World Journal of Agricultural Science and Technology
2023; 1(4): 83-97
http://www.sciencepublishinggroup.com/j/wjast
doi: 10.11648/j.wjast.20230104.12
ISSN: 2994-7332 (Online)

Role of Underutilized Crops in Improving Food Security and Livelihoods of the Households: A Case Study in GutoGida District, Ethiopia

Dhaba Mengesha Adula[1], Messay Mulugeta Tefera[2], Bogale Ayana[3]

[1]Crop and Processing Department, Ethiopian Institute of Agricultural Research, Addis Ababa, Ethiopia

[2]Food Security Departments, Addis Ababa University Centre for Food Security and Development Studies, Addis Ababa, Ethiopia

[3]Plant Protection Department, Ethiopian Institute of Agricultural Research, Holeta Agricultural Research Centre, Holeta, Ethiopia

Email address:

dhabaadula@gmail.com (Dhaba Mengesha Adula), mesay.mulugeta1@aau.edu.et (Messay Mulugeta Tefera), bogaleayana@gmail.com (Bogale Ayana)

To cite this article:

Dhaba Mengesha Adula, Messay Mulugeta Tefera, Bogale Ayana. Role of Underutilized Crops in Improving Food Security and Livelihoods of the Households: A Case Study in GutoGida District, Ethiopia. *World Journal of Agricultural Science and Technology*. Vol. 1, No. 4, 2023, pp. 83-97. doi: 10.11648/j.wjast.20230104.12

Received: September 7, 2023; **Accepted**: September 25, 2023; **Published**: October 14, 2023

Abstract: This study was examined how agricultural diversification using underutilized crops could increase household food security and livelihoods in Ethiopia's GutoGida district. Staple crops are what are raised. Regardless of their nutritional content, productivity and production sustainability, the majority of farmers plant reliable food crops. Farmers still experience food insecurity since the crops are not productive enough to lower household food insecurity. Additionally, despite of the fact that underutilized crops improve nutritional quality and boost household purchasing power, their nutritional role, productivity, and stress tolerance were not universally recognized and promoted in this region. On a sample of 120 smallholder farmers, multistage sampling approaches were used. Households are divided into non-producers and producers. The Food consumption score and coping strategy index were used to gauge the level of household food security. The data were analyzed using descriptive statistics, simple leaner regression models, and ordinary least squares. In comparison to non-producers of underutilized crops at alpha 5%, the diversified producers of underutilized crops had significantly higher levels of crop production (22.48%), consumption (11.73%), total annual sale (19.32%), and total income generation (26.67%). Based on this finding, we draw the conclusion that a crop diversification using neglected crop is a practical strategy that can greatly improve household food security and economic well-being. The survey's overall findings show that the Ethiopian government current agricultural policy should pay enough attention to diversify and promoting underutilized crops, and that this has to change in light of the country's ongoing threat from hunger and food insecurity.

Keywords: Underutilized Crops, Food Security, Food Consumption Score, Cropping Strategy Index, GutoGida District

1. Introduction

The population of the globe is currently growing quickly. The prevalence of food insecurity and malnutrition is widespread in developing nations, not only Ethiopia, according to reports [1] that up to 840 million people are food insecure. The majority of the emerging counties are growing dependent on a select few high yielding crops and intensifying crop cultivation, according to this analysis. Knowing the potential of the area and improving the agricultural farming system of the area are essential to boost production and productivity and stop the spread of hunger and food insecurity. In underdeveloped nations, very few crop species are grown and used to provide food. The majority of the countries in Sub-Saharan Africa are considered to have malnutrition, with the frequency of food and nutritional insecurity currently standing at 23.8%. The primary sector that is a vehicle for tackling food and nutrition security is agriculture [2] with the intensification of a few number of crop species, especially the sole cereal crops, the modern agricultural system and new technologies are encouraging the production and productivities of high-input

