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Analyzing the contribution of crop diversification in improving household food security among wheat dominated rural households in Sinana District, Bale Zone, Ethiopia

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Abstract

Background: Agriculture is considered an important strategy for overcoming many of the emergencies faced by rural households in developing countries. In rural Ethiopia household access to food largely depends on what the household grows, either because they consume what they grow, or they purchase food with the income earned from what they grow. This study examines effect of crop diversification on food security and determinants of household food security among rural farm households of Sinana District, Oromia Regional state. The study uses a multi stage sampling procedure to select 384 sample households. Data were collected using a household survey, a focus group discussant (FGD), and key informant interviews. Ordinary least squares regression (OLS) and multinomial logistic regression model were used to analyze the data collected.

Results: We found that crop diversification had a positive and significant effect on household food security. Although crop diversification was positively associated with household food security, several other factors were found to be as or more important in increasing household food security. The education of the household head, access to irrigation system, livestock owned, total income, and remittance positively affected household food security. In contrast, age of household head and distance to nearest market were negatively associated with food security.

Conclusions: The study conclude that any effort to increase household food security should consider empowerment of farmers through adequate training and informal education, enhancing crop diversification, strengthening the rural infrastructural development (roads, market centers, and cooperatives).

Keywords: Food security, Multinomial logistic model, Rural households, Bale zone

Background

In developing countries, agriculture contributes to the entire economy and a source of food. It directly contributes to food security by making more food available or by enabling farm households to access using their farm income. Agriculture is also an important strategy to overcome many of the emergencies faced by rural in developing countries [1, 2]. In rural Ethiopia households' access to food largely depends on what the household grows, either because they consume what they grow, or they purchase food with the income earned from what they grow.

Food insecurity and undernutrition have been the major development challenges of developing countries

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[3, 4]. Food security is achieved when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life [5]. Despite growing national and global commitment towards the food and nutrition problem, a significant proportion of the population is food insecure and suffers from micronutrient deficiencies [6].

A latest report by Food and Agriculture Organization (FAO) shows that 10.9% of the world, 20.4% of Africa and 31.4% of Eastern Africa people were undernourished in 2017 [7]. Likewise, study [8] shows that in many developing countries, the condition of household food security depends mainly on physical and economic means (accessibility). It stated that economic, social, and environmental sustainability are essential for the accessibility to food for all people. Hence, without integrating sustainability to food security, it is impossible for policymakers to mitigate food insecurity. In Ethiopia, about 80% of the society lives in rural areas under insufficient infrastructural facilities. The majority of the households are smallholders [9]. They often face recurrent drought, weather variability, and food insecurity. Endalew et al. [10], for instance, came across that about 10% of Ethiopians were chronically food insecure throughout the normal year and this figure increased to 15% during frequent drought periods. In connection with the situation of food insecurity, in 2018, the Global Food Security Index (GFSI) of the Economist Intelligence Unit (EIU) ranked Ethiopia as 100th among 113 countries based on food affordability, availability, quality, and safety. According to the EIU Index [11], Ethiopia is a state with 28.8% prevalence of undernourishment, and very low in diet diversification, sufficiency of food supply, micronutrient availability, and food consumption as a share of household expenditure.

Albeit, household food insecurity, hunger and undernutrition have major implications for smallholder farmers in Ethiopia. Undernutrition is an underlying cause of 53% of infant and child deaths. Over the past decade, rates of stunting and underweight have decreased gradually but it remains high with 44% of children under-five stunted and 29% underweight [9, 12].

Food insecurity in Ethiopia is derived primarily from dependence on undiversified livelihoods based on low output rain-fed agriculture [13]. The challenges are traced back to poor infrastructure, declining soil fertility and climate change, among others. Like most part of Ethiopia, Sinana District, the focus of this study, has been stricken by poverty and experiencing household food insecurity [14]. Consequently, smallholder farmers in the areas are forced or encouraged to diversify crop production in order to overcome twine-objective of stabilize their food stocks and incomes. Crop diversification, characterized by, cultivating more than one variety of crops belonging to the same or different species in a given area, is the mechanism to overcome household food insecurity problems [15]. It is a method of developing a resilient agricultural system, especially where communities depend largely on agricultural products (food and fodder) for his or her livelihoods [15, 16]. Pellegrini and Tasciotti [17] illustrated that the number of crops produced highly contributes to household food security and dietary diversity. They also argued that crop diversification has a double role: it has high impact on households' diets and, other things being equal, it increases agricultural revenues. A study by [18] also suggested that families who grow a diverse set of crops are less likely to be poor as compared with households specializing in their crop production. According to [19], cultivating several crop species can also help smallholder farmers to manage price and production risks. Ultimately, crop diversification contributes to improved yield for the smallholder farmer, which in turn translated into more and a variety of food for consumption and marketable surpluses from production. Therefore, this study aimed at examining the effect of crop diversification on food security (access and utilization) and identifying determinants of household food security among rural households of the Sinana District, Ethiopia.

Materials and methods

Sinana Woreda setting

The study was conducted in Sinana District which is located in Bale zone (Fig. 1). It is bounded with Goro and Ginir in East, Dinsho in West, Agarfa and Gasera in North and Goba and Barbare Oreda in the south. The district lies between 6° 55′ 00″ to 7° 18′ 00 North and 39° 53′ 00″ to 40° 26′ 00″ East. The altitude of the district ranges from 1650 to 2950 m a.s.l.

The district has 20 rural kebeles. The total area of the district is about 1168 km^2. About 73.54% is plain land, 3.7% is hills, 9.6% is mountains, 12.3% is rugged and 0.86% is gorge. The annual average temperature is 16.5 °C, whereas the minimum and maximum temperature is 9 °C and 23 °C, respectively. Rainfall pattern of the District is characterized by bi-modal rain fall distribution. The annual average rainfall is 1105 mm, whereas the minimum and maximum rainfall is 1060 and 1150 mm, respectively [20].

