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The Nexus between Cluster Farming and Household Dietary Diversity among Smallholder Wheat Farmers in Ethiopia

Addisu Bezabeh Ali[1,a,*], Tesfaye Lemma Tefera[2,b]

[1]*Ethiopian Institute of Agricultural Research P.O.Box 2003, Addis Ababa, Ethiopia*
[2]*School of Rural Development and Agricultural Innovation, Haramaya University, PO Box 192, Dire Dawa, Ethiopia*
[*]*Corresponding author*

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A B S T R A C T

This study examined the nexus between cluster farming and household dietary diversity among smallholder wheat farmers in Oromia region, Ethiopia. Three-stage sampling procedures were employed to gather data from 384 household heads on a cross-sectional survey that was carried out in June 2022. Descriptive statistics and a binary logistic regression model were used for data analysis. The average, minimum, and maximum household dietary diversity scores were 7.10, 1, and 11, respectively. A significant difference was observed: participants in cluster farming had 14% more dietary diversity than their counterparts. Sex, marital status, participation in wheat cluster farming, home gardening, off-farm income, number of crops grown, cooperative membership, and access to training determined household dietary diversity. The study indicates that dietary diversity in households is influenced by a variety of factors. While wheat cluster-based farming is heavily promoted, household food and nutrition security also need to consider other elements like home gardening, off-farm income, cooperative membership, and training access.

[a] addisu.nmy@gmail.com https://orcid.org/0009-0005-6535-9465 | [b] t.lemma41@yahoo.com https://orcid.org/0000-0002-2659-3575

Introduction

Goal 2 of the seventeen Sustainable Development Goals (SDGs) of the UN calls for the elimination of hunger, all other forms of malnutrition by ensuring adequate amounts of food that is safe, nourishing, and affordable are available to everyone (Headey and Alderman, 2019; Herrero et al., 2021). It also acknowledges the significance of increasing the productivity and incomes of small producers and calls for a range of actions, such as trade, investment, and market development, to support the equitable and sustainable development of agriculture and agrifood systems. Despite a halt in the number of hungry people worldwide between 2021 and 2022, there are still numerous regions of the world experiencing worsening food problems. Since 2019, the epidemic, recurrent weather shocks, wars, notably the war in Ukraine, have resulted in about 122 million extra people going hungry worldwide (Lile et al., 2023; Laborde et al., 2021b). In 2022, there were around 2.4 billion people worldwide—mostly women and people living in rural areas who did not always have stable access to enough food that was safe, nourishing, and sufficient (FAO et al., 2023). As with many other African nations, food security and nutrition is a development challenge in Ethiopia. Due to the effects of drought and political instability, Ethiopia faces significant levels of food insecurity that urge food aid.

Numerous policies, programs and projects have been put in place to address food system disruptions, from global (such as the UN Food Systems Summit in 2021) to regional (such as the Food System Resilience Program (FSRP) for Eastern and Southern Africa) and the Alliance for a Green Revolution in Africa (AGRA)) and local (such as commercialization clusters, ten in ten, irrigated wheat, yelemat tirufat, urban agriculture, etc.) initiatives aimed at promoting the transformation of the food system. The altered food system is anticipated to be adaptable to climate change, safe for humans and the environment, and safe for the food systems. While it generates enough calories to support the world's present and expanding population, eliminating a significant contributor to inequality for the three billion individuals who do not currently have access to nutritious food (Bommer et al., 2018).

Since the early 2000/01 to 2020/21, the production and productivity of maize, wheat, tef and sorghum were the highest of all the cereals, while barely comes in last (Bezabih et al., 2023). Ethiopia still has yield gaps that can be bridged to increase overall cereal production, despite the fact that major staple grain productivity and production have typically increased (Demil et al., 2020; Senbeta and Worku, 2023) The yield gap refers to the difference between crop yields attained in a certain place and locally attainable yields with the application of improved varieties, inputs, and other management techniques. For inputs like improved seeds, fertilisers, agro-chemicals, advisory service delivery, and output market facilitations, the cluster-based production approach has been devised and is being widely promoted in major cereal production areas in Ethiopia. Particularly, this study aims to assess the relationships between wheat cluster farming and household dietary diversity status and its determinants in the major wheat-producing areas of Arsi highlands, Oromia region, Ethiopia.

