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CASE STUDY

Synergies and tradeoffs between cash crop production and food security: a case study in rural Ghana

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Abstract Despite dramatic improvements in global crop yields over the past half-century, chronic food insecurity persists in many parts of the world. Farming crops for sale (cash cropping) has been recommended as a way to increase income that can, in turn, improve food security for smallholder farmers. Despite long-term efforts by development agencies and government to promote cash cropping, there is limited evidence documenting a relationship between these crops and the food security of households cultivating them. We used a mixed methods approach to build a case study to assess these relationships by collecting quantitative and qualitative data from cacao and oil palm farmers in the Ashanti region of Ghana. Three dimensions of food security were considered: *food availability*, measured by the months in a year households reported inadequate food; *food access*, indicated by the coping strategies they employed to secure sufficient food; and *food utilization*, gauged by the diversity of household diets and anthropometric measurements of child nutritional status. We found significant negative relationships between each of these pillars of food security and a household's intensity of cash crop production, measured by both quantity and area. A qualitative assessment indicated community perception of these tradeoffs and identified potential mechanisms, including increasing food prices and competing activities for land use, as underlying causes. The adverse relationship between cash crop production and household food security observed in this paper calls for caution; results suggest that positive relationships cannot be assumed, and that further empirical evidence is needed to better understand these tradeoffs.

Keywords Food security · Nutrition · Agriculture · Cash crop · Cacao · Oil palm · Ghana

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Introduction

Despite dramatic increases in global crop yields over the past half century, rising and volatile food prices, fueled by expensive agricultural inputs and weather variability, point to modern-day chronic food insecurity in many parts of the world (Godfray et al. 2010; FAO and IFAD 2012). Food insecurity comprises inadequate food availability, access and utilization (FAO and IFAD 2012). Cash crop farming, agriculture geared towards sale rather than household consumption of agricultural products, is an often-employed but controversial strategy aimed at reducing smallholder vulnerability to food insecurity by increasing household incomes (Von Braun and Kennedy 1986; Von Braun 1995; Maxwell and Fernando 1989; Zeller and Sharma 2000). While cash crops have existed in sub-Saharan Africa since the advent of the colonial era, production of many of these crops is increasing (FAOSTAT 2012). This is exemplified by Ghana, where the quantities of oil palm and cacao (Fig. 1) as well as pineapple, cotton, and tobacco produced annually are expanding (FAOSTAT 2012).

The cash crop strategy stands in contrast to subsistence farming, in which food is grown directly for household consumption; in reality many smallholder farmers engage in both cash crop and subsistence production (semi-subsistence).

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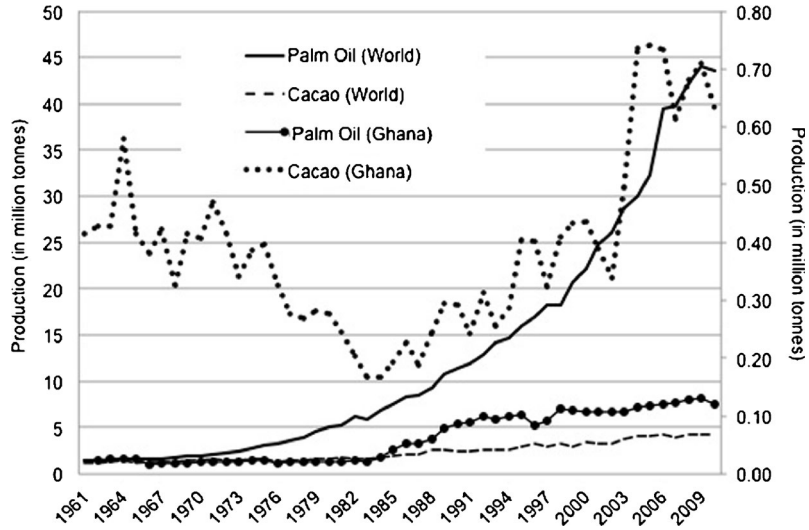

Fig. 1 World (primary axis) and Ghanaian (secondary axis) production of palm oil and cacao from 1961 to 2009. Production expressed in millions of tonnes (FAOSTAT 2012)

Those who make the transition from subsistence farming to semi-subsistence farming by increasing cash crop production undergo several changes at the household level that may influence food security by affecting its distribution and related assets. These changes include the frequency and amount of household incomes, spousal control over income, increased dependence on local markets, and intensified vulnerability to changes in food prices (Fig. 2) (Von Braun and Kennedy 1986; Maxwell and Fernando 1989; Fafchamps 1992). While cash crop agriculture has been promoted as a strategy to support food security via income generation (Zeller and Sharma 2000), factors such as these can make cash cropping ineffective at achieving these ends, regardless of potential gains in household earnings.

The relationship between cash crop farming and food security varies significantly across geographical areas, crop choice, and existing local and global social structures (Branca et al. 1993; Dewalt 1993; Sharma 1999). For example, cash crop production of castor beans in Ethiopia (Negash and Swinnen 2013) was positively correlated with food availability—the local food supply or the amount of food available for household consumption—but negatively correlated with production of cold weather vegetables in Guatemala (Immink and Alarcon 1993). Alongside factors such as marital status and education levels, cash cropping has had other varying effects on household food availability (Kiriti and Tisdell 2004; Gauchan 1997; Komarek 2010). Regarding food access—the ability of consumers to access or purchase food—positive associations were found with vanilla production in