With 99% of the population engaged in farming, agriculture is one of the economic activities of the district. Farmers in the district practice mixed farming that incorporates both crop and livestock. The major crops produced in the district are cereals, pulses and oil crops [14].

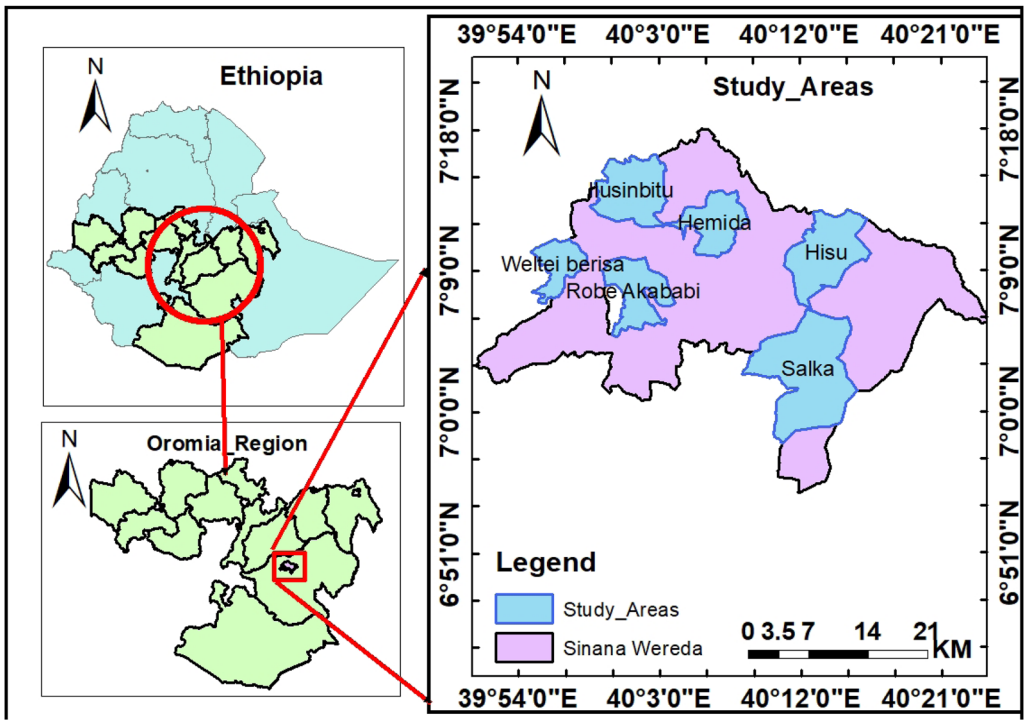

Fig. 1 Map of study area

Study design

The study employed a cross-sectional survey using a mixed methods research approach. The choice of mixed methods was dictated by the research problem under [21, 22]. It involves a multi stage sampling technique to select sample kebeles and households surveyed. First, the district was selected purposively due to dominance and potential in wheat production. Second, representative Kebeles were selected using simple random sampling method. Third, respondent households were randomly selected from lists of names of household head in the Kebeles using computer-generated random number table.

The primary data were collected from the households, key informants such as, community elders, Development Agents (DAs), and Health Extensions and Researchers and different development experts in the district. Before starting the actual data collection, the questionnaire was pre-tested. Based on the pretest results, the necessary modifications were made to the questionnaire. Focus group discussions (FGDs) were also conducted with group of male and female on the issues related to economic activities, food security and home consumption behavior among rural households. Twelve FGDs, two in each selected kebeles were made to obtain important qualitative data.

In order to obtain a representative sample size, the study employed the sample size determination formula given by [23]

$$n = \frac{N}{1 + N(e^2)} = \frac{9768}{1 + 9768(0.05^2)} = \frac{9768}{1 + 24.42} = 384 \quad (1)$$

where n is the sample size, N is the population size (total households in the six kebeles, which is 9768) and e is the level of precision.

Methods of data analysis

The survey data were coded, organized, summarized and analyzed using descriptive, and econometric model analysis. STATA version 14.2 was used to aid data analysis. While the qualitative data were analyzed using narration and conceptual explanation, quantitative data were analyzed using Ordinary least square (OLS) method and a multinomial logit model.

Crop diversification analysis

The study adopted one of the widely used in crop diversification analysis called Herfindahl–Hirschman Index (HHI) to measure crop diversification to represent relative land sizes of farming activities undertaken by a given farm [24]. The crop diversification index (CDI) is an

index of concentration. It has a direct relationship with diversification such that a zero value indicates specialization and a value greater than zero signifies crop diversification. The CDI is obtained by subtracting the Herfindahl index (HI) from one (1-HI). Precisely, the CDI is calculated as follows:

$$p_i = \frac{A_i}{\sum_{i=1}^{n} A_i} \tag{2}$$

where P_i = proportion of ith crop, A_i = area under ith crop (ha), $\sum_{i=1}^{n} A_i \text{totalcropland(ha)and} i = 1, 2, 3 \ldots, \text{n(numberofcrop)}$

$$\text{HerfindahlIndex} = \text{HI} = \sum_{\text{i=1}}^{\text{n}} \text{p}_\text{i}{}^2 \tag{3}$$

$$\text{Crop diversification index} = \text{CDI} = 1 - \text{HI} \tag{4}$$

Food security analysis

In this paper, we adopt Household Food Insecurity Access Score (HFIAS) and Dietary Diversity as a measure of household food security in the study sites.

Household Food Insecurity Access Score (HFIAS)

The HFIAS is a continuous measure of the degree of food insecurity (access) in the household in the past 30 days. Despite the limitations of all measures, the HFIAS has been found to be understandable and applicable across varying contexts [25]. Additionally, it has been identified as it uniquely able to detect aspects of food insecurity involving decreased access to a sufficient quantity or quality of food [26].