Literature Review

Agricultural productivity and land size are inversely associated and are one of the topics of continuous discussion in the literature on development. Researchers and politicians have focused on the problematic implications of the farm-size inverse relationship for land reform, despite the close relationship between the inverse plot-size and farm-size relationships. Research reveals that the primary source of crop productivity inefficiencies is land fragmentation, which increases production costs through additional operational costs (Tan, 2005; Kakwagh et al., 2011; Deininger et al., 2017). This inefficiency is worsened by insufficient use of inputs that lower overall land returns due to extra transit time delays, underutilized border regions, inadequate farm monitoring, and challenges with making cost-effective use of farm machinery. On the other hand, Shuhao et al. note that farmers can lower their risk of fire, flood, and drought by growing a range of crops on scattered plots of land with various biophysical characteristics (Shuhao et al., 2008). Again, Knippenberg's et al. research supports the idea that land fragmentation facilitates the growth of a wide range of crops with varying maturation dates (Knippenberg et al., 2020). This helps farmers avoid times when labor is scarce by combining their efforts on various plots at specific intervals. From 1.2 to 0.9 hectares, the average farm size of Ethiopian smallholders declined over a ten-year period (2004–05 and 2016–17), according to Bachewe and Minten's analysis of the national agricultural sample survey (Bachewe and Minten, 2023). The decline in farm sizes of households headed by women was more marked, falling by over 21%.

Despite Ethiopia's relatively small average farm sizes by worldwide standards, the country's landholdings are decreasing further as a result of rising urbanization, rapid population expansion, and soil degradation. Thus, the agricultural land governance system in Ethiopia turns to cluster farming among smallholder farm households as a solution to the growing fragmentation and decreasing size of land holdings. The ultimate objective is to progressively approach the expansion of agribusiness and the planned, voluntary consolidation of land.

Smith defines clusters as geographic concentrations of businesses in linked industries that gain from co-location-related increased competitive pressure in addition to the agglomeration economies resulting from their physical closeness (Smith, 2003). One of the main interests of cluster farming is the establishment of farmers' cooperatives, which provide financial support, advice, and training to farm families as they set up their operations. Hilchey posits that a functional cluster should possess a clear vision and mission, strong leadership, an organisational structure, representation from a diverse range of stakeholders, regular meetings, identified and prioritised concerns, and prevent vertical or horizontal mergers (Hilchey, 2008). Research indicates that the agricultural clusters located in the southern Philippines have enhanced economies of scale, promoted knowledge and risk sharing, and nurtured innovation, all contributing to the financial gains of smallholder farmers (Shepherd, 2005). Studies conducted in various places reveal the advantage of clustering small farm holdings. For instance, Montiflor et al. identified that in the Philippines, clustered vegetable farmers' profits rose by 42% after they joined the cluster (Montiflor et al., 2008). The same study found that, as compared to individual farming, cluster farming generated a higher income for over 82% of the farmers. The authors went on to say that in addition to these advantages, respondents mentioned that cluster farming offered access to production inputs, financial support, marketing support, high or higher market pricing, and improved market prospects. Compared to what they received from traders, farmers obtained higher and more consistent prices through cluster farming. Smallholder farmers' business networks and entrepreneurial skills develop when they are grouped together, according to Goetz et al. (2008). Clusters create new avenues for the exchange of information and expertise as well as new routes for technological transfer. Agricultural businesses likely form in clusters, and clusters encourage competition and innovation. Cluster approaches were found to be critical in the Fiji Islands for raising tilapia fish productivity and production (Varawa et al., 2014). This was because they improved marketing coordination, facilitated better access to financing, gave farmers more negotiating power when obtaining orders for farm inputs like hatchery seed and feed, and encouraged knowledge-sharing among participating farmers.

Cluster farming, which encourages the adoption of a full package of improved technologies, is being implemented in Ethiopia to bridge production and productivity gaps in the main staple crops. Implementation of various wheat production schemes, such as cluster farming and irrigated wheat production, has resulted in a significant increase in wheat self-sufficiency and surplus for export. Specifically, the wheat production scheme, which consists of cluster farming and irrigated wheat production, led to a significant increase in wheat self-sufficiency and surplus for export. A record-breaking 8.2 million tons of wheat, grown on 2.6 million hectares of irrigated and rain-fed land, were harvested in 2022, helping the nation meet its targets for wheat production (Effa et al., 2023). The recent experience is consistent with previous practices; for example, cluster farming has been shown to give potential benefits for increasing farm output and productivity, which would impact smallholder commercialization (Montiflor et al., 2008; Goetz et al., 2008).