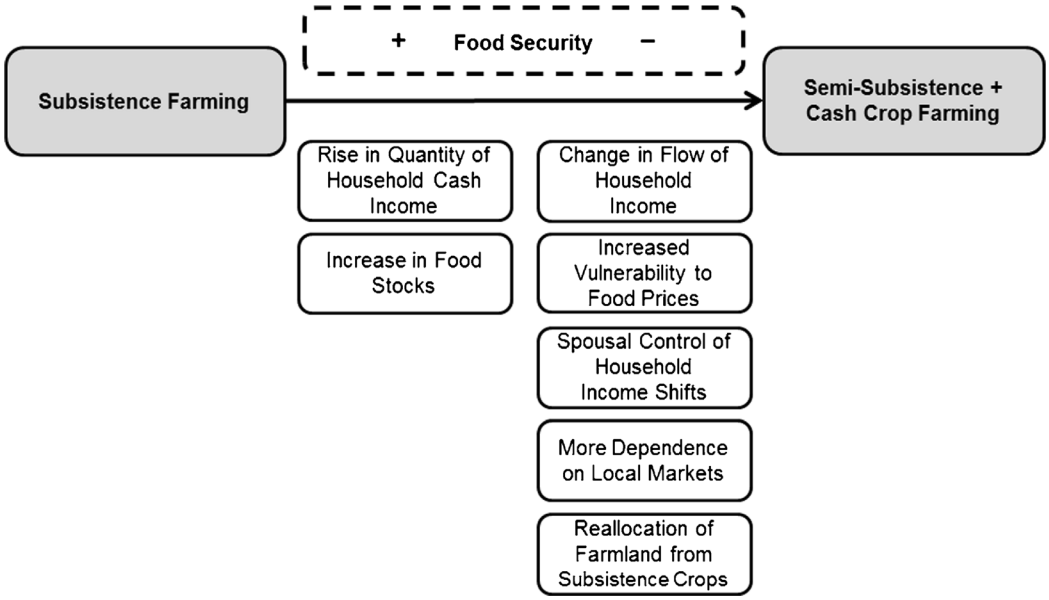

Fig. 2 A schema illustrating multiple pathways through which transitioning from subsistence to semi-subsistence farming and cash cropping can affect food availability, access, and utilization

Uganda (Komarek 2010) but there were negative correlations with sugarcane production in Swaziland (Terry and Ryder 2007, 2005). Despite other studies on food access and cash cropping, this relationship is still uncertain (Mintz-Habib 2013; Kanyamurwa et al. 2013; Hought et al. 2012; Bellow et al. 2008). Food utilization—defined as sufficient energy and nutrient uptake by individuals—may be either positively or negatively correlated with cash cropping (Dema 1964; Dewalt 1993; Dewey 1981; Kennedy et al. 1992; Leonard et al. 1994; Mueller et al. 2001; Sharma 1999; Von Braun 1995; Pierre-Louis et al. 2007; Wood et al. 2012). For example, there were positive correlations with diet diversity for production of peanuts in Mali (Pierre-Louis et al. 2007) and with anthropometric indicators for cardamom in Papua New Guinea, rice in the Gambia, maize in Zambia, and potatoes in Rwanda (Von Braun 1995; Kennedy et al. 1992). However, negative correlations were found with cash crop production of cassava in Ecuador (Leonard et al. 1994) and cacao, sugarcane and cattle production in Mexico (Dewey 1981).

In sub-Saharan Africa, despite continued efforts to promote cash crop agriculture as a means of reducing rural poverty and food insecurity (Jones and Gibbon 2011), it is unclear to what extent and under which conditions cash crop production achieves these ends at the household level. There is also a shortage of analyses using multiple indicators to capture how cash crop production interacts with the three components of food security—availability, access and utilization—such that the relationship between cash cropping and food security remains unclear. In the present case study, we explore this question by focusing on a community in the Ashanti region of Ghana where farmers grow two main cash crops, cacao and oil palm.

We hypothesize that smallholder farmers in the Ashanti region producing greater amounts of oil palm and cacao will have better food availability and access because of higher family incomes with which they can purchase food (Von Braun and Kennedy 1986; Komarek 2010). At the same time, we predict food utilization will be worse in households growing more cash crops because cash cropping frequently shifts control of household income from female to male household heads (Fafchamps 1992; Leonard et al. 1994; Tripp 1982; Due and Gladwin 1991) and control of household income by women has a positive influence on household nutrition (Kennedy and Peters 1992; Hoddinott and Haddad 1995). We also expect greater amounts of cash cropping to correlate with lower food utilization because cash cropping increases smallholders' reliance on local markets, which can decrease dietary diversity where locally available food items are limited (Von Braun and Kennedy 1986; Adam et al. 2012). By exploring these hypotheses through quantitative and qualitative methods, we aim to develop a better understanding of the tradeoffs and synergies between the production of two cash crops—oil palm and cacao—and the three elements of food security in this local context.

Materials and methods

Study site

Our study focused on the Bonsaaso village cluster of the Millennium Villages Project (MVP) (Fig. 3) in the Ashanti region of south-central Ghana (Mensah-Homiah et al. 2011; Sustainable Engineering Lab 2014). The Bonsaaso cluster was chosen for this study because of its diversity of agricultural practices, with households employing a range of subsistence and cash cropping strategies.

The Bonsaaso village cluster spans 389 km^2. It constitutes 29 % of the total land area in the Amansie West District of the Ashanti Region, an area of moist, semi-deciduous forest. The cluster has a total population of approximately 32,000 people. Agriculture is the basis of livelihood for most households, with major annual food crops including yam, cassava, maize, cocoyam, and plantains. Cacao and oil palm are the two main cash crops, each with one major and one minor cropping season locally. Cacao in this area is grown exclusively for export, where it is used to produce foodstuffs and beauty products. The crop was introduced by Dutch and Spanish colonialists at the end of the 19th century and is now a key government regulated industry nationally, and Ghana's top export by both value and quantity (Clark 1995; FAOSTAT 2012). Oil palm is a non-staple item for both local consumption and export, where it is used in industrially processed foods, biofuel, cosmetics and cooking. Derived from a tree indigenous to the region, palm oil is extracted from the tree fruit's pulp and kernel. Commercial trade in oil palm began mid-way through the 19th century, quickly evolving into a major export commodity (Ministry of Food and Agriculture 2011). Oil palm is currently Ghana's third largest export in value and quantity (FAOSTAT 2012). Both oil palm and cacao are predominantly grown by smallholder farmers in six heavy rainfall forested regions including Ashanti (Ministry of Food and Agriculture 2011; Clark 1995). Production of these crops (Fig. 1) in Ghana has increased steadily over the past thirty years at average annual growth rates of 5.1 % for cacao and 3.4 % for oil palm, due in part to competitive export prices of, for example, cacao (Fig. 4a) (Kuwornu et al. 2009; FAOSTAT 2014).