According to [27], the HFIAS reflects the three universal domains of household food insecurity that is anxiety about household food insecurity, insufficient quality and insufficient quantity of food supplies. This indicator captures the household's perception about their diet regardless of its nutritional composition [28]. It is supported the idea that households' experiences of food insecurity cause predictable reactions and responses which will be captured and quantified through a survey then summarized into a score. Following [29], the HFIAS is computed as follows:

HFIAS (0–27) = summation of the frequency of occurrence during the past 30 days for the nine-food insecurity-related conditions

$$\begin{aligned}\text{HFIAS}\ (0-27) = {} & Q1a * F1 + Q2a * F2 + Q3a * F3 \\ & + Q4a * F4 + Q5a * F5 + Q6a * F6 \\ & + Qa7 * F7 + Q8a * F8 + Q9a * F9\end{aligned} \tag{5}$$

At a household level, a high HFIAS shows that a household is very food insecure, while a low score shows that a household is less food insecure.

Dietary diversity score

According to FAO's guidelines for assessing household dietary diversity, the population of interest should be chosen prior to the start of the data collection. Because it helps to adapt the questionnaire to the local survey context [25]. A dietary diversity questionnaire can be used to collect information at either household or individual level. The decision on how to collect information depends on the purpose and objective of the survey. If the purpose and objective of the survey are to determine nutrition, assessing household dietary diversity would be the best approach [30]. The dietary diversity score (DDS), is calculated by summing the number of unique food groups consumed during the last 7 days [31]. The value ranges from 0 to 12, in which lowest DDS value signifies higher food insecurity status and vice versa. Even though there is no international consensus on which food groups to include in the scores [32], the DDS denotes 12 food groups. These are cereals; root and tubers; vegetables with tubers; leafy vegetables; fruits; meat, poultry; eggs; fish; pulses/legumes/nuts; milk and milk products; oil/fats; and sugar/honey. This study considered the 12 food groups in the analysis.

Effect of crop diversification on household food security

In the analysis of the relation between crop diversification and food security, the study used an ordinary least squares (OLS) regression. Crop diversification index (a continuous variable and food security outcomes DDS and HFIAS are taken as dependent variables (all continuous variables) that, we decided to use OLS regression. According to [33], it is appropriate to use OLS to ascertain influence of a continuous variable on another continuous variable similar to the current study. The OLS model is specified as

$$Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} \cdots + \beta_n X_{in} + e \tag{6}$$

where Y_i = household food security outcome (either DDS or HFIAS), X_{i1} = crop diversification index, X_{i2} = sex of household head, X_{i3} = age of household head (in year), X_{i4} = education level of household head, X_{i5} = household size, X_{i6} = farm land size, ..., β_0 = intercept, β_1 to β_n are coefficients, and e is the error term. Table 1 shows the description of variables used in our analysis.

Specification of multinomial logit model

We assessed the determinants of the levels of household food insecurity status using a multinomial logit model. The dependent variable is the discrete or categorical variable represented by household food insecurity access prevalence (HFIAP) status. According to [34], the multinomial is a generalization of the familiar logistic regression, which is used when there are more

Table 1 Summary of variables included to affect household food security status. Source: Own hypothesis

Variables	Variables unit and measurement	Variable class	Sign
Dependent variables			
HFIAS	Household Food Insecurity Access Score	Continuous	
DDS	Score of food group consumed	Continuous	
Explanatory variables			
CDI	Crop diversification index	Continuous	±
Gender	Household head, 1 = male, 0 = female	Discrete	±
Age	Age of household head in year	Continuous	±
Edu	Education in year of schooling	Continuous	+
Hsize	Size of household in number	Continuous	±
Lsize	Size of Farm in ha	Continuous	+
Iuse	Access to irrigation land, Yes = 1, No = 0	Continuous	+
Cuse	Access to credit, Yes = 1, No = 0	Discrete	+
Coops	Member to farmers cooperatives, Yes = 1, No = 0	Discrete	+
Market	Distance to local market in hour	Continuous	−
Nincome	Total annual income in birr	Continuous	+
TLU	Livestock holding in TLU	Continuous	+
Remit	Remittance, Yes = 1, No = 0	Discrete	+
Nonfarm	Participation on non-farm activities, Yes = 1, No = 0	Discrete	+
extenvisit	Extension contact in days per month	Continuous	+
Aginform	Access to agriculture information Yes = 1, No = 0	Discrete	+

than two discrete possibilities for the dependent variable. The multinomial logit model generally captures how households' socio-economic and demographic variables affect the probability that a household within the sample exhibit any of the identified possible levels of food insecurity in reference to base outcome. As noted by [35], the use of multinomial logit model is often an important econometric strategy when the choices are unordered. In this case, the test of independence of irrelevant alternatives (IIA) assumption of this model is required. Independence of irrelevant alternatives implies the marginal effect of choosing food secure households as reference households is not affected by the existence of other levels of food insecurity ($p = 1$, 2, 3). In other words, even if households in other levels of food insecurity are taken as a reference point, the outcomes or estimated parameters are expected to be the same. Subsequently, we tested the assumption of IIA and confirmed the suitability of multinomial logit model in the study.

Following [36] the multinomial logistic regression model is defined as follows:

$$\mathrm{p}_{ji} = \frac{e^{x_j'\beta j}}{\sum_{j=1}^{m} e^{x!j\beta j}} = 1, \ldots, m, \tag{7}$$

where $p = 1$ food secure households; $p = 2$ mildly food insecure households; $p = 3$ moderately food insecure households and $p = 4$ severely food insecure households; β_j is a vector of coefficients on each of the independent variables X. Equation (7) can be normalized to remove indeterminacy in the model by assuming that $\beta_0 = 0$, and the probabilities can be estimated.