and high-yielding crop species. In agricultural systems all over the world, this has resulted in a fall in crop diversity and a uniform nutrition system, which has been linked to a decline in nutrition diversity and a loss of the environmental regulating services [3]. Different agricultural and development programs instead focused on orienting the production and farming system into high-input and only high yielding crops. These programs did not analyze local opportunities of the communities' livelihood based on local crop species and other local agricultural resources. The only method for improving farmers' livelihoods is the agricultural system [4]. Even though such crops have a greater potential to increase the food and nutritional security of communities, cultivation and output of underutilized or neglected crops has dropped and is still declining globally [5]. In a world with finite resources, this is especially crucial to guarantee food and nutritional security for the growing population [6]. They are nutrient-rich crops that show the capacity for adaptation and production across various continents, highlighting the significance of agricultural variety in the face of food insecurity and climate change and requiring that it take precedence in future studies [7]. The majority of Ethiopians rely primarily on cereal crops for their nourishment. Teff, wheat, maize, sorghum, and barley are the five main cereals that make up the bulk of Ethiopia's agricultural and food economy. According to the FAO, these few cereal crops account for about three-fourths of the country's total area under cultivation, 29% of the country's agricultural GDP (14 percent of total GDP), and 64% of all calories consumed. According to a report from the World Food Programme (2012), rural populations in Ethiopia experience food insecurity at a higher rate than urban areas (13%), with rural communities experiencing it at a rate of 29%. In order to boost domestic output, Ethiopia has over the years imported a number of important staple commodities, including wheat, rice, and others [8]. However, the paper points out that import of rice and wheat, in particular, have risen steadily over time, a development with economic ramifications.

In various regions of Ethiopia, there are a variety of underutilized vegetable and root crops that are used as a food, cultural, social, and economic crop for the farming community. Studies and written material on these neglected crops in Ethiopia are insufficient. Despite their significant contributions to food security, income generation, the provision of food energy, and the preservation of Ethiopia's resource base, the food potential of various vegetables, root crops, and tuber crops has not yet been fully exploited and utilized in all regions of the country. The aim of the study was to examine how agricultural diversification using underutilized crops could increase household food security and livelihoods in GutoGida district.

Even in areas with similar environmental conditions, such as the GutoGida district in western Ethiopia, different types and quantities of crops are produced. In some kebeles, people only grow high-yielding cereal crops using intensive farming techniques, but in other kebeles, people grow a variety of crops, such as root and tuber crops or underutilized crops using local resources. The finest district to analyze these production variations within the same agro-ecological household is GutoGida. The following fundamental inquiries, which are extensions of the aforementioned research objectives, were the focus of this study:

1) What underutilized crops are there, and how may they be identified as promising underutilized crops, in the smallholder agricultural system?
2) What social, economic, and institutional variables affect the production of underutilized crops in smallholder farms?
3) Do households that produce a lot of underutilized crops earn more money and have better access to food?
4) In the research area/region, what agricultural policies and initiatives are guiding the promotion, production, and consumption of underutilized crops?

1.1. Concepts and Empirical Studies on Crop Diversification Through Wider Use of Underutilized Crops

Regarding their potential to help meet the growing food demands of the world, tens of thousands of edible plant species continue to be mostly "underutilized". As a result, there has been a decrease in the genetic diversity that supports agriculture, and this has been accompanied by the displacement of native species by important crops that are more popular. Numerous causes, including as inadequate research, a lack of knowledge about their manufacturing, and socioeconomic variables that affect dietary choices, among others, might be blamed for the displacement of NUCS [9].

Locally adapted plant species that significantly contribute to the food and traditions of the areas where they are locally grown by the farmers are considered underutilized crops [9]. A major argument in favor of their increased use is that most of these crops are resilient and can thrive on poor soils and in stressful environments. Additionally, these crops frequently have a long history of enhancing local food security, particularly in times of crop failure for the major crops. By utilizing the available agro-ecological resources effectively, diversification enables growers to create a localized system that ensures food sovereignty.

1.2. Diversified Production for Food and Nutritional Security

Globalization and luxury play a significant effect in determining modern consumer eating habits. In addition to the demands of an increasing population, an expanding middle class with a predilection for processed and easily accessible food goods must also be catered [11]. Food demands are becoming more and more comparable across borders, and life trends are no longer regional [12]. The expansion of international trade, urbanization, and the rise of multinational food firms, along with the rising regionalization of diets, all have a significant impact on consumer patterns [13].