MVP interventions began in Bonsaaso in June 2006. The MVP is a rural development program aiming to achieve the Millennium Development Goals (MDGs) at 14 sites in 10 countries in rural sub-Saharan Africa by 2015 (Pronyk et al. 2012). The MVP strategy is based on concurrent investments in five sectors: agriculture and environment, health, education, infrastructure, and business development. This simultaneous intervention approach strives to break interacting limitations on achieving the MDGs (e.g. health challenges that also prevent agricultural achievement). The particular strategies put in place in each site are science-based and made in co-

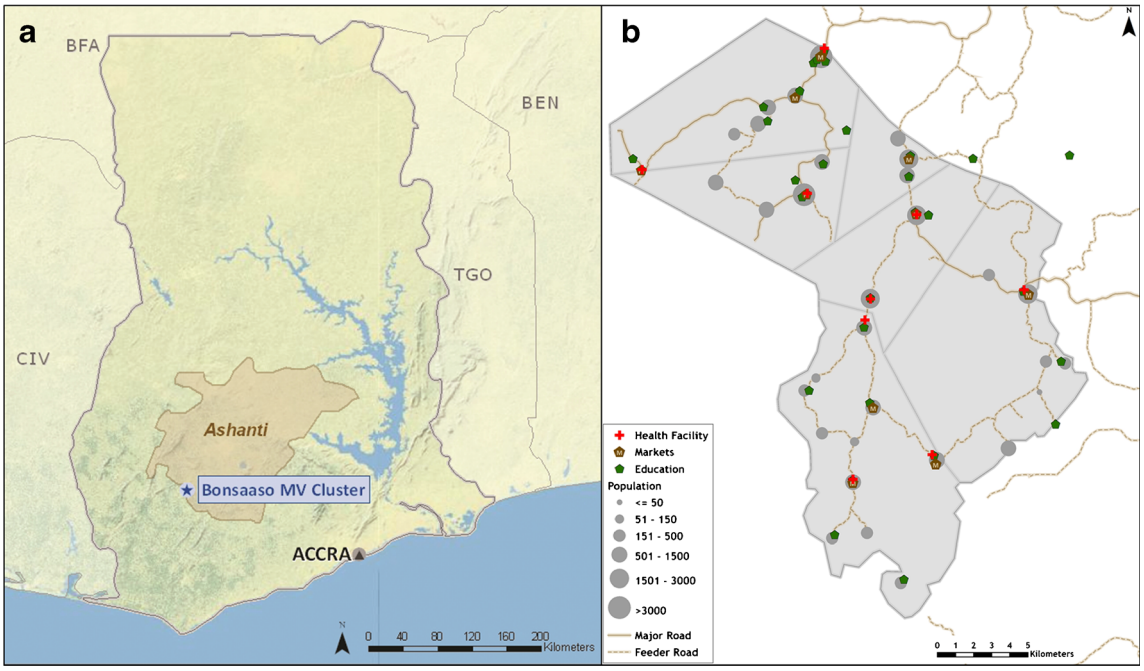

Fig. 3 Map of Ghana showing the location of the Bonsaaso Millennium Villages cluster (**a**), with details of Bonsaaso's administrative boundaries, major infrastructure, facilities, and population (**b**) (Sustainable Engineering Lab 2014)

operation with the community, NGOs, and local and national governments. In Bonsaaso, MVP agricultural initiatives (Fig. S1) include the introduction of and a subsidy on seeds, fertilizer, and training on quality protein maize and cowpeas, which can improve nutrition, especially for children and pregnant women; promotion through education of citrus and vegetable production, as well as community-based aquaculture, to diversify household diets; and, new technologies for paddy rice, intended to increase yields and decrease inputs (Mensah-Homiah et al. 2011). The MVP has also been supporting cacao and oil palm production by providing hybrid cacao and high yielding oil palm seedlings; inorganic and compost fertilizer; extension services, including training on planting techniques and cash crop marketing; improved storage facilities to reduce post-harvest losses; and, formation of farmer cooperatives to facilitate the processing of oil palm (Mensah-Homiah et al. 2011).

Data and indicators

Data for this study (summarized in Table 1) were gathered in 2009 toward the end of the third year of project interventions. Surveys were administered to approximately 250 household heads living in 11 sub-villages within the Bonsaaso cluster in the areas where intervention delivery originally began. A population census was undertaken at baseline to establish sampling frames, with households randomly sampled proportionally from strata defined by sub-village, wealth, and sex of household head (Sanchez et al. 2007). To assess the multiple dimensions of food

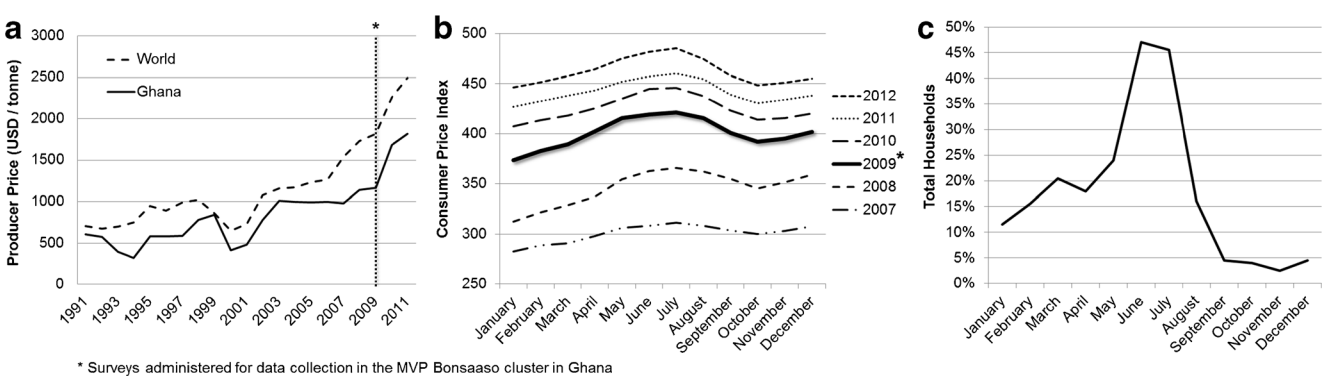

Fig. 4 World and Ghanaian producer prices of cacao, expressed in USD/tonne, from 1991 to 2011 (**a**) and Ghana's monthly Consumer Price Index for the years 2007–2012 (**b**) (FAOSTAT 2014). Seasonal variation of food availability is indicated by the months during the year prior to surveying in which MVP smallholders in this study in the Bonsaaso village cluster reported having insufficient food supplies (**c**)