The multinomial logistic coefficients are difficult to interpret, and associating the β_j with the jth outcome is tempting and misleading. Thus, in order to interpret the effects of explanatory variables on the probabilities, marginal effects are usually derived [37]:

$$\frac{\partial p_j}{\partial x_i} = p_j\left[\beta_j - \sum_{k=0}^{j} p_{k\beta_k}\right] = p_j\left(\beta_j - \bar{\beta}\right) \tag{8}$$

where P is the probability, X is socioeconomic characteristics and other factors, and β is a vector of coefficients. The marginal effects measure the expected change in probability of a household fall into particular household food insecurity level with respect to a unit change in an explanatory variable [38]. The signs of the marginal effects and respective coefficients could also be different. The marginal effects depend on the sign and magnitude of all other coefficients.

Results

Socio-demographic and socio-economic characteristics

The average age of household-head was 44 years with standard deviation of 10.0. The age of sample household heads ranged from 25 to 68 years. The study revealed that the majority of respondents were within the active labor force. The study also found that two to five persons participated in farming activities for most families.

The mean distance between the sample kebeles and the nearest market place in kilometer is 10.4 km with a minimum of 1.2 kms and a maximum of 15 kms (Table 2).

The study shows the average family size of household is 7.06 persons with standard deviation of 2.24. About 82.8% of household heads were unable to read and write. The remaining 17.2% had attended education level of (primary school 15.4%, secondary school 1.6 and university or college level 0.5%). The average farm experience of household heads is 24.7 years with standard deviation of 8.7.

Regardless of the size of landholding, all the respondents operate farm plots. The landholding size vary from 0.25 to 9 ha. The average landholding is about 2.99 ha with standard deviation of 1.59 ha. In the same token, almost all sample household's own livestock with the mean livestock ownership of 7.5 in Tropical Livestock Unit (TLU) with standard deviation of 4.5 (Table 2).

About 88.25% of studied households were male-headed, while the remaining 11.75% were female-headed households. About 96.87%, 1.83% and 1.13% were married, divorced, and widow/widower, respectively.

In Sinana District, almost every one is a member of the traditional local institutions such as Idir/Afosha self-help group to cope with funerals, house construction and savings. The study result indicates that the majority (67.97%) were not members to farmers' cooperatives. Only 12.50% of the sample households received credit, while 87.50% did not due to various reasons. Out of the non-users, 79.9% did not used credit due to their religion affiliations and 5.9% failed to use credit due to fear of repayment (Table 3).

Most respondents (72.66%) did not receive any remittance from anywhere, while the remaining 27.34% received some remittances. The survey results also showed that 95.05% of the sample households obtained agricultural extension contact (Table 3).

In order to triangulate the above results, focused group discussions were made. The discussants revealed that for rural farmers' food availability is highly determined by their own agricultural production and available assets mainly livestock. Moreover, landholding size is crucial for farmers' food security situation. However, focus group participants argued that landholding size in the study area is diminishing mainly due to increasing population size and problem of engaging in the non-farm sector. Furthermore, participants also indicated that the increased variability of rain fall has triggered and escalated the vulnerability of food production. Consequently, the seasonal variability of rain-fall has pushed

Table 2 Household socio-economic characteristics for continuous variables ($n = 384$)

Variables	Mean	St. dev	Min	Max
Age of household head (in year)	44.33	9.95	25	68
Education level of hh head (in year)	0.36	0.81	0	4
Household size (number)	7.06	2.24	2	17
Farm/land size (in hectares)	2.99	1.59	0	9
Distance to nearest market (walking munit)	29.34	10.19	10	50
Total net income (birr)	6943.19	6899.99	1200	90,000
Total non/off-farm income (birr)	1333.33	2139.50	0	9000
Livestock holding (TLU)	7.48	4.46	0	27.017
Length of food store after harvest (in month)	1.81	1.25	0	3

Table 3 Household characteristics for categorical variables ($n = 384$)

Variables	Frequency	Percent
Sex of household head (gender)		
Male	46	11.75
Female	338	88.25
Marital status (Mstatus)		
Married	371	96.87
Divorced	7	1.83
Widowed	5	1.31
Participation on irrigation farming (iuse)		
Yes	354	92.19
No	30	7.81
Use of credit (Cuse)		
Yes	48	12.50
No	336	87.50
Extension agent visit to farm (extenvisit)		
Yes	365	95.05
No	19	4.95
Members to famers cooperative (Coops)		
Yes	261	32.03
No	123	67.97
Remittance (remit)		
Yes	105	27.34
No	279	72.66
Participation on non/off-farm income (nonffarm)		
Yes	132	34.62
No	252	65.38

the farmers toward unforeseen margin of vulnerability due to low food production. In other words, unpredicted extreme weather events have impacted on the livelihood assets and threaten the stability of food supply system.

On the issue of crop management particularly, pests and disease control, high incidence of disease and pests cause substantial yield loss, lower grain quality and it interfere with normal physiological development of crops. In this regard, FGD participants has emphasized that the existence of plant disease associated with their wheat farms. Hence, farmers used chemical methods (use of pesticides and herbicides) for wheat farmers in the study areas. Low income households opt to use cultural pest and disease control methods. These methods include: hand weeding and crop rotation.

Similarly, findings from key informant explained that availability of inadequate infrastructures and social services development like road, transportation, communication, electrification, clean water, and agricultural services are the impediments for the sustainability of agricultural production and food security in the study area.

Household food security status

Household food insecurity status measured by HFIAS

The result indicates that 55.73% ($n=213$) of households were never worried about having no enough food. In contrast, the remaining 44.2% ($n=170$) of surveyed households have experienced problems of both economic and physical access to food at various degree (Table 4).