The consumption of rice worldwide increased by over 4.5%

yearly between 1961 and 2006 [15]. Africa also saw a large rise in rice consumption as a result of urbanization and changing lifestyles (Africa Rice Center, 2008). Additionally, a rapid rise in energy-dense diets that heavily rely on meat, dairy, and plant oils has had a profound effect on how we raise food, leading to a greater reliance on a small number of crops. A yield and profitability analysis revealed that mono-cropping on roughly 1,000 m2 could only yield 3,409 kg of spider plant, 7,500 kg of amaranth, 2,841 kg of cowpea (Vigna species), 2,841 kg of African nightshade (S. scabrum), and 2,273 kg of Jew's mallow, for a total of 18,864 kg with a market value of USD 2,515, with a net profit of USD 1,539 [15].

Although underutilized foods are a vital component of the meals of many people worldwide, their global significance is still relatively modest [16]. The four primary components of food provision availability, stability, access, and utilization must all be met in order for there to be food security [17]. The presence of food does not imply that food security is being achieved, and the stability, accessibility, and usage of food are rarely included in the most recent data on world hunger (Wheeler & von Braun 2013). Increasing output to improve food security does not address local issues of access and consumption of food [18]. Additionally, environmental risks and climate change pose a threat to food stability, and these have typically been seen as short-term shocks that influence food security. Marginal land crops typically exhibit resistance to adverse weather, including drought, waterlogging, and damaged soils, and could therefore increase food availability and stability.

For nutritional security, FAO (2012) has advised improving dietary diversity and nutrient content in addition to increasing food production. In order to prevent non-communicable diseases including cancer, diabetes, obesity, and cardiovascular disease as well as other harmful health effects of micronutrient deficiencies like blindness and birth defects, FAO/WHO recommend daily intake of 400g or more of fruits and vegetables. Promoting varied diets and enhancing micronutrient intake [19] through increased accessibility to underutilized crops are necessary for achieving nutritional security. Through focused research on cultivation techniques, water-use efficiency, and plant nutrition of regional vegetables like amaranths and okra, the Agricultural Research Council (ARC) of several African countries promoted the production of underused crops of various vegetables [20]. As a result, vegetable farming expanded in a few provinces, and the nutrition and health of the targeted populations both improved.

The urban poor in developing nations have significantly expanded their intake of staple food types [21]. The lack of essential vitamins and minerals, like iron, in the diets of the majority of urban households in Africa and Asia is demonstrated by the rising incidence of iron deficiency anemia in sub-Saharan nations [22]. Additionally, in today's globalized economy, developing nations are heavily reliant on food imports to meet the rising demand for staples, making them susceptible to price fluctuations on the international market [23].

According to Bakhtsiyarava, M. and Grace, K. [24], there is a direct correlation between expanding your crop diversification portfolio and a lesser likelihood of staying in poverty. They looked at the households' crop diversity in relation to the customs of the village and included in their research a diversity count of 50 different crops, including cash crops like sesame, linseed, coffee, chat, and enset as well as staple crops like tef and maize. The examination of the advantages of crop diversification in Ethiopian households, the likelihood of living in poverty dropped by 18.3% for households already in poverty and by 16.9% for homes over the poverty line. To promote the biodiversity of crops farmed, they advocated for expanding agricultural diversification rather than encouraging specialization in cash crops. According to a number of writers, diversity is an effective farming strategy for boosting livelihoods in different communities and promoting agricultural progress. When growing vegetable crops [25] found a link between diversification and higher income returns for traditional rice farmers in China. To combat food poverty and malnutrition in Africa, particularly in Ethiopia, attention must be focused not just on staple foods but also on diet-relevant neglected crops [26] 9% of the world's population currently lives in sub-Saharan Africa, which is characterized by a high prevalence of food and nutrition insecurity, which is partially caused by a lack of crop variety. Apart from playing an important role in the African diet, neglected crops can also contribute to the local economy and are part of traditional medicine as leaves of certain crops are used both as a food and a medical source. The majority of the plants are either native plant that grow wild or are grown on a very modest scale. As a result, both availability and production are constrained [27].

But it's crucial to remember that there are a number of variables that limit the use and cultivation of NUCS. Studies and written material on these neglected crops in Ethiopia are insufficient. Agronomy, water needs, and nutrition continue to be obstacles to their development and promotion because there is very little knowledge available explaining fundamental parts of their genetic potential. There is now "an increasing acceptance at national and worldwide level of the crucial role in sustainable agricultural systems and human well-being of less-used crops and species, particularly in less advantageous and marginal soils" [28].