Table 1 Synthesis of study variable characteristics for the three dimensions of food security and a set of confounding factors included in the models as controls. Table presents the indicator, survey source, mean, standard deviation, and sample size of each variable. All surveys are from the MVP dataset

	Variable	Indicator	Source	Mean	Standard Deviation	Sample Size
Food Security	Availability	Months Adequate Food Supply	Nutrition Survey	9.40	2.47	118
	Access	Food Coping Score	Nutrition Survey	0.80	0.18	96
	Utilization	Diet Diversity Score Food Variety Score	Food Frequency Survey	9.55 25.07	1.89 9.19	100 100
		Child Anthropometric z-scores: Height-for-Age Weight-for-Age Weight-for-Height	Anthropometric Measurements Survey	-1.13 -1.03 -0.33	2.05 1.18 1.17	67 66 67
Confounding Factors	Cash Crop Production	Quantity of cash crops produced (kg) Percent of Total Land for Cash Crops (%)	Household Survey	1017 44	1477 27	126 92
	Household Demographics	Female headed households (% of total) Dependency Ratio	Household Survey	19.1 134.0	n/a 114.7	110 116
	Wealth	Total Land (ha) Asset Index	Household Survey	5.65 0.32	12.44 1.99	112 119

security, several indicators were collected for each of the three metrics. In order to generate a food availability score, which ranged from 0 to 12, we applied a module from the nutrition survey to 118 households that asked which months in the past year a household had enough to eat (Months Adequate Food Supply) (Bilinsky and Swindale 2007). This indicator reflects the availability of food by measuring the ability of households to obtain it through various channels including own production, stocks, purchases, or food transfers from relatives, neighbors, government or donors (Bilinsky and Swindale 2007).

Ninety-six observations from the nutrition survey also provided a food access score, ranging from 0–1, derived by equally weighted presence/absence responses to 11 food insecurity and coping strategy questions (Table S1) over 7 day and 12 month recalls (Food Coping Score) (Coates et al. 2007). This indicator reflects the notion that inadequate food access is experienced through anxiety over food and its insufficient quantity or quality and reported consequences of reduced food intake, among other variables, that can in turn be captured through a survey and summarized in a scale (Coates et al. 2007). A higher value indicates better food availability and access. Given that answers to questions used in the food coping score are self-reported, they are subject to the potential tendency of households to exaggerate their experiences. The validity of such subjective food security measures have, however, been shown in several studies (Bilinsky and Swindale 2007; Coates et al. 2007; Nord et al. 2002).

Indicators for food utilization include diet diversity and food variety scores, and three anthropometric measures of nutrition-related health outcomes for children under-5 years of age. The diet diversity score serves as a proxy for diet quality (Shimbo et al. 1994; Hatloy et al. 1998; Steyn et al. 2006; Moursi et al. 2008). To generate this score, which ranged from 0 to 13, we drew on data from a food frequency survey with 100 (of the total 250) observations reported, via a 30-day recall, of the frequency of consuming 120 locally available food items (times per day, week, month, or year) (Swindale and Bilinsky 2006). Scores were generated for weekly time periods by categorizing food items into 13 food groups as recommended by the Food and Nutrition Technical Assistance Project: cereals, green leafy vegetables, vitamin A vegetables and tubers, other vegetables, white roots and tubers, vitamin A fruits, other fruits, meat, eggs, fish, legumes, dairy, and oils and fats (FAO/FANTA 2007). Both the diet diversity score and each of the thirteen food groups that together create it were analyzed. A food variety score, with a range of 0–120, was generated for the same 100 observations by giving equal weight to consumption of each of the 120 food items, rather than dividing them into groups (Swindale and Bilinsky 2006). The food variety score is also a proxy for diet quality (Steyn et al. 2006). It complements the diet diversity score by offering insight into the number of different food items accessible across food groups, thus also providing a measure of household resilience. With greater variation than the diet diversity score, it is more sensitive to differences between households. Furthermore, the food variety score includes items not directly necessary for meeting nutritional requirements, such as tea and coffee, and thus more thoroughly reflects consumption choices made by households. The nutrition and food frequency surveys were administered to households toward the end of 2009.

Anthropometric measurements provide insight on how food is ultimately absorbed and converted in the body, and therefore can be used as an indicator of food utilization. It should be noted, though, that food security is only one

determinant of child anthropometric outcomes; other key determinants include child and maternal caring practices and disease control (UNICEF 1990). Data were collected through anthropometric measurements in 67 of the 250 surveyed households with children under-5 years of age, for a total of 203 children. Measurements were made using standard best practices (Cogill 2001) for three measures of nutritional status: height-for-age, weight-for-height, and weight-for-age. Stunting, wasting, and being underweight were defined, respectively, as a height-for-age, weight-for-height, and weight-for-age z-score (the number of standard deviations an observation is from the mean) of less than −2 (WHO 2005). Stunting, a slowing of vertical growth, is a measure of chronic malnutrition. Wasting is a measure of acute malnutrition, and can be the result of recent rapid weight loss due to acute infection and/or inadequate dietary intake. Being underweight can be linked to chronic or acute malnutrition, or a combination of the two (UNICEF 1990). Indices were calculated with STATA (StataCorp) macros provided by the World Health Organization (WHO), with the use of international standard growth references (WHO 2005). Extreme z-scores (less than −6 or > 6 for height-for-age; less than −5 or > 5 for weight-for-height; and less than −6 or > 5 for weight-for-age) were excluded following the WHO protocol (WHO 2005).