The severity level depicted that during the last 1-month period, about 44.56% of households encountered access problems "rarely"; about 24.87% "sometimes" and about 30.57% "often". Furthermore, the finding shows the mean score of HFIAS for the respondents is 11.63 with a standard deviation of 5.16. The finding further showed that 55.87% ($n=214$) were most food secure; 24.02% ($n=92$) were medium food insecure; and 20.10% ($n=77$) were most food insecure. The result implies only 7.32% of the respondent's *food secure,* i.e., such households never experience or worried about any form of the food insecurity conditions. In contrast, about 8.07% of the respondents were *severely food insecure,* while about 49.96% and 34.64% of the respondents were *mildly food insecure* and *moderately food insecure,* respectively.

Food security measured by DDS

The results of the finding on the DDS show respondents were found to have consumed an average of 5.73 food groups with a standard deviation of 1.97. The minimum DDS value is 2 and the maximum DDS value is 11. The summary of the DDS in study area is presented in Fig. 2. Further, based on FAO [36] categorization about 13.54% of the respondents were found to consume less dietary diversity, implying they are more food insecure due to lack of the means to acquire and consume a variety of foods. Those who have medium level of DD account for 50.52%, and about 35.94% of the respondents have DDS ≥ 8 that they were food secure and were able to acquire and consume a variety of foods.

Effect of crop diversification on household food security

We run *F*-statistics and found out that the variables included in the OLS models are significant in influencing the respective dependent variables DDS and HFIAS. The value of R^2 for the DDS and HFIAS model is 22% and 15%, respectively. This means that 22% of the variation in DDS and 15% of the variation in HFIAS are explained by the variables included in the two respective models. As such CDI, Farm land size, TLU, positively influence DDS, while distance to nearest market and access to remittance have a negative influence on DDS. While CDI, age and education have a negative influence on HFIAS, the

Table 4 Distribution of households by HFIAS condition

HFIAS condition	Rarely		Sometimes		Often	
	N	%	*N*	%	*N*	%
Worry about food	136	80.00	19	11.78	15	8.82
Unable to eat preferred foods	195	53.72	114	31.40	54	14.88
Eat just a few kinds of foods	92	30.46	84	27.81	126	41.72
Eat foods they really do not want eat	41	11.40	87	23.77	238	65.03
Eat a smaller meal	99	51.03	63	32.47	32	16.49
Eat fewer meals in a day	75	68.81	19	17.43	15	13.76
No food of any kind in the household	38	82.61	5	10.87	3	6.52
Go to sleep hungry	16	88.89	2	11.11	0	0
Go a whole day and night without eating	12	100	0	0	0	0

Clues to the severity status: (1) Rarely (once or twice in the past 4 weeks); (2) Sometimes (three to ten times in the past 4 weeks); (3) Often (more than ten times in the past 4 weeks)

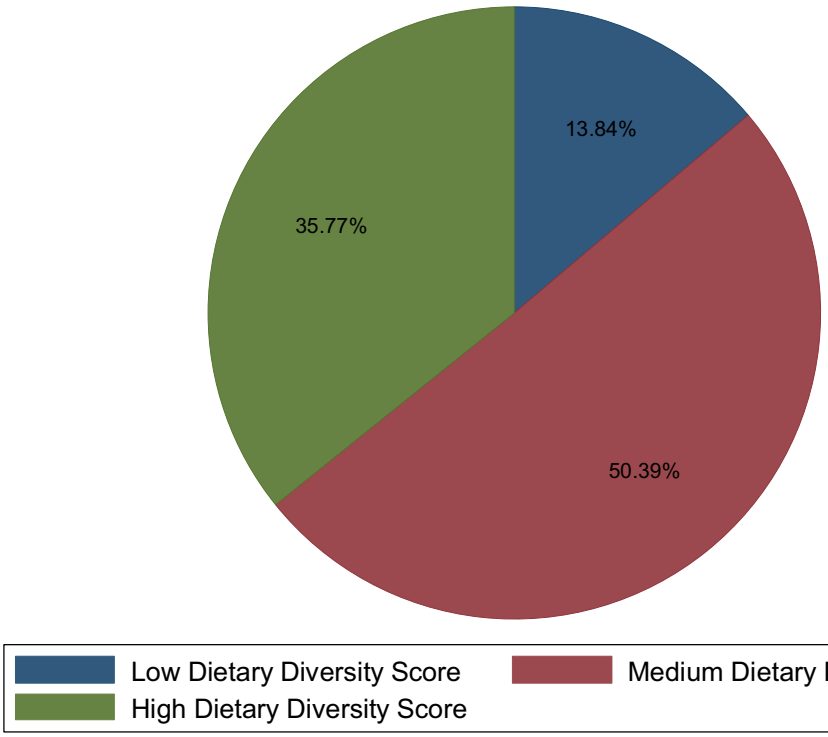

Fig. 2 Dietary diversity status of study site (Source: Field survey 2019)

distance to nearest market and access to remittance positively influence HFIAS (Table 5). Crop diversification as measured by the index has a positive influence on DDS and a negative influence on HFIAS. The coefficient of CDI is also significant at 1% and shows a positive influence on household DDS. Oppositely, the coefficient of CDI is significant at 1% and shows a negative influence on HFIAS.

Determinants to household food insecurity

We employed multinomial logistic analysis to determine factors affecting household food security phenomenon. We hypothesized independent variables were expected to affect the household food security. Before running the econometric model, the independent variables were tested for the presence of multicollinearity. The calculated VIF values are all less than 10 (the cut-off point) which indicated that multicollinearity is not a serious problem. The goodness of fit in multinomial logistic regression analysis was checked and the likelihood ratio test statistics indicated by the Chi-square statistics is highly significant (significance = 0.0000) suggesting strong explanatory power of the model. The value of R^2 for the multinomial logistic regression analysis is 12%. The result of the multinomial logit analysis of the hypothesized independent variables which were expected to affect the household food security are provided in Table 6.