Despite their substantial contributions to food security, income production, the provision of food energy, and the preservation of the resource base, not all regions of Ethiopia have yet completely utilized and exploited the food potential of various vegetables, root crops, and tuber crops [29]. The lack of an appropriate legal framework, a lack of knowledge about how the market affects food security, a lack of land use policies, and a loss of traditional knowledge about indigenous crops are the other gaps.

2. Conceptual Framework

Farming systems become more tolerant to biotic and

abiotic challenges and improve food and nutrition security as they become more varied. Maintaining biodiversity with underutilized crops in agriculture is vital for providing regulatory ecological services like nutrient cycling, soil erosion control, reduction of greenhouse gas emissions, and regulation of hydrological processes, in addition to providing for food and nutrition. It also used to improve production and productivity of land because it is produced on marginal land and also it gives high productivity on small area of land. Marginal land crops typically exhibit resistance to adverse weather, including drought, waterlogging, and damaged soils, and could therefore increase food availability and stability. The cultivation of underused crops has the potential to increase genetic variety, increase food and nutritional security, and benefit both the population's well-being and the environment. In a world with limited resources, this is especially crucial to ensure food and nutritional security for the growing population. The main concept of this study is summarized as follow:

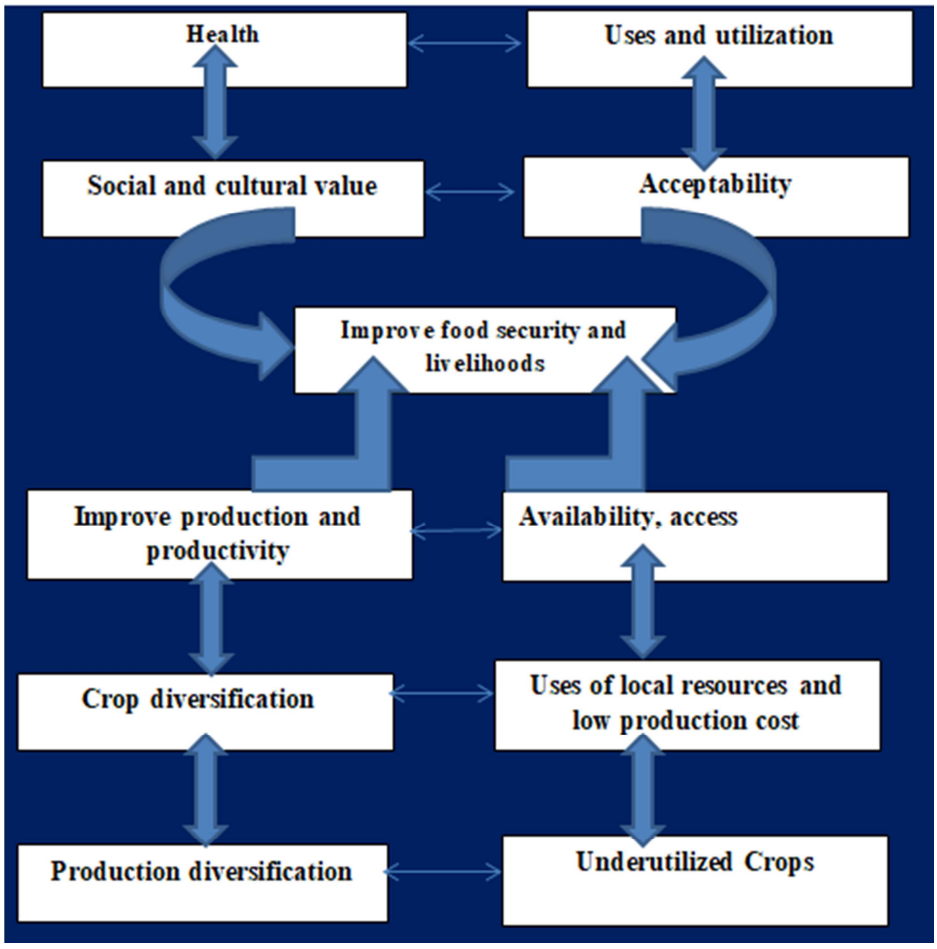

Figure 1. *Conceptual framework of production diversification and food security (Source: prepared by the researcher).*