To measure amounts of cash crop agriculture, household demographics, and wealth, a household survey was administered to the 250 households. The amount of cash crop agriculture was measured by the total quantity of oil palm fruit and cacao beans produced by each household per year (kg yr^{-1}) and as the percent of a household's total land dedicated to these crops, which indicates the proportion of a household's land resources being allocated to cash crop production. The quantity of oil palm fruit and cacao beans produced by each smallholder was analyzed as a summed value per household, to account for disparities in sample size between the number of farmers growing cacao and those growing oil palm. The same approach was used for measures of area: the land under production of oil palm fruit and cacao beans were added together per farmer to represent the total area each household dedicated to cash crops. Though households could sell surpluses of subsistence crops as cash crops, current data was not able to capture this dynamic. However, our focus on oil palm and cacao is useful as households dedicating land to these cash crops cannot revert back to subsistence crops, making them more vulnerable during instances of food insecurity.

Household demographics were measured by a dependency ratio as well as the gender of the household head. The dependency ratio was used to control for household size and composition, as households with more children might have different dietary patterns from those with more adults. The dependency ratio was obtained by dividing the number of household members aged between 0 and 14 years and over 65 years by the number between 15 and 64 years of age. This value was then multiplied by 100 to make ratios easier to interpret, following methodology currently used by the World Bank (2014). The values in the dependency ratio thus represent the proportion of dependents per 100 working-age people. The gender of the household head was included to account for possible effects of changing from female to male control of household income as a result of cash cropping, which has been shown to correlate negatively with household nutrition (Hoddinott and Haddad 1995; Kennedy and Peters 1992; Due and Gladwin 1991). Household wealth was measured by a household's total land and their asset index. The asset index was derived from reported ownership of 21 asset indicators (Table S2); responses were entered into a principal component analysis determining the relative weight of each asset. The weighted indicators were then summed per household to generate the asset index (Filmer and Pritchett 2001; Michelson et al. 2013). Our data did not include a metric of household liquid capital, which would have been a useful comparison to the asset index as income may be a more flexible measure of wealth that could better meet acute food insecurity. However, analysis on the relative merits of different asset indices, including a metric of structured income, show that the principal component analysis-based asset index used in our study offers the best indication of the relative socioeconomic position of each household, and therefore of local wealth distributions and orderings in the MVP Bonsaaso cluster (Michelson et al. 2013). Taken together, these data were used to make an analytical assessment of the relationship between cash crop farming and food availability, access and utilization in Bonsaaso, Ghana. The results of these models (methods of analysis are outlined in the *Analysis* section) are presented in Table 2.

A qualitative module was performed to enhance our understanding of local perceptions of food insecurity and its interaction with cash and food crop production (Vargas and Penny 2010; Chung 1997; Carvalho and White 1997; Maxwell 1998; Marsland et al. 2001; UN WFP 2009). Qualitative data were gathered from June to August 2012 through ten structured focus group discussions, as well as through in-depth interviews with community members and MVP staff, in four villages in the Bonsaaso cluster. Focus group participants were selected at random from cash crop and subsistence farming households. Five focus group discussions were held with women and five with men. Several tools were employed, including seasonal calendars (ICRISAT 2009). This tool was used to indicate the timeframe of cropping seasons and related dynamics such as food price fluctuations and income generation. The groups then discussed how these periods interacted with food insecurity patterns, their intensity, and underlying causes. Two independent enumerators took minutes from all focus group discussions and interviews.

Table 2 Multiple regressions between cash crop agriculture (quantity and the percent of a farmer's total land for cash crop production) and three dimensions of food security (food availability, access, and utilization) including controls for household demographic and wealth indicators

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	Months adequate food supply		Food coping score		Diet diversity score		Food variety score		Weight-for-age		Height-for-age		Weight-for-height	
	Quantity	% Area	Quantity	% Area	Quantity	% Area	Quantity	% Area	Quantity	% Area	Quantity	% Area	Quantity	% Area
Cash crop quantity	−0.14		−0.068		0.34		1.73		−0.79*		0.93		−0.61	
	(0.55)		(0.039)		(0.43)		(2.11)		(0.30)		(0.55)		(0.34)	
Cash crop area (% total)		−1.65**		−0.16***		0.80		3.61		0.02		0.048		−0.64
		(0.51)		(0.47)		(0.50)		(2.53)		(0.47)		(0.82)		(0.52)
Household head gender	−0.51	0.19	0.091	0.13*	−0.45	−0.70	−0.58	−2.91	0.15	−0.13	−0.33	−0.52	0.44	0.34
	(0.69)	(0.65)	(0.053)	(0.057)	(0.59)	(0.65)	(2.91)	(3.28)	(0.38)	(0.48)	(0.969)	(0.86)	(0.42)	(0.51)
Dependency ratio	−0.022	−0.13	0.043	0.016	0.66	0.76	1.42	1.53	−0.78**	−0.83*	−1.14*	−1.26	−0.49	−0.54
	(0.50)	(0.47)	(0.038)	(0.040)	(0.41)	(0.46)	(2.04)	(2.29)	(0.29)	(0.38)	(0.53)	(0.68)	(0.33)	(0.42)
Asset index	0.26	0.71	0.023	0.057	0.45	0.37	−0.60	−1.51	0.44	0.35	0.19	−0.024	0.15	0.18
	(0.58)	(0.54)	(0.043)	(0.045)	(0.48)	(0.53)	(2.36)	(2.65)	(0.31)	(0.38)	(0.55)	(0.69)	(0.34)	(0.41)
Total land	−0.16	−0.86	0.26	0.12	0.41	0.68	2.79	4.10	0.75	0.40	3.31	3.18	0.10	−0.66
	(0.61)	(0.54)	(0.15)	(0.17)	(0.47)	(0.49)	(2.31)	(2.49)	(1.15)	(1.46)	(2.00)	(2.54)	(1.22)	(1.52)
Child gender									−0.40	−0.30	−0.81	−0.89	−0.42	−0.28
									(0.32)	(0.39)	(0.57)	(0.70)	(0.37)	(0.44)
Child age									0.34	0.40	0.76	0.68	−0.24	−0.43
									(0.33)	(0.44)	(0.60)	(0.77)	(0.39)	(0.49)
Observations	103	84	82	67	86	70	86	70	59	47	60	48	58	46
R-squared	0.01	0.13	0.11	0.25	0.07	0.11	0.03	0.07	0.26	0.14	0.18	0.13	0.19	0.13
RMSE	2.53	2.13	0.17	0.17	1.92	1.92	9.54	9.69	1.07	1.24	1.96	2.22	1.19	1.32