By linking smallholders to markets and advancements, cluster farming is seen to be a platform that can increase their income and food security (Goetz et al., 2008; Goni et al., 2023). A study conducted by Dureti et al. has shown that clustering also increases smallholder productivity and outputs, hence reducing poverty in Ethiopia (Dureti et al., 2023). Even if cluster farming has numerous advantages, to justify expanding the practices, it is critical to comprehend how the participation of smallholder farmers in wheat cluster farming connects to household dietary diversity. In wheat cluster farming situations, it is also critical to identify the factors driving household dietary diversity. Consequently, the purposes of this study ware to: (1) assess the current household dietary diversity status in wheat cluster farming families; and (2) look into the variables influencing household dietary diversity in connection to cluster farming involvement.

Methodology

Descriptions of the Study Area

The study was conducted in the major wheat cluster areas of Tiyo and Limu Bilbilo districts of the Arsi zone, as well as Kofele and Shashemene districts in the west Arsi zone, Oromia region, Ethiopia (Figure 1). The Arsi and West Arsi zones are located between 7°08'58" N and 8° 49' 00" N and 38°41'55" E and 40° 43' 56" E. On average, the study areas receive between 1020 and 1300 mm of precipitation. A number of major annual crops are cultivated in the two zones, which include potatoes, linseed millet, beans, peas, maize, tef, sorghum, oats, chickpea, nueg, and other vegetables (CSA, 2022). Among the initiatives of the transformation of subsistence agriculture is cluster farming, which concentrates on the study area with wheat and barley as priority commodities. When it comes to commodity-focused interventions in the country, the study areas feature availability and utilization of the well-functioning inputs delivery, mechanization services, and extension and advisory services.

Publication Approval Committee

The Directorate of Knowledge Management and Scientific Communication (KMSC) approves research publications under the Ethiopian Institute of Agricultural Research (EIAR). The approval made by the head of the department in charge of a given research topic, the research center or research sector director, the deputy director general for research, and the KMSC director. Correspondingly, the publishing of this work has been allowed with decision number 227/0812/2024 on June 20, 2024.

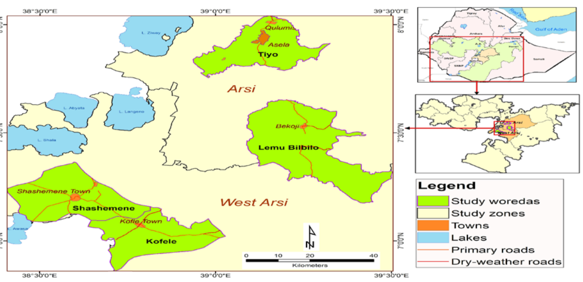

Figure 1. Map of the study area

Sampling Methods and Sample Size

The sample was chosen using both probability and purposive sampling techniques. A multistage stratified random sampling procedure was employed to acquire survey data from household heads. Wheat production potential, cluster farming practices, and cluster farming scalability were the three criteria considered while selecting sample districts. Hence, the districts of Kofele and Shashemene from the West Arsi zone and Limu Bilbilo and Tiyo from the Arsi zone were selected in the first stage. In the second stage, two Kebeles (Kebele is the smallest unit of administration in Ethiopia) were chosen at random from a list of the major wheat producers in the targeted districts. In the third and last stage, the relevant Kebeles provided a list of farm households that grew wheat under cluster or without a cluster during the previous cropping season. Subsequently, each farm household's name was allocated a consecutive serial number. Next, using a basic random sampling procedure, the sample farm households were drawn. And then the representative sample size has been determined by the formula Kothari (2004).

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

$$n = \frac{95,750}{1 + 95,750\ (0.5)\ (0.5)} \approx 384$$

Wherein, n is the sample size; N is the population size, and e is the 5% err term.

Methods of Data Collection

This study included both primary and secondary data. In order to gather primary data, in-person interviews with 384 wheat growers were conducted (Table 1). There were randomly selected 190 cluster participants and 194 non-cluster interviewee wheat farmers from targeted study Kebeles. There were both open-ended and closed-ended questions on the interview schedule in order to get information relevant to the study's objectives. The study utilised both primary and secondary data sources.