Age of household head The result of the model depicted that the age of the household head was negatively related to household food security compared to base category, which is mildly food insecure. Keeping other factors constant, food security condition decreases by 0.50% when age of the household head increases by 1 year.

Marital status Marital status of the household head positively affected household food security when compared to base category. The model predicted that the likelihood of household being food secure increases by a factor of 0.121 when household is married.

Education level of household head The result of this study indicates that when comparing with the base category, household head education level positively affected household food security. From the model result, the marginal effect reveals that the literacy level of household head increase likelihoods of household food security by 7.9%.

Access to irrigation farming Participating in irrigation is another important factor in determining house-

Table 5 OLS regression of the effects of crop diversification on household food security

Variables	DDS		HFIAS	
	Coef	*P>t*	Coef	*P>t*
Crop Diversification Index (number)	1.01	0.00*	− 1.48	0.00*
Sex of household head (male/female)	− 0.27	0.36	0.02	0.98
Age of household head (year)	0.01	0.32	− 0.05	0.07***
Edu of household head (year of schooling)	0.14	0.25	− 0.79	0.02**
Household size (number)	− 0.05	0.32	0.18	0.16
Farm land size (in hectares)	0.14	0.05**	− 0.29	0.13
Irrigation farming (yes/no)	0.63	0.10	− 0.35	0.74
Access to credit (yes/no)	0.00	0.99	− 0.10	0.90
Membership to famers cooperatives (yes/no)	0.10	0.60	− 0.25	0.67
Distance to the nearest market (walking min/h)	− 0.03	0.00*	0.06	0.02**
Total annual net income (birr)	0.18	0.18	0.83	0.12
Livestock ownership in TLU	0.06	0.01**	0.03	0.64
Access to remittance (birr)	− 0.68	0.01**	2.82	0.00*
Participation on off/non-farm activities (yes/no)	0.14	0.56	− 0.21	0.74
_cons	4.99	0.00	7.11	0.00
R^2	22.0		15.0	
Adjusted R^2	19.01		11.7	
F	1.8		4.9	
N	383		383	

* , **, and *** indicate statistical significance at 1, 5, and 10% probability levels, respectively

Table 6 Multinomial logit model

Variables	Food secure			Moderately food insecure			Severely food insecure		
	Coef	Std.err	M.eff	Coef	St.er	M.eff	Coef	St.err	M.eff
Gender	0.645	0.523	0.079	0.281	0.465	0.008	0.271	0.509	0.002
Age	− 0.029***	0.018	− 0.005	0.007	0.017	0.002	0.020	0.020	0.003
Mstatus	1.332***	0.781	0.121	1.264	0.781	0.113	1.013	0.832	0.030
Edu	0.496**	0.225	0.079	0.079	0.179	0.034	0.003	0.222	0.011
Hsize	− 0.011	0.075	− 0.006	0.070	0.073	0.010	0.056	0.088	0.004
Lsize	0.068	0.116	0.011	0.047	0.111	0.008	− 0.085	0.133	− 0.013
luse	− 0.512	0.546	− 0.012	− 1.469**	0.817	− 0.217	− 0.093	0.895	0.059
Cuse	0.886**	0.441	0.101	0.293	0.466	− 0.020	0.787	0.543	0.054
Coops	0.226	0.380	0.059	− 0.461	0.333	− 0.079	− 0.174	0.379	− 0.008
Market	0.026	0.017	0.002	− 0.003	0.016	− 0.005	0.091*	0.021	0.010
Nincome	0.193	0.206	0.061	− 0.219	0.213	− 0.014	− 0.800*	0.274	− 0.088
TLU	0.013	0.036	0.005	− 0.082**	0.039	− 0.015	0.028	0.039	0.006
Remit	− 0.338	0.449	− 0.115	0.912**	0.394	0.131	0.897	0.459	0.076
Nonfarm	− 0.367	0.402	− 0.044	− 0.464	0.373	− 0.072	0.294	0.448	0.061
Prodpyear	0.663	0.542	0.072	0.697	0.488	0.087	− 0.019	0.516	− 0.047
agrinform	0.257	0.450	− 0.015	− 0.468	0.395	0.098	− 0.850**	0.437	0.040
CDI	− 0.472	0.312	− 0.029	0.818*	0.304	− 0.025	0.689**	0.355	− 0.066
_cons	− 2.620	1.627		− 2.432	1.524		− 5.551	1.708	
Log likelihood = − 440.689				Number of observation =				384	
				LR Chi^2 [49] =				122.17	
				Prob > Chi^2 =				0.0000	
				Pseudo R^2 =				0.1217	

* , **, and *** indicate statistical significance at 1, 5, and 10% probability levels, respectively

hold food security. In study area merely about 21.7% of households participate in irrigation farming despite optimistic view of the focus group discussants and key informants who outlined the presence of some opportunities for irrigation-based farming. The model result indicated that there is a negative association between irrigation and moderately food insecurity status of the studied households. Irrigation negatively and significantly affected moderately food insecurity. All other things remain constant, the marginal effect of the model predicted that participation in irrigation farming decreases moderately food insecurity by a factor of 0.012.

Access to credit Use of credit was also one of determinant factors that affect household food security. Credit utilization positively determines household food security. The marginal effect shows, other things being constant, the likelihood of household being food secure increase by 10.10% when household used credit.

Distance to the nearest market In this study, distance to the nearest market was found to be the most important predictor variable affecting household food security. From the results we see that comparing with the base category, distance to the nearest market. The marginal effect indicates that, the likelihoods of the household being severely food insecure decreases by 1.00% as distance to the nearest market increases by one-minute walking.

Total the net income There is a negative relationship between total net income of the households and their food security conditions when comparing with the base category. The marginal effect shows other things being constant, the likelihood of household being severely food insecure decrease by 8.80% as income of household increase by one birr.