Each column is a separate regression model. Column headings indicate response variables, while row labels delineate predictor variables. Each response variable was run once with a predictor variable for quantity and percent area of household-level cash cropping, respectively. Models were run with and without outliers (defined as quantities of oil palm fruit and/or cacao beans outside 1.5 × interquartile range) and were found to be robust; outliers were subsequently removed. Continuous predictor variables were standardized by their mean and two standard deviations. Binary predictor variables were centered. Response variables were left unstandardized. This standardization procedure was used to ensure that variables were expressed in common units so that correlation coefficients within each model could be compared

Robust standard errors in parentheses

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Analysis

All statistical analyses were conducted with STATA (StataCorp 2013). Outliers to the dataset (defined as quantities of oil palm fruit and/or cacao beans outside 1.5 × interquartile range) were identified as individual households growing more than 10,000 kg of oil palm fruit (two households) or 5,200 kg of cacao beans (three households). Models were run with and without outliers and were found to be robust; outliers were subsequently removed. Continuous predictor variables were standardized by two standard deviations, while binary predictor variables were centered (Gelman 2008). Response variables were left unstandardized (Gelman 2008). This standardization procedure was used to ensure that variables were expressed in common units, so that correlation coefficients within each model could be compared. Separate regression models were run for each response variable of food availability, access, and utilization; results are presented in Table 2 and Table S4. Each of these variables was first regressed with the quantity of production and second with the percent of a farmer's total land used to produce oil palm and cacao. Quantity and area of cash cropping were both used in order to provide more robust measurements of production levels. In each regression, all household demographic and wealth indicators were included as control variables. In the food utilization analysis for anthropometric measures of child nutrition status, the child's age and sex were also included to account for differences in physiological development (De Onis and Blössner 2003). Collinearity was systematically checked using variance inflation factors, where a value of 10 or higher suggests collinearity. All variables had a variance inflation factor less than 1.25 (Table S3) and were thus considered not to be collinear.

Results

Description of household characteristics

Mean household total land size was 5.7 ha (standard deviation ±12.4) (Table 1), with an average asset index of 0.3 (±2.0). Female headed households accounted for 19 % of those surveyed. The average dependency ratio (134 ± 115) indicated a high level of dependency in the sample population. Farmers in the study area produced a mean of 816 kg (±878) of cacao beans and 202 kg (±910) of oil palm fruit annually, by dedicating an average of 42 % (±27 %) and 2 % (±11 %) of their total land to cacao and oil palm production, respectively. In aggregate, they produced a mean of 1,017 kg (±1,477) of cash crops annually, dedicating 44 % (±27 %) of their land to oil palm fruit and/or cacao bean production.

On average, farmers reported experiencing 9.4 months (±2.5) of adequate food supply annually (Table 1). The mean food coping score was 0.80 (±0.18) out of 1, indicating that households answered positively to 80 % of the food coping questions. This score provides a relative range by which to compare the ability to access food across different households. For food utilization, a mean diet diversity score of 9.6 (±1.9) was observed, indicating that on average households consumed 9 to 10 different food groups on a weekly basis. The food groups consumed most frequently were cereals and white tubers, followed by vegetables other than green leafy and vitamin A rich vegetables. The number of different food items consumed weekly by households varied from 7 to 54, and was 25.1 (±9.2) on average. Prevalence of chronic malnutrition, acute malnutrition and being underweight was 34.5, 3.0 and 16.8 %, respectively.

Cash cropping and food security

Regression results showed a significant negative relationship between a household's percent of total land dedicated to cash crops and their food availability and access (Table 2). Farmers dedicating a greater percent of their land to oil palm and/or cacao production had more trouble finding enough food to eat (availability), while they also employed more intense coping strategies to obtain food (access). We also found a significant negative relationship between a household's cash crop production and several metrics of food utilization (Table 2, Table S4). The relationship between cash crop intensity and the diet diversity and food variety scores were not significant, but some important shifts in food groups were observed. Households growing more cacao and oil palm reported consuming significantly less vegetables but more white tubers and fruits, indicating a decrease in dietary quality with higher levels of cash crop production (Table S4). Furthermore, children of farmers producing larger quantities of cash crops had significantly lower weight-for-age z-scores. Weight-for-height and height-for-age z-scores also correlated negatively with the quantity of a household's cash crop farming, however at insignificant levels (Table 2).

Taken together (Fig. 5), we show that farmers with greater percentages of their total land dedicated to cash crop production had significantly lower food availability and access while they had higher food utilization. In this figure—which uses standardized values ranging from 0 to 1 for all metrics—food utilization is presented as an average of the diet diversity score, food variety score, and weight-for-age, height-for-age, and weight-for-height anthropometric measurements of children under-5. From t-tests, we find that farmers dedicating less than 25 % of their land to cash cropping had significantly lower mean utilization scores than those dedicating more than 25 %. At the same time, mean availability and access scores