Data Analysis

The Household Dietary Diversity Score (HDDS) is a qualitative indicator of food consumption that shows how many different food types a household has access to at any given time (Table 6). The data for this study met the following assumptions: one or more of the independent variables were continuous or categorical, and the outcome, or dependent variable (HDD), was quantified dummy. Therefore, the logistic regression model was used, along with descriptive statistics and the computation of the Household Dietary Diversity Score (HDDS). Additionally, the independent variables did not show multicollinearity. HDDS calculates the variety of meals or food groups consumed the day before the interviews on a scale from 0 to 12 (Kennedy et al., 2011). Equation 1 shows how the diversity of meals or food categories consumed the day before the interview schedule is calculated by the HDDS. According to Swindale and Bilinsky, the HDDS provides an illustration of the range of foods consumed throughout the course of the previous day as well as their nutritional variability (Swindale & Bilinsky, 2008). The food groups are: cereals, vegetables, fruits, meat, eggs, poultry, seafood, pulses, legumes, nuts, milk and milk products, sugar, honey, roots and tubers, miscellaneous (which includes sauces, spices, salt, and other condiments), and oil and fats.

Thus, HDDS was calculated by summing the points allotted to the various food groups that the households consumed throughout the 24-hour recall period. Following that, households were divided into three categories based on their HDDS: low dietary diversity (<6 food groups), medium diversity (6-8 food groups), and high diversity (>8 food groups), using the methodology developed (Swindale & Bilinsky, 2008; Table 2). Similar studies that studied household food and nutrition security on basis of HDDS based categorization documented in Ethiopia and elsewhere (Moroda et al., 2018; Jebessa et al., 2019; Ngema et al., 2018; Rubhara et al., 2020).

In order to demonstrate the variability in nutrition among participants in cluster and non-cluster farming, the HDDS was employed in this study as an outcome or dependent variable.

$$HDDS(0-12) = SFG\ (A + B + C + \cdots + L) \quad (1)$$

SFG: Sum of food groups

Based on farmers' participation in the wheat cluster farming, a binary logistic model was employed to determine the factors that influence household dietary diversity status. A set of predictor variables and the dependent variable HDDS related to each other (Table 3). In order to find factors that might be affecting the dietary diversity of households that grow wheat, the logistic regression model was employed. The model is specified as:

$$\text{logit}\ (p) = \ln\frac{P}{(1-P)} = \beta_0 + \beta_i X_i + \mu_i \quad (2)$$

Where P denotes the probability of attaining the dietary diversity of 7 or more food groups out of 12 and dietary diversity of less than 6 food groups out of 12 respectively, the β_i are the parameter estimates of the independent variables, the X_i represent the independent variables and μ_i are the stochastic error terms.

Table 1. Selected study districts, Kebele and household sizes

District	Sampled Kebele	Household size	Sample households	Cluster farming	
				CF*	NCF*
Limu Bilbilo	Chiba Micheal	1323	90	23	23
	Limu Dima	1261		21	21
Tiyyo	Haro Bilalo	1,233	84	19	19
	Dosha	1,358		23	23
Kofele	Gurmicho	1,203	92	22	22
	Alkaso	1,249		24	24
Shashemene	Hursa Simbo	1037	118	31	32
	Gonde Karso	946		28	29
Total		9,610	384	190	194

*CF= Cluster farming participants while NCF denotes non-participants of cluster farming; Source: Agriculture Office

Table 2. Category of level of dietary diversity score

Level of HDDS	Range of food groups
High	>8
Medium	6≤X≤8
Low	<6

Source: Adapted from Swindale and Bilinsky

Table 3. Summary of explanatory variables

Variables	Type of variable	Descriptions	ESI
Dependent variable HDDS	Dummy	1 if a household is food secure 0 otherwise	None
Gender of household head	Dummy	1 if male 0 otherwise	+/−
Age of the household head	Continuous	Year	+/−
Level of education	Dummy	1 if male literate and 0 otherwise	+
Marital status	Dummy	1 married 0 otherwise	+
Number of family members	Discrete	Number of individuals	−
Cultivated farm size	Continuous	Hectare	+
Livestock ownership	Continuous	TLU	+
Cooperative membership	Dummy	Yes=1, otherwise =0	+
Credit access	Dummy	Yes=1, otherwise =0	+
Access to advisory service	Dummy	Yes=1, otherwise =0	+
Off/non-farm income	Continuous	Amount of money in Birr/year	+
Cluster farming experience	Continuous	Number of year	+
Yield	Q/ha		+
Distance to market	Number of minutes		−
Access to improved varieties	Yes=1, otherwise =0		+
Participation in home-gardening	Yes=1, otherwise =0		+
Access to training	Yes=1, otherwise =0		+
Number of crops cultivated	Number		+
Cluster farming participation	Dummy	Yes=1, otherwise =0	+