Livestock own in TLU Livestock own in TLU is significant at 5% probability level and influences negatively the moderate food insecure category. Other things remain constant, the marginal effect of the model shows, with a one-unit increase in livestock holding in TLU decreases the household's tendency to fall in moderately food insecure by 1.50%.

Income received through gift (aid) and remittance Income received through gift (aid) and remittance positively affected moderately and severely food insecurity categories. The marginal effect of the model shows, with a one-birr increase in household remittance, the household's tendency to fall in moderately food insecure increases by 13.1% *ceteris paribus*.

Access to agriculture information Access to agriculture information is significant at 5% probability level and influences negatively the severely food insecure category. Holding other variables in the model constant, the marginal effect of the model shows, access to agriculture information decreases the household's tendency to fall in severely food insecure by 4.00%.

Crop diversification Crop diversification index negatively affects moderately and severely food insecure categories in study area. The marginal effect shows, other things being constant, the likelihood of household being fall in the moderately and severely food insecure categories decreases by 2.50% and 6.60%, respectively, as crop diversification index increases by one unit.

Discussion

This study assessed effect of crop diversification on household food security and determinants to household food security in Ethiopia. In this study, the average family size of 7.06 persons is by far larger than the national average of 4.6 persons per household [39, 40]. The findings of this study revealed that households with higher crop diversification intensities are more likely to have diversity in terms of food crops that can be consumed within the household thus justifying the positive relationship. This implies crop diversification improves dietary diversification in Sinana District.

The result also showed crop diversification reduces the severity of food insecurity in Sinana District. It suggests that households with higher crop diversification intensities are more likely to diversity in terms of food crops. This indicates crop diversification improves dietary diversification in study area. The negative relationship between CDI and HFIAS implies that households with higher crop diversification intensities are more food secure as compared to those with relatively lower crop diversification intensities. The possible clarification of this result could be that households that engage in multiple cropping are diversifying the possible risk of a particular crop failure in a season. Households that cultivate multiple crops are better assured of food availability and access than household who practice mono cropping. For instance, in a season, where one particular crop fails to give much yield, other crops may be better off on which farmers may rely on for survival. Thus, farmers who intensify crop diversification are better off than their counterparts, because diversification is positively related to dietary diversification and negatively related to food insecurity. This is mainly attributed to the benefits of crop diversification to include, raising farm productivity, income, and reducing production and price risks. Our finding concurs with previous similar studies,

which demonstrated positive relationship between crop diversification and food security of the household [16, 41, 42]. For example, Jones and others [43] found that farm production diversity was consistently and positively associated with household dietary diversity. More generally, Agriculture, crop diversification in particular can offer opportunities for soil and land use management, and biomass production [44]. Others, for instance [45, 46], found that crop diversification positively influence participation in insurance schemes that help reduce farmers' risk from weather and price shocks. Further, the merits of crop diversification in improving food security can be manifested through better management of price and production risks [47]. This is probably due to growing more than one crop species in a single season gives the farmers more options. It in turn helps the farmers to manage price and production risks better as compared to less diversified farming enterprises.

Although crop diversification was positively associated with household food security, several other factors were found to be as or more important in increasing household food security. The age of household head negatively associated with household food security. However, this finding contradicts our expectation (Table 6). The possible reason could be as the age of the person increase, one may lose job and/or could not participate in other income generating activities. Furthermore, elderly farmers do not have the required labor force to produce more food crops compared to the young people. This is in line with findings from other studies [48]. Previous studies argued that younger farmers are more likely to be food insecure than the older farmer due to better capital accumulation of the later [49].

Marital status affected household food security. However, being married in itself is not an assurance to escape from the risk of food insecurity. This might imply that a household headed by married parents support each other all their way to food sufficiency in contrast to a single or widow household who often lacks mutual support. It is related to factors such household size, level of income household, among others that affect food security status associate to marital status. Consonant with our study [50], found that marital status has positive relation with household food security.

On average, large number of farmers did not attend the minimum required educational level. They may not understand adequately written agricultural instructions and information provided by the extension workers. The finding of the study indicates that education and farm experiences significantly affect household food security in study area. The possible reason is better educated household heads are more likely to secure food than uneducated (illiterate) household heads. This is due to the fact that the contribution of education to work efficiency, competency, diversify income and becoming visionary in creating conducive environment is positive. It has had a spillover effect on the education of dependents and long-term target to ensure better living condition than illiterate ones. The result coincides with the theoretical evidences that educational improvement could lead on reducing the matter of food insecurity. Studies [50–52] in Dire Dawa, Addis Ababa and elsewhere supported our expectation that a household head with higher education level increases the chance of household achieving food security.

Participation in irrigation farming affected household food security. This implies that irrigation enables households to grow food crops more than once a year, hence increased production, income and food availability of the household. So, it overcomes of food insufficiency in dry or food shortage circumstance and normal seasons. This result is similar with the result of [53].

Credit is a source of capital that boosts the capacity of rural households to purchase yield enhancing agricultural inputs and has remained to be a shortcoming for poorer households in intensifying the farming sector. Thus, the influential association between use of credit and household food security may be due to the fact that households that use credit has opportunity to purchase agricultural input and allow households that cultivate larger land areas produce enough food to feed their household members and also produce surplus to sell and increase their household income. Similar study found out that credit is important to invest on activities that generate income for farm households. The households can purchase agricultural inputs such as improved seeds, fertilizer, and fattening and selling livestock to earn additional income. Farm households who have access to credit could increase their production and other possibilities and hence escape food shortage [54].

Market distance refers to the number of kilometers farmers have to travel to reach the next marketplace to sell their produce. Farmers who live near to the market places are more food secure than their counter part. Previous studies [55, 56] in Ethiopia revealed that market access has negative and significant effect on household food security.