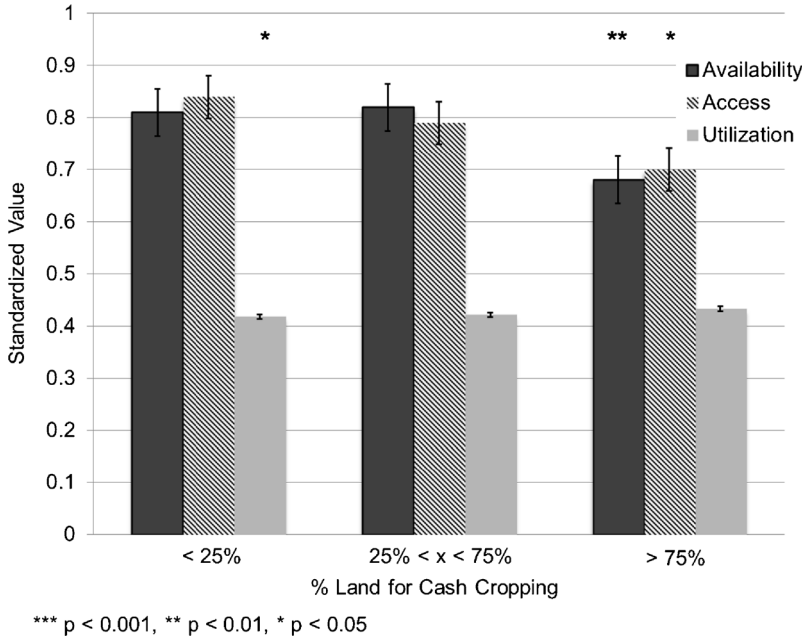

Fig. 5 Tradeoffs for cash crop agriculture and food availability (Months Adequate Food Supply), access (Food Coping Score), and utilization (an average of the Diet Diversity and Food Variety scores as well as child height-for-age, weight-for-height, and weight-for-age anthropometric measurements of nutritional status). All metrics were standardized ranging from 0 to 1 and expressed as the mean value for farmers dedicating less than 25 %, those dedicating greater than 25 % and less than 75 %, and those dedicating greater than 75 % of their total land to cash cropping. T-tests indicate that there are statistically significant differences in utilization between farmers dedicating less than 25 %—lower utilization—and those dedicating more than 25 %—higher utilization—of their land to cash cropping. There are also significant differences in availability and access between farmers dedicating less than 75 %—higher availability and access—and those dedicating more than 75 %—lower availability and access—of their land to cash crop production

were significantly lower for farmers dedicating more than 75 % of their land to cash cropping. This enforces the results from our regressions, which indicate that farmers with higher amounts of cash cropping in the Bonsaaso cluster experienced lower levels of food availability and access (Table 2).

Qualitative data from focus group participants indicated that food security remained a challenge at varying extents across the villages, with households claiming to have insufficient food supplies due to inadequate food availability and financial access. Households reported that local food prices had increased from 50 to 200 %, while prices for cacao beans and oil palm fruit had remained relatively stable. Food access was reportedly affected by increasing food prices, declining purchasing power, seasonal variation in food prices and demand, and limited access to markets with sufficient variety and quantities of food items. As a result, cash cropping households described having a limited ability to buy sufficient food, including especially non-staple items such as pepper, tomato, okra, and other vegetables. Farmers reported competition with cash crop production, small-scale mining, and poor farming practices as factors that limited self-production of food crops. Increased activity in small-scale mining also attracted foreign investment from China which, through migration, catalyzed increases in food demand and price, which food supply was unable to match. Finally, limited knowledge about nutrition and an inability to access locally available food items were identified as factors influencing food utilization.

Discussion

Our results indicate a significant negative relationship between the extent of household cash crop farming and measures of food access, availability, and utilization in the Bonsaaso MVP in Ghana. Given increasing global production of both oil palm and cacao (Fig. 1; FAOSTAT 2012), it is vital to enhance our understanding of the relationship between these crops' production and the communities in this study. It is equally important to stimulate discussion around strategies that could help avoid the observed tradeoffs, while exploring potential positive outcomes for food security of cash crop production in Bonsaaso. This analysis contributes to literature on the relationship between cash cropping and food security by providing a case study of a community participating in a rural development project in Ghana. By investigating cash cropping and the three pillars of food security simultaneously, while combining quantitative and qualitative measures, we provide new insights on this relationship that can help guide adaptive management of the MVP.

Several limitations of this study should be outlined. First, the data were collected in a setting undergoing a set of multi-

sector development initiatives (the MVP). As such, results are not readily comparable to sites lacking similar interventions. Second, the data were limited to one point in time; as such, there was no temporal component to the analysis. Consequently, in order to examine the relationship between cash crop agriculture and food security, comparisons were made among households with different levels of production. Third, as noted above, it is possible that households sold surpluses of subsistence crops as cash crops. Our data was not able to capture this dynamic. Finally, the sample size for each model was small (max $N=103$) and varied across indicators. A larger more uniform dataset would increase the consistency of study outcomes.

Based on the literature, we expected higher incomes from cash crop farming to augment a household's ability to obtain food (Von Braun and Kennedy 1986; Komarek 2010; Gauchan 1997; Negash and Swinnen 2013), but if local markets fail to supply adequate quantities of food items, or new variables such as migration linked to mining come into play, then this dynamic is unlikely to be observed (Gollin and Rogerson 2010; Adam et al. 2012). Indeed, households in our focus group discussions cited competition with cash cropping and small-scale mining, increasing food prices, and reduced purchasing power as major causes of the insufficient availability of food. This happened despite efforts from the MVP to increase productivity of food crops and strengthen the value chains of cash crops. Similarly, if families dedicating substantial proportions of their land to cash crops—rather than food crops—have to travel considerable distances to access markets, food availability could again be compromised. In both cases, regardless of whether a family's income increased as a result of cash crop production, food security would be diminished because of an inability to substitute crops previously grown with food purchases.