ESI: Expected sign of influence

Results

Demographic and Socioeconomic Characteristics

A sample of 384 farm household heads is included in the study. From that, roughly half, or 49.50%, were wheat cluster participant farmers, while the remaining 50.50% were non-cluster wheat farmers. Analyses were conducted on farm characteristics, household characteristics (age, sex, education level, and size); institutional factors (cooperative membership, membership in savings and credit institutions); and proximity to various service centres (Table 5).

Age of the household head: Forty-five is the average age of the sample household heads. The mean ages of wheat farmer household heads under cluster and non-cluster participation heads had been forty-three and forty-six respectively. Age wise, a statistically significant difference observed between the two groups when comparing their means, with a significance level of 0.05 for cluster farming participation status.

Level of education: The average level of education held by the heads of households in the sample is 6 grades completed. There were no significant variations in the educational attainment of the cluster and non-cluster wheat farmers groups. The mean number of years of education for cluster and non-cluster household heads was 6.1 and 6.1, respectively. Where just 20.05% have completed secondary school.

Family size: The sample household heads had an average of 7 members in their families. For farmers in clusters and those in non-clusters, the average family size was eight members, respectively. At the 0.01 level, the two group mean comparison test reveals statistically significant differences. This suggests that families with bigger sizes engage in cluster farming more than households with smaller families.

Landholding size: The sample household heads have an average landholding size of 1.84 hectares. Wheat farmers cultivated 1.98 hectares on average in clusters, compared to 1.70 hectares for non-clusters. Statistically significant differences are shown at p<10% in the mean total cultivated land t-test between the groups. The implication is that cluster farming is more advantageous for farmers who possess larger farms.

Size of livestock holdings (TLU): Livestock is a factor that could affect a farm household's income and food security status. Based on conversion factors, tropical livestock units (TLU) were computed to standardise the sample families' livestock holdings. The sample households' average livestock holding was 7.26, as determined by the TLU measure. Moreover, the average livestock holdings for farmers in clusters and those in non-clusters were 7.69 and 6.84 TLUs, respectively. At p<10%, the t-test for mean equality between cluster and non-cluster households is statistically significant. This indicates that more agricultural households with livestock have a higher likelihood of being able to engage in cluster farming.

Distance to main all-weather road: It takes an average of 26.74 minutes for all sample household heads to get to the main road. Moreover, the mean minutes spent by wheat farmers in clusters and those in non-clusters were, respectively, 23.53 and 30.03 minutes. As per the t-test result, there exists a significant difference between the two groups at p<1%. Farmers who reside far from major roads hence have less opportunities to benefit from better supply chain arrangements like cluster farming.

Amount of credit used: The average amount of money used from credit for the total sample household heads is 435.86 Birr. While the average amounts of credit received and used by cluster and non-cluster farmers are 707.96 Birr and 179.28 Birr, respectively. The t-test for mean credit amount used between cluster participant and non-cluster is statistically significant at p<1%. That is the use of credit increases the prospect of wheat cluster farming participation.

Access to credit: Across all sample household heads, 435.86 Birr is the average amount of credit use. On average, cluster and non-cluster farmers got 707.96 and 179.28 Birr loans each. For mean credit amount used, the t-test with p<1% statistically significantly differentiates that the likelihood of engaging in wheat cluster farming is increased with credit availability.

Wheatland size (ha): The average farm size allotted by the sample household heads to produce wheat is 0.74 hectares. Furthermore, 0.83 ha and 0.66 ha, respectively, were the average farm sizes allotted by cluster and non-cluster farmers for wheat production. Farmers who own large wheat farms are more likely to engage in cluster farming, according to the t-test mean comparison, which showed a significant difference.