3. Research Approaches

3.1. Description of the Study Area

GutoGidais one of the woredas in the Oromia Region of Ethiopia. It is part of the East Wollega Zone. It is bounded by WayuTuka in the east, Sasiga and Diga in the west, Gida Ayana and Gudaya Bila in the north and LekaDulacha to the south. The woreda encircled the capital of East Wollega zone capital city called Nekemte, it is located at about 331kms from Addis Ababa. The occupations of the inhabitants are primarily agriculture, semi-agriculture or mixed agriculture. It is geographically located between latitude 8057’00”N-9032’00”N and longitude 36026’00”N-36044’00”N the study area encircled Nekemte city. The sample kebeles are in the mid altitude it ranges from 900m to 1800m above sea level. The dominant soil type of this area is nitosoil [30].

The study aims to attribute food security outcomes of farmers to crop diversification with the underutilized crops. The study is based on an extract of 120 households interviewed in GutoGida district in Ethiopia in 2021. The data were collected through questionnaire survey of stratified random sample of farmers of the study area. This section briefly describes sampling methods used to measure food security, crop diversification with underutilized crops contribution used to establish relationship between food security, socioeconomic and crop diversification with underutilized crops.

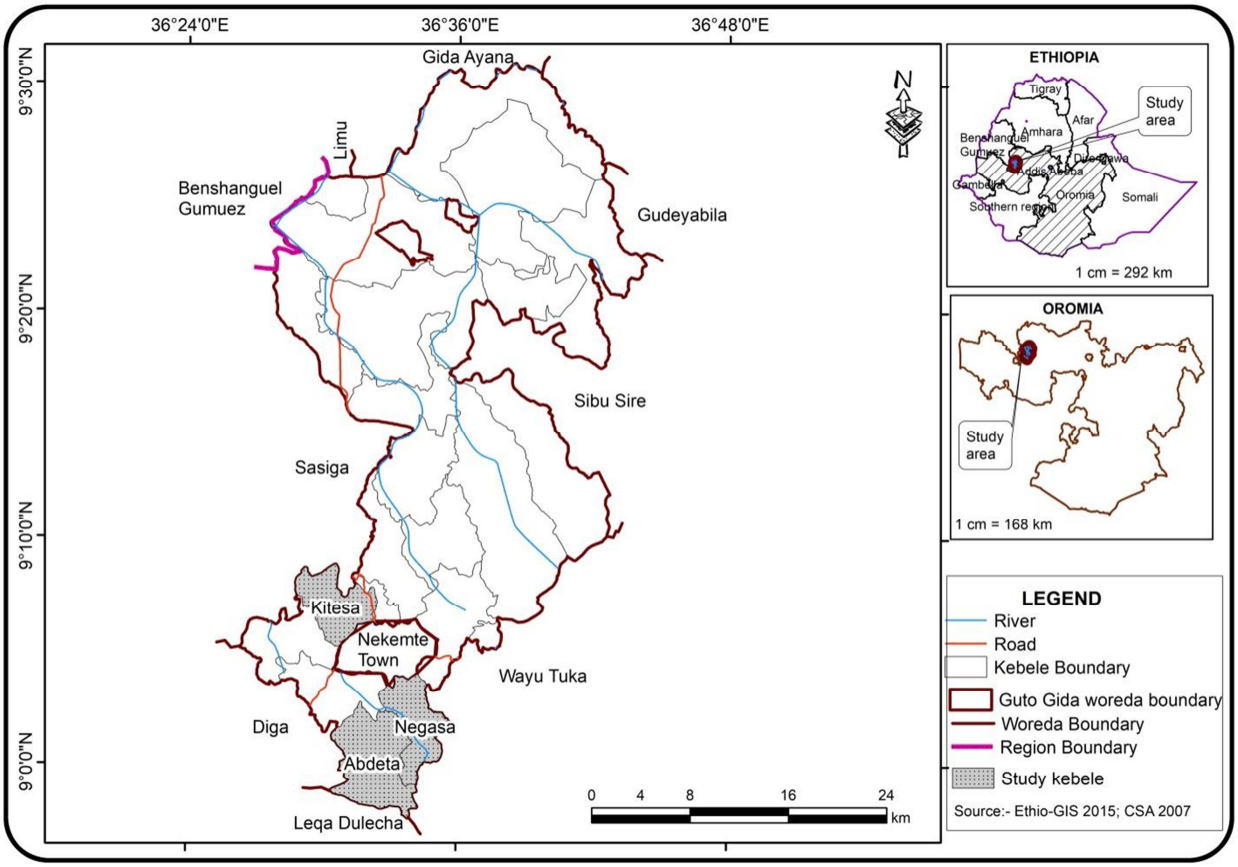

Figure 2. *GutoGida woreda, Oromia, Ethiopia (Source: Authors' own construction).*

3.2. Sampling and Data Collection Technique

A mixed method approach, which included combining quantitative and qualitative research or outcomes with process studies, was used. Emphasis was placed exclusively on identifying literature on NUS from Ethiopia. Briefly, the study initially identified the terms or key words commonly used to refer to underutilized crops in Ethiopia and other east African countries literature. The five (5) commonly used terms that were identified were; (i) underutilized crops, (ii) indigenous crops, (iii) traditional crops, (v) neglected crops, and (vi) orphan crops. This was based on common terminology identified in the initial study [31]. The terms were used to conduct online searches using Google and Google Scholar, ScienceDirect and SpringerLink search engines. Articles of interest were those relating to Ethiopia and other African country literature hence the search was set to filter results to the country Ethiopia. Results were further filtered to only show results that featured at least one of the following exact words "underutilized/indigenous/traditional/neglected/orphan." Thereafter, results were separated into pre- and post-2015 periods and further separated into scientific, public, and online publications. Scientific articles included research papers, thesis, conference proceedings, and technical reports.