The result shows that those households who possess large income are more likely classified as food secure. The result corresponds with the prior expectation, and therefore, the possible explanation is that income determines purchasing power of the household with the prevailing price in order that those households having higher income are less likely to become food insecure than low income households. This finding is consistent with a study reported from Ethiopia, Ghana and South Africa [57–59].

The positive relationship between livestock owned and household food security is explained by the fact that livestock size being a proxy for rural household resource endowment and asset accumulation. As such, those sample respondents with large livestock size have better chance to earn more income. This demonstrated that as the livestock resources increases, the probability of the household to secure food increases. In support our finding [60], found out that households with more livestock ownership were less likely to be food insecure in rural Ethiopia. Similarly [61, 62], demonstrated that livestock ownership and sales contributed to the household food security through increasing in food consumption expenditure and dietary diversity.

The positive relationship between household food security and remittance is due to the fact that an increase in remittance and gifts income will have a positive effect, because the change in income will cause constant change in expenditure. Thus, the income received from remittance and gifts increases the income in order that capacity of the households to consume more will increase. In support of this findings [63, 64], revealed that households with remittances had better food consumption, minimized vulnerability, and better food security than the households that did not have remittances, but contended that the benefit to solve food insecurity was temporary. Further, the result is in line with the findings of [65]. They argued that remittance contributes to economic development and protects basic human rights, where the aid fills a severe food gap. In contrast, a study conducted in Niger by [66] revealed that food aid influences negatively and significantly the household food security. Similarly, a study done by [49, 67] in Ethiopia suggests that food aid displaces domestic production and commercial trade by depressing prices in the recipient countries; it affects the labor supply negatively, enhances market imperfections and information asymmetries, and this, in turn, affects economic development.

Based on household food insecurity access prevalence, our study is in line with that of [43] who found out that more diverse production system can also lead to more diverse household diets in Malawi. Regarding the remoteness and the poor quality of infrastructure in our study areas, the household food access depends on what the household often produces. In other words, the households' food diet is closely linked to their experiences of crops production. Household may choose to diversify crops because of poor infrastructure [68]. This would help them to obtain the kind of food they need at the local level. Concurrent results were reported from Kenya and Tanzania by [69] who found that in, the number of crops grown by a household has associated with the dietary variety of the household.

Conclusion and recommendation

The main aim of this study was to examine the effect of crop diversification on household food security and analyze socioeconomic factors affecting food security. Crop diversification was measured by Herfindahl–Hirschman Index, while food security was measured by the household food insecurity access scale and household dietary diversity. Crop diversification index negatively influenced HFIAS and positively influenced DDS. Notwithstanding, the HFIAS multinomial regression model revealed that higher education levels of household head, age of household head, participating in irrigation farming, livestock holding in TLU, access to agriculture information and crop diversification index positively influenced household food security conditions. On the other hand, distance to the nearest market negatively affected household food security.

We tend to conclude that rural households with diversified cropping systems were more secure in terms of food supplies and income and hence they are able to meet for the food requirement of their households. This suggests that crop diversification potentially improves food security through improving food security stocks in terms of quantity and variety and also in improving income through sale of crop produced from a variety of crops grown which in turn, improve consumption patterns of the household. Therefore, District Agriculture office needs to intensify the promotion of crop diversification in rural farming with particular focus to less diversified households so as to improve the food security status of the rural people.

Considering the fact that a larger number of households kept livestock based as a tradition, increasing the number of livestock kept as a means of boosting income should be prioritized. To this end, provision of support towards training and animal husbandry and pastureland development may enhance the livestock production and productivity and hence increase food security.

In tandem, any efforts geared towards improving household food and nutritional security in the long run should be centered on the development of irrigation farming as one of the key determinants of food security. Precisely to say irrigation farming tremendously increases household food security status. Thus, to increase food security, measures that would improve irrigation farming should be introduced.

In addition, household educational level immensely contributed to the status of food security. Therefore, any interventions meant to support rural households by governmental and non-governmental organizations need to emphasize capacity building through training and informal/alternative basic education. Informal education and training could create opportunities for

gaining knowledge on nutritious food production and consumption and sharing of experiences among farmers. Thus, empowerment of farmers through adequate training and informal education has the potential to improve household food security condition.

Finally, households' distance to nearest market was significantly and negatively associated with food security. Thus, improving rural infrastructural development such as roads and market center and market information contribute to enhance food security status of rural residents.

Abbreviations

CSA: Central Statistical Agency; CDI: Crop Diversification Index; DA: Development agents; DDS: Dietary Diversity Score; EIU: Economist Intelligence Unit; FAO: Food and Agriculture Organization of the United Nations; FGDs: Focus group discussions; GFSI: Global Food Security Index; HFIAP: Household food insecurity access prevalence; HFIAS: Household food insecurity access scale; HHI: Herfindahl–Hirschman Index; HI: Herfindahl Index; IIA: Independence of irrelevant alternatives; KIIs: Key informant interviews; OLS: Ordinary least square; TLU: Total livestock unit; VIF: Variance inflation factors.

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Authors' contributions

DDM designed the study, collected the data, performed the analysis, and developed the manuscript. DTD and AST contributed to the research design and analysis, reviewed and made editorial comments on the draft manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

The authors want to declare that they can submit the data at whatever time based on your request. The datasets used and/or analyzed during the current study will be available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The researchers have obtained a support letter from Addis Ababa University. The letter was submitted to Bale Zone Agriculture and Natural Resource Office and obtained consent. Then, the zonal offices have written an official letter to Sinana District Agriculture and Natural Resource Office, where the study was conducted. Informed consents were also obtained from the households, discussants, and informants before data collection in conformity with anonymity of the study participants.

Consent for publication

Not applicable.

Competing interests

The authors declare they have no competing interests.

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