Table 4. Summary of demographic and socioeconomic variables

Item	Number of respondents		Wheat non-cluster farmers		Wheat cluster farmers		T-Test
	Avg.	SD	Avg.	SD	Avg.	SD	
Age	44.50	11.00	43.40	11.10	46.00	11.10	-2.02**
Family size	7.32	3.04	6.88	3.00	7.77	3.02	-2.90***
Level of education (grade completed)	6.10	3.47	6.07	3.37	6.13	3.59	-0.18
Landholding (ha)	1.84	1.57	1.70	1.66	1.98	1.46	-1.77*
Wheatland size (ha)	0.74	0.56	0.66	0.60	0.83	0.52	-2.88***
Household income (Birr/year)	66925	58042	48045	51292	86203	58317	-6.80***
Distance to main road (Min.)	26.74	18.73	30.03	18.17	23.53	18.76	3.44***
Livestock size (TLU)	7.26	4.31	6.84	4.28	7.69	4.31	-1.94*
Amount of credit used (Birr)	435.86	786.57	179.28	472.79	707.96	946.92	-6.90***

Note: ***, **, & * represent significant t-test results at 1%, 5%, and 10% levels, respectively; Source: Estimated from survey data

Table 5. Demographic and social networks

Item	List	Number of respondents		Cluster farming		Non-cluster farming		χ^2 − test
		No.	Percent	No.	Percent	No.	Percent	
Gender	Female	20	5.21	8	4.12	12	6.32	0.93
	Male	360	94.79	186	95.88	178	93.68	
	Total	384	100	194	100	190	100	
Marital status	Unmarried	21	5.47	9	4.64	12	6.32	0.52
	Married	363	94.53	185	95.36	178	93.68	
	Total	384	100	194	100	190	100	
Participation of training	Yes	321	83.59	140	72.16	181	95.26	37.34***
	No	63	16.41	54	27.84	9	4.74	
	Total	384	100	194	100	190	100	
Association in cooperative	Yes	203	53	57	29.38	146	76.84	86.77***
	No	181	47	137	70.62	44	23.16	
	Total	384	100	194	100	190	100	
Getting to credit	Yes	94	24.48	24	12.37	70	36.84	31.09***
	No	290	75.52	170	87.63	120	63.16	
	Total	384	100	194	100	190	100	
Having improved seeds	Yes	318	82.81	154	79.38	164	86.32	3.24*
	No	66	17.19	40	20.62	26	13.68	
	Total	384	100	194	100	190	100	

Note: *** and ** represent significant t-test results at 1%, 5%, and 10% levels respectively.

Table 6. Summary of Household Dietary Diversity Scores (HDDS)

In the last 24 hours, did your household consume…?	Response	Total (n=384)		Non-cluster (n= 194)		Cluster (n= 190)		χ^2
		Freq.	%	Freq.	%	Freq.	%	
Cereals	Yes	348	90.63	181	93.30	167	87.89	3.30*
	No	36	9.37	13	6.70	23	12.11	
Vegetables	Yes	282	73.44	132	68.04	150	78.95	12.03***
	No	102	26.56	62	31.96	40	21.05	
Roots or tubers	Yes	20	5.21	8	4.12	12	6.32	5.85**
	No	364	94.79	186	95.88	178	93.68	
Fruits	Yes	81	21.09	52	26.80	29	15.26	7.68***
	No	303	78.91	142	73.20	161	84.74	
Meat	Yes	89	23.18	37	19.07	52	27.37	3.71*
	No	295	76.82	157	80.93	138	72.63	
Eggs	Yes	97	25.26	41	21.13	56	29.47	3.54*
	No	287	74.74	153	78.87	1340	70.53	
Fish	Yes	16	4.17	6	3.09	10	5.26	1.13
	No	368	95.83	188	96.91	180	94.74	
Legumes	Yes	288	75.00	159	81.96	129	67.89	10.13***
	No	96	25.00	35	18.04	61	32.11	
Milk or milk products	Yes	341	88.80	179	92.27	162	85.26	4.74**
	No	43	11.20	15	7.73	28	14.74	
Oils, fat, or butter	Yes	325	84.64	180	92.78	145	76.32	20.02***
	No	59	15.36	14	7.22	45	23.68	
Sugar or honey (sweets)	Yes	335	87.24	181	93.30	154	81.05	12.93***
	No	49	12.76	13	6.70	36	18.95	
Condiments or coffee/tea	Yes	360	93.75	185	95.36	175	92.11	1.74
	No	24	6.25	9	4.64	15	7.89	

*P < 0.10, **P < 0.05, ***P < 0.01

Wheat sale (q): Among all sample households, 19.75 quintals of wheat were sold on average. Farmers in the cluster and those outside it sold an average of 22.91 Qt and 16.66 Qt of wheat, respectively. At p<5%, the t-test for the mean quantity of wheat sold was statistically significant. It was anticipated that cluster farming would pave the way for wheat marketing outlets, thereby increasing the amount sold. Cluster participants sold more wheat than their counterparts, according to Dureti et al. (2023) who also found the same results.