By using the first phase identified (i) common underutilized crops in the study area, the resource identification was also developed as an initial step toward developing a tool for achieving information on and developing a database for underutilized crops research in Ethiopia. i. Crops that were identified included groundnut (*Vignasubterranea* (L.), amaranth (*Amaranthus* sp.), bottle gourd (*Lagenariasiceraria*), eggplant, African yam bean, maize landraces (*Zea mays*), cowpea (*Vignaunguiculata* (L.) Walp), sweet potato (*Ipomoea batatas*), taro (*Colocasiaesculenta*), sword bean (*Canavalia gladiate*), anchote (*Cociniaabysinia*), Oromo dinich (*Plectranthus edulis*), marama bean (*Tylosemaesculentum*), spider plant (*Cleome gynandra*), finger millet (*Eleusinecoracana*), nightshade (*Solanumnigrum*), cocoyam (*Xanthosoma* spp.), sunberry (*Solanumnigrum*), wild water melon (*Citrulluslanatus*), wild mustard (*Sinapisarvensis*), sorghum (*Sorghum bicolor*), and sesame (*Sesamumindicum* L.).

For the second part multi-stage sampling technique was applied that focuses on underutilized crop producers and non-producers of local producers. The sample kebeles in the district will be stratified based on their crop production types focusing on underutilized crops with comparison of the other crops. Then purposive sampling technique will be employed to select 3 rural kebeles from the total 20 rural kebeles in the woreda. The kebeles' study zones, households are purposely selected based on underutilized crop producers and non-producers households. This ensures most representation stratum than the total population and results in more reliable

and detailed information. These kebeles are Abdata, Qitesa and Nagasa; they are in the mid altitude it ranges from 900m to 1800m above sea level. The sample kebeles are in the same environment but great variation in their crop production amount and type they produce according to the data obtained from the woreda agricultural office of 2019/20 production year.

Both primary and secondary data were collected from different sources to identify important variable that may affect household food security. To generate primary data, a semi structured questionnaire was used to collect quantitative data through a household survey involving household heads and their spouses from three kebeles (Abdeta, Nagassa and Qitesa). The survey covered a total of 120 selected households (90 men headed households and 30 female headed households). The survey was conducted that was done once; data were collected on based on underutilized crop producers and non-producers. The research was employed household questionnaire survey, FGD, KIIs and field observation in primary data collection.