Furthermore, outcomes for food access could point to the seasonal flow of income from cash cropping (Khandker 2012; Pitt and Khandker 2002) and the potential for food gaps that occur when households expend their subsistence food supply and/or food stocks (Dostie et al. 2002; Devereux and Longhurst 2010; Kranjac-Berisavljevic et al. 2009). During the year quantitative data was collected, many families experienced a food gap, indicated by a spike in the number of households unable to attain sufficient food in June and July of 2009 (Fig. 4c). This gap coincided with an upward trend in the national consumer price index, which reflects the cost of a basket of essential food items and commodities (Fig. 4b) (FAOSTAT 2014). Given the crops native to the Ashanti region, subsistence farmers could obtain staple foods year-round. Subsistence crops in this region, such as cassava, plantains, and maize, are each grown several times during the year, allowing for more continuous opportunities to produce adequate amounts of staple foods needed for household consumption. In contrast, with the production of oil palm and cacao, which each have one major and one minor harvest season locally, cash is generated in lump sums at irregular intervals. As a result, cash cropping farmers in Bonsaaso may have been at a disadvantage in accessing sufficient food, especially during food gaps when consumer prices were at their highest.

Our results indicate that farmers were having more difficulty accessing adequate food for their families during certain months of the year (Fig. 4c). In particular, cash crop farmers had less access to high quality foods, including vegetables and fruits (Table S4). Echoing results from the literature, female-headed households had an easier time accessing food than households led by a male (Table 2) (Hoddinott and Haddad 1995; Kennedy and Peters 1992; Due and Gladwin 1991). While total income may or may not increase, the shift in income composition—from continuous flows to lump sums—may have affected the distribution of available capital over time, and thus farmers' ability to consistently access food if they were not employing appropriate savings strategies during food gaps (Von Braun and Kennedy 1986; Fafchamps 1992; Mainardi 2012; Pitt and Khandker 2002). Households in our focus group discussions described experiencing seasonal price variations during these food gaps, and cited them as an inhibiting factor in their ability to obtain food.

At the same time, an overall increase in food prices and decrease in purchasing power may be contributing to the lower levels of food access in cash cropping households in the Bonsaaso cluster (Fafchamps 1992; Zeller et al. 1997; Terry and Ryder 2007; Abdulai et al. 1999; Devereux and Longhurst 2010; Skoufias 2003; Batisani 2012). Similar negative relationships between cash cropping and nutrition outcomes, specifically stunting, have been observed in Malawi and linked to rising global and local food prices (Wood et al. 2012). Ghana's consumer price index increased each year during our study period (Fig. 4b), while there was a gap between the price of Ghanaian and international cacao prices (Fig. 4a). Cash crop farmers likely rely more on purchasing food items than fully subsistence farmers, and thus could be more affected by increasing commodity prices. According to our focus group discussions, the price of cacao plays a major role in local food access and availability; farmers stated that income from cacao production was not enough to meet household expenditure on food and other necessities, especially as profits are highly seasonal. Thus the gap between Ghanaian and international cacao prices, which can create a decreased purchasing power for cacao farmers, as well as an increase in the price of basic household commodities, could explain one aspect of the significant negative correlation between levels of cacao and oil palm production and the ease with which smallholders in Bonsaaso were able to purchase food (Fafchamps 1992; Abdulai et al. 1999; Skoufias 2003; Batisani 2012). This, however, is only one of many possible explanations,

and the cost of food and other commodities at local markets is essential in order to draw a more concrete connection between cash cropping, food prices, and food insecurity in Bonsaaso.

Prevalence of stunting, an indicator of chronic under-nutrition often used to assess overall development, did not change significantly with amounts of cash crop production (nor did measurements of the related variable, height-for-age). This could indicate that overall development is similar between food crop and cash crop producers in this setting, and that the effect on food security is mainly in food access and choices. The lack of a significant correlation between height-for-age and cash crop farming may also indicate that negative relationships between cash crop farming and food security are relatively recent in Bonsaaso—relating to, for example, increasing food prices. The effect, therefore, may already be apparent in short-term nutrition indicators such as weight-for-age, but has yet to surface in longer-term indicators including height-for-age. Other studies do show a significant relationship between chronic under-nutrition and cash crop farming, as for example among farmers growing tobacco in Malawi (Wood et al. 2012).

The interventions of the MVP, which focused initially on food crop productivity while gradually investing more in cash crops, might have contributed to a distortion in our results between cash crop farming and food security. In the first few years of the project, households investing heavily in food crops may have benefited more from interventions, in comparison with cash crop-oriented farmers. There are also many possible additional factors contributing to all three dimensions of food insecurity at the household level in Bonsaaso. Food access can be influenced by external variables affecting income, such as taxes, social safety nets, and cultures of governance (Zeller and Sharma 2000). There are many further aspects contributing to food utilization, and specifically the nutritional status of children. These include access to health services, sanitation, hygiene, feeding practices, and food preparation (UNICEF 1990). Since our analysis does not include changes over time nor reveal underlying drivers responsible for the relationships observed, future research to better understand these dynamics will be needed to further enhance our understanding of results from this study. Additionally, a more thorough understanding of intra-household dynamics, including allocations of food between family members, would shed a clearer light on potential benefits and detriments of cash crop agriculture in Bonsaaso.

In conclusion, this study demonstrates significant negative relationships between cash cropping and the three dimensions of food security—correlations rarely hitherto studied in tandem—through a case study of oil palm and cacao farmers in the MVP Bonsaaso cluster in Ghana. This research is crucial given continued rapid growth in both of these cash crop industries (Fig. 1; FAOSTAT 2012). While in some cases our findings echo the variability found in earlier studies, our analysis makes an important advance by considering multiple elements of food security and their relationship with cash crop practices. Our results emphasize the value of gaining a better understanding of the underlying drivers responsible for the observed adverse correlations between cash cropping and food availability, access, and utilization, in order to galvanize local policies aimed at improving food security for cacao and oil palm farmers in rural Ghana. On the whole, the adverse relationship between cash crop production and household food security observed in this paper calls for caution; results suggest that positive relationships cannot be assumed, and that further empirical evidence is needed to better understand these tradeoffs.

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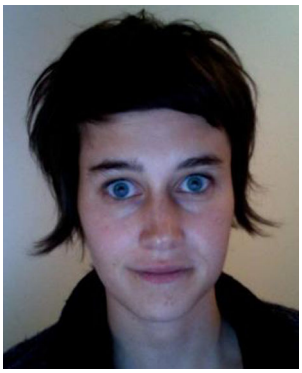

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