Total income (Birr/year): The farm household's annual revenue from all sources combined, such as crop production, animals' husbandry, off-farm labour, non-farm jobs, and remittances. Among the sample households studied, the mean annual income was 48,045.10 Birr for those not in a cluster and 86,202.66 Birr for cluster farming participants respectively. It is found that there is statistical significance difference at p<1% in the main income differences between cluster and non-cluster farming practices.

Table 7. Estimates of the logistic regression of household dietary diversity

Covariates	Coef.	Std. Err.	z	P>|z|	dy/dx
Sex	2.180**	0.982	2.220	0.026	0.493
Age	-0.017	0.015	-1.150	0.252	-0.004
Education	0.015	0.042	0.350	0.723	0.003
Marital status	1.488*	0.864	1.720	0.085	0.250
Household size	0.037	0.048	0.760	0.446	0.008
Land holding size	0.086	0.099	0.880	0.381	0.020
Cluster farming	0.634**	0.296	2.140	0.032	0.143
Livestock holding	-0.027	0.038	-0.710	0.476	-0.006
Access to home-garden foods	1.114**	0.436	2.560	0.011	0.252
Off/non-farm income	0.000**	0.000	2.200	0.028	0.000
Number of crops grown	0.236*	0.130	1.810	0.070	0.053
Cooperative membership	0.985***	0.291	3.390	0.001	0.223
Access to credit	-0.262	0.297	-0.880	0.377	-0.058
Access to training	4.152***	1.067	3.890	0.000	0.940
Access to extension	0.000	0.000	-1.530	0.126	0.000
Constant	0.462	2.061	0.220	0.823	
Number of obs	384				
Wald chi^2 (15)	53.08				
Prob > chi^2	0.0000				
Log likelihood	-208.54109				
Pseudo R^2	0.2060				

*P < 0.10, **P < 0.05, ***P < 0.01

Statistics of Categorical Variables

Sex of the household head: from total sampled household heads, largely male headed - 94.79%. A chi-square test, however, reveals no statistical significance between the gender of the head of the family and cluster farming participation.

Access to training: Eighty-five percent of the sample households took part in training. A statistical significant difference observed between training access and cluster farming, in favour of farmers engaged in wheat cluster farming: $\chi^2(1, n = 384) = 37.34, p = 0.00$.

Access to improved varieties: Access to and use of high-quality inputs, such as improved varieties, has been identified as a major barrier to achieving the highest productivity potential of most crop production and wheat production specifically. Between cluster and non-cluster wheat producers, improved variety access and use were 86% and 79.38%, respectively. A statistical test revealed substantial differences between cluster and non-cluster wheat at: $\chi^2(1, n = 384) = 3.24, p = 0.07$.

Cooperative membership: Cooperative membership aids farmers in many areas, including technology, input and product markets, information access, and more. Based on a statistical test, it was revealed that farmers who had previously belonged to marketing or producer groups were more likely to produce wheat in clusters. This was demonstrated by the statistical test result: $\chi^2(1, n = 384) = 86.77, p = 0.00$.

Access to credit: From the total surveyed households, only 25% revealed a tangible access to credit services. Differences observed between cluster and non-cluster wheat farmers in terms of the utilisation of financial services the former are in better position of credit uses:

$$\chi^2(1, n = 384) = 31.09, p = 0.00.$$

Logistic Regression Results

A binary logistic regression model was used to reveal the factors that determine the household dietary variety score (Table 7). The likelihood ratio statistics was strongly significant (P <0.000), suggesting that the model has a strong explanatory power. The pseudo R^2 value (0.206) is also suggesting a good fit of the model. Diagnostic tests for model fitness were undertaken. Multicollinearity was not a problem in this model as the correlation coefficients for all covariates are less than 0.18 (-0.357–0.177) and the mean VIF is 1.74 with maximum 3.18 (1.12–3.18). The parameter estimates of the binary logistic regression model provide only the sign of the effect of the covariates on the dependent variable but not the magnitude. The household dietary variety score was significantly influenced by eight of the fifteen variables that were added into binary logistic regression models. Significant variables are discussed here.