3.3. Measuring Crop Diversification Index with Underutilized Crops

In order to measure crop diversification for the particular crops of interest, we employed the Crop Diversification Index (CDI). The CDI is an index of concentration and has a direct relationship with diversification such that a zero value indicates specialization and a value greater than zero signifies crop diversification. With the CDI index, it was then easy to identify those farmers that are practicing crop diversification and those not practicing diversification. The CDI is obtained by subtracting the Herfindahl index (HI) from one (1-HI). Precisely, the CDI is calculated as follows:

$$Si = \frac{Ai}{\sum_{i=1}^{n} Ai}$$

Where, S_i = proportion of i^{th} crop; A_i = area under i^{th} crop; $\sum_{i=1}^{n} Ai$= total cropped area; and i = 1, 2, 3, 4… n (number of crops)

$$HI = \sum_{i=1}^{n} S_i^2$$

$$Therefore\ CDI\ becomes\ 1 - \sum_{i=1}^{n} S_i^2 = 1 - HI$$

In this study, we used thirteen crops common in smallholder farming in GutoGida district to calculate the index. These crops included cereals (maize, barley, wheat, tef, amaranths and sorghum), pulses (groundnut, cowpea, soybean, and common bean), root and tubers (anchote, taro, sweet potatoes) and vegetables. On vegetables, the household considered vegetable growers were the ones growing at least one vegetable crop per season.

3.4. Measuring Influence of Crop Diversification with Underutilized Crops on Food Security

To ascertain causality between crop diversification with underutilized crops and food security outcomes, the study adopts an ordinary least squares (OLS) regression. Since the CDI (a continuous variable and food security outcomes FCS and Coping strategy index (CSI) as dependent variables (all continuous variables), we decided to use OLS regression. According to Compton et. al., [2], it is very sound and correct to use OLS to ascertain influence of a continuous variable on another continuous variable like in our case. The OLS model is specified as

$$Y_i = \propto_0 + \propto_1 X_{i1} + \cdots + \propto_7 X_{i7} + e$$

Where, Y_i= household food security outcome (either FCS or CSI), X_{i1} = crop diversification, X_{i2} = underutilized crops (1 = yes; 0 = no), X_{i2} = cattle (1 = yes; 0 = no), X_{i3} = household size, X_{i4} = access to resource or land (1 = yes; 0 = no), X_{i5} = education of household head (1 = at least primary education; 0 = otherwise), X_{i6} = age of household head and X_{i7} = ownership of a grain storage facility, α_0 = intercept, α_1 to α_7 are coefficients, and e is the error term. Table 1 shows the description of variables used in our analysis.

To estimate food security, the study employed FCS approach and computed in accordance with guidelines provide by EFSA, [31]. FCS was measured based on dietary diversity, food frequency, and the relative nutritional importance of nine different food groups. The FCS is designed to reflect the quantity and quality of people's diet at household level. A composite score is derived from a weighted sum based on the food type and frequency of consumption during a 7-day period. Precisely, dietary recalls questions were used to collect information on the consumption of selected food groups common in Ethiopia (GutoGida district). The interviewees were asked about frequency of consumption over a recall period of past 7 days. FCS was calculated using the formula proposed by EFSA [31]. In the formula, FCS is derived by multiplying the weight for each food group/type by the frequency (number of days) these food groups/types were consumed; the values for all food types consumed during the 7 days recall period were summed up to give the FCS. The formula can be expressed as follows:

$$FCS = axf(cereal\ and\ or\ tubers) + axf(pulse) + axf(milk) + axf(fruit) + axf(meat\ and\ orfish) + axf(sugar) + axf(vegetables) + axf\ (oil) + axf(condiments)$$

Where FCS = Food Consumption Score, f = frequency of food consumption (number of days for which each food group was consumed during the past 7 days), and a = weighted value representing nutritional value of selected food groups EFSA (2015). Food groups were assigned different weights reflecting their nutritional density. The FCS has thresholds consumption categories of poor food consumption (0–21), borderline food consumption (21 < FCS ≤ 35), and acceptable food consumption (FCS > 35) EFSA (2015). The FCS was adopted as it provides a more accurate measure of the quality of the household diet. Moreover, it accounts for the nutritional value of food in addition to the number of different types of food consumed. However, the

FCS bears some weaknesses, mainly because the measure does not consider foods consumed outside the household and it does not provide any information of intra-household food distribution. To some extent, the 7-day recall makes it impossible to consider quantity of food eaten. Despite its weaknesses, FCS is still considered one of the very useful measures of household food security.

