11)	−0.78*** (0.10)
Arronkand2	1.91*** (0.24)	1.89*** (0.33)	0.63*** (0.15)	0.81*** (0.15)
ArronKandi1	0.50** (0.23)	0.49* (0.28)	0.60*** (0.16)	0.43** (0.18)
Arronkandi3	1.08*** (0.37)	1.07** (0.43)	0.63** (0.27)	0.71*** (0.24)
Arronkassakou	−1.58*** (0.34)	−1.59*** (0.39)	−0.41* (0.23)	−0.10 (0.19)
Arronpehunco	0.56*** (0.15)	0.55*** (0.18)	−0.60*** (0.11)	−0.82*** (0.09)
Arronsaah	−1.57*** (0.13)	−1.58*** (0.14)	−0.97*** (0.20)	−0.99*** (0.15)
Arronsam	−2.20*** (0.17)	−2.21*** (0.19)	−2.09*** (0.17)	−1.68*** (0.21)
Arronsonsoro	−0.50** (0.25)	−0.50** (0.25)	−0.71*** (0.24)	−0.13 (0.15)
Arrontobre	0.65*** (0.20)	0.65*** (0.23)	−0.14 (0.13)	−0.23 (0.16)
Constant	5.98*** (1.29)	6.01*** (1.17)	5.98*** (0.94)	6.80*** (0.45)
Observations	985	985	650	497
R squared.	0.19	0.19	0.14	0.14
Weak instruments		491.28***		153.83***
Wu-Hausman test		0.03		0.05
Note:				*p<0.1; **p<0.05; ***p<0.01

A.7 Treatment regression

Gender (male)	−0.46	−0.45	−0.52	−0.52	−0.53	−0.48
Age of household head	0.01	0.01	0.01	0.01	0.01	0.01
Years of education	0.01	0.01	0.01	0.004	0.01	0.01
Literacy	0.25	0.26	0.27	0.28	0.26	0.28
Experience in agriculture	0.01	0.01	0.01	0.01	0.01	0.01
Household size	−0.002	0.004	0.001	0.0005	0.001	−0.004
Dependency ratio	0.05	0.05	0.01	0.02	0.03	−0.03
asinh(Total land owned (ha))	−0.39	−0.40	−0.37	−0.38	−0.36	−0.38
Distance to closest market	−0.01	−0.01	−0.02	−0.02	−0.02	−0.01
Tarred road	−0.10	−0.11	−0.09	−0.08	−0.11	−0.04
log(Household assets (million FCFA))	0.04	0.05	0.05	0.05	0.05	0.05
log(Working Capital (million FCFA))	0.003	0.002	0.004	−0.01	−0.001	0.001
Distance to health facility	0.05	0.05	0.05	0.05	0.05	0.04
Arronangaradebou	0.45	0.43	0.47	0.45	0.47	0.39
Arronbensekou	0.16	0.15	0.15	0.11	0.15	−0.01
Arrondonwari	−0.38	−0.39	−0.32	−0.32	−0.29	−0.34
Arrongnemasson	−4.74	−4.70	−4.78	−4.74	−4.82	−4.48
Arronkand2	−4.75	−4.71	−4.85	−4.81	−4.74	−4.53
ArronKandi1	−4.50	−4.54	−4.65	−4.65	−4.67	−4.52
Arronkandi3	−4.89	−4.85	−4.90	−4.90	−4.82	−4.62
Arronkassakou	−4.96	−4.97	−5.02	−5.05	−4.99	−4.75
Arronpehunco	−0.61	−0.63	−0.58	−0.59	−0.60	−0.66
Arronsaah	−4.69	−4.65	−4.71	−4.72	−4.67	−4.52
Arronsam	−4.74	−4.74	−4.88	−4.93	−4.74	−4.83
Arronsonsoro	−0.27	−0.28	−0.22	−0.24	−0.20	−0.32
Arrontobre	−0.44	−0.46	−0.40	−0.39	−0.43	−0.36
Share of Organic household	0.12	0.12	0.11	0.11	0.11	0.11
Organic	−0.19	−0.19	−0.30	−0.17	0.46	−0.35
Gender (male)	−0.46	−0.45	−0.52	−0.52	−0.53	−0.48
Age of household head	0.01	0.01	0.01	0.01	0.01	0.01
Years of education	0.01	0.01	0.01	0.004	0.01	0.01
Literacy	0.25	0.26	0.27	0.28	0.26	0.28
Experience in agriculture	0.01	0.01	0.01	0.01	0.01	0.01
Household size	−0.002	0.004	0.001	0.0005	0.001	−0.004
Dependency ratio	0.05	0.05	0.01	0.02	0.03	−0.03
asinh(Total land owned (ha))	−0.39	−0.40	−0.37	−0.38	−0.36	−0.38
Distance to closest market	−0.01	−0.01	−0.02	−0.02	−0.02	−0.01
Tarred road	−0.10	−0.11	−0.09	−0.08	−0.11	−0.04
log(Household assets (million FCFA))	0.04	0.05	0.05	0.05	0.05	0.05
log(Working Capital (million FCFA))	0.003	0.002	0.004	−0.01	−0.001	0.001
Distance to health facility	0.05	0.05	0.05	0.05	0.05	0.04
Arronangaradebou	0.45	0.43	0.47	0.45	0.47	0.39
Arronbensekou	0.16	0.15	0.15	0.11	0.15	−0.01
Arrondonwari	−0.38	−0.39	−0.32	−0.32	−0.29	−0.34
Arrongnemasson	−4.74	−4.70	−4.78	−4.74	−4.82	−4.48
Arronkand2	−4.75	−4.71	−4.85	−4.81	−4.74	−4.53
ArronKandi1	−4.50	−4.54	−4.65	−4.65	−4.67	−4.52
Arronkandi3	−4.89	−4.85	−4.90	−4.90	−4.82	−4.62
Arronkassakou	−4.96	−4.97	−5.02	−5.05	−4.99	−4.75
Arronpehunco	−0.61	−0.63	−0.58	−0.59	−0.60	−0.66
Arronsaah	−4.69	−4.65	−4.71	−4.72	−4.67	−4.52
Arronsam	−4.74	−4.74	−4.88	−4.93	−4.74	−4.83