Sex of the household head: It was found to be positively and significantly associated with the household dietary diversity score at the p<5% level. According to the marginal impact analysis, the dietary diversity score of a male household head was 0.49 times higher than a household headed by female. Research pertaining to the impact of gender on the food security of households has yielded inconsistent findings. In South Africa, for instance, households headed by women scored higher on dietary diversity than households headed by men, according to Taruvinga et al. (2013). The results of the study are in line with those of Kassie et al. (2014), who show that access to food and nutrition in Kenyan homes varies depending on gender.

Marital status of the household head: This variable is found to be positively correlated and statistically significant, indicating that married households had more access to a wider variety of foods than their non-married counterparts at p<10%. In order to combine resources for mutual sharing, household members are said to benefit economically from being married. This finding is consistent with studies carried out in Ghana and Kenya, which found a positive relationship between dietary quality and marital status among agricultural households, respectively (Etwire et al., 2013; Kabunga et al., 2014)

Cluster farming participation: It has had a positive and significant effect on the HDDS at p<5%. The marginal effects analysis showed that cluster farming participants had 0.14 times higher access to diversified dietary foods than their non-cluster counterparts. Possibly this could be the better production pay that cluster farmers received allows them to buy more food to meet their nutritional needs. This outcome is in line with the research conducted by Dureti et al. (2023), which showed that cluster members had been able to raise their income through yield advantage and were able to pay for more diversified meals since they were able to cover expenses.

Access to home garden foods: There was a positive and significant association between access to home garden food sources and the dietary diversity of households at a p<5%. A farm household head with access to home garden foods was 0.25 times more likely to have access to a diversified diet than their counterpart with no home garden foods. Studies on home gardening and food security reveals mixed results. In South African rural households, for example, participation in a home gardening program significantly reduced food insecurity as well (Tesfamariam et al., 2018). However, in their study done in Kenya, Tanzania, and Uganda, Depenbusch et al. (2021) could not establish a causal link between home gardening and food security, emphasizing the need for additional empirical research on the subject.

Off/non-farm income: This variable was discovered to be positively and significantly associated with HDDS at p<5%. A unit increase in off-farm income, however, had no effect, according to the marginal effect analysis. Therefore, it can be concluded that there is no difference in the HDDS effects between wheat farmers under cluster or non-cluster, regardless of whether the farmer receives off-farm income. Although the magnitude of the effects was not expected, it is consistent with Bellemare and Bloem's (2018) conclusion that off-farm income has little bearing on household food security.

This was found to be statistically significant with positive coefficient at 10%. The marginal effect indicates that an increase in the number of crops cultivated by one crop, so shall the dietary diversity increases by 0.05 times. The result of this study is consistent with the conclusions drawn by Sibhatu and Qaim (2018b), who evaluated the significance of crop diversification and discovered a positive relationship between the quantity of crops grown and markers of dietary diversity.

Number of crops cultivated: A positive coefficient at 10% indicated that the number of crops cultivated was statistically significant. Although the magnitude is small, the marginal effect shows that if one crop is grown more often, the amount of nutritional diversity will also rise by 0.05 times. The present study confirms the findings of Sinyolo et al. (2021), who evaluated the value of agricultural diversification and discovered a positive relationship between the number of crops cultivated and indicators of dietary diversity.

Cooperative membership: It was significantly and positively associated with household dietary diversity score at p<1%. The marginal effect analysis indicated that households that were members of cooperatives had 0.22 times higher HDDS as compared to households which were not members. In line with earlier research, the result cooperative membership enhances technology adoption and household food and nutrition security (Aweke et al., 2021).

Access to training: It was found that household dietary diversity score was positively and significantly determined by training accessibility at p<1%. The marginal effect analysis showed that farmers with access to farming related training had a household dietary diversity score that was 0.94 times greater than farmers without such access. The outcome is consistent with studies carried out in Malawi that demonstrate that training in agricultural production and marketing expands the range of foods available to farm households in Malawi (Kennedy et al., 2011; Koppmair et al., 2017).

Conclusion

The study was conducted to examine how cluster farming participation affects household dietary diversity in one of the major wheat-growing areas in the Oromia region, Ethiopia. Cluster farming participants consumed 14 percent more diversified dietary as compared to their non-cluster farming counterparts. Assuming that all other variables stay unchanged, the study found that wheat cluster farming can improve the dietary diversity of farm households, which will increase their food and nutritional security. Cluster farming can be maintained and extended elsewhere while appropriately considering other factors that influence the whole results of food diversity in households.

Declarations

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Conflict of Interest

The author declares no conflict of interest.

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