3.5. Data Analysis Techniques

Data was subjected to analysis of variance. The statistical analysis was done using STATA MP 15. Mean separation was done using Ordinary Least Significant Difference (OLSD) at 5 % significance level. The means, standard errors (SE), and least significant differences, coefficients of variation were computed [33]. Linear correlation was applied to all parameters to establish the relationship between them. The quantitative data mainly obtained from household surveys were analyzed using STATA computer software package.

4. Results and Discussion

4.1. Underutilized Crops Identification and Research Gaps

The initial literature search showed that, in Ethiopia, "indigenous crops" was the most popular term with more than 1,000 hits, while "traditional crops" was the least popular with 109 hits and underutilized crops was less 105. When results were filtered to only show results that featured at least one of the exact words "underutilized/indigenous/traditional/neglected/orphan," "neglected crops" became the most popular term total with 7,000 hits.

Results of underutilized crop identification showed that the most researched themes on underutilized crops were agronomy, food security and nutrition with 87, 42 and 36 publications, respectively (Table 1). Themes that featured prominently (>30 publications) were post-harvest and medicinal properties, while climate change, breeding and biotechnology, peoples' perceptions and commercialization featured to a limited extent (<25 publications). This confirmed previous reports that have identified crop improvement and development of value chains or marketing as key impediments to the promotion of NUS is Sub-Sahara countries and elsewhere [33]. As this result showed more than 95% of these crops are found in our country especial in the study area or in western part of our country (Table 1). In addition the regional or sub Saharan underutilized crops there are two more very common and very popular underutilized crops (Anchote and Dinich Oromo) in this study area, however as this study showed there were a very limited research work was done on these crops. These result showed that they were underutilized crops because there research and promotion done on these crops were very limited. Hence much work has been done addressing tolerance to abiotic stresses (drought and heat) and nutritional value; there is a need to focus on crop improvement and promotion for NUS and developing their value chains.

In addition this result showed that there is no enough research outputs for these underutilized cereals, vegetables, fruits, root and tuber crops links with their role in addressing food security and micronutrient deficiencies in diets of poor rural people. Groundnut and cowpea were the most researched grain legumes with 15 and 16 publications, respectively. The high number of publications on groundnut also aligns with international efforts being driven by the Bambara Groundnut Network (BamNetwork) to promote groundnut as an exemplar underutilized crop [32].

Table 1. *List of underutilized crops and number of times each crops was researched under a theme based on the Ethiopia resource identification search.*

Crops	Nutrition	Agronomy	Food security	Seed quality	Breeding	Perception
Groundnut	1	2	3	0	1	0
Amaranth	2	3	6	0	2	1
Bottle gourd	0	1	3	0	1	0
Maize landraces	6	3	8	5	2	0
Cowpea	2	2	6	1	0	0
Sweet potato	4	5	9	0	5	2
Taro	1	2	5	0	0	0
Sword bean	0	1	0	1	0	0
Anchote	3	2	5	0	1	0
Dincha Oromo	2	3	4	2	0	2
African yam bean	0	0	0	1	0	0
Marama bean	0	1	2	0	2	0
Eggplant		0	0	0	0	2
Spider plant	1	1	2	0	1	0
Finger millet	2	3	4	1	1	1
Nightshade	0	0	2	1	1	0
Cocoyam	2	2	3	2	2	1
Sunberry	0	0	2	1	1	0
Wild water melon	2	2	4	1	0	0
Wild mustard	3	2	4	1	0	0
Sorghum	3	4	8	3	2	0
Sesame	2	3	7	3	3	3
Total	36	42	87	23	25	12

Table 1. *Continued.*

Crops	Resilience of Climate change	Post- harvest	Commercializatin		Biotechnology	Total
Groundnut	3	2	0	0	1	13
Amaranth	0	3	1	2	2	22
Bottle gourd	0	1	0	1	0	7
Maize landraces	2	4	1	2	0	33
Cowpea	2	0	1	2	0	16
Sweet potato	2	4	3	4	2	40
Taro	1	2	0	4	1	16
Sword bean	0	0	0	0	0	2
Anchote	0	1	0	2	1	15
Dincha Oromo	0	0	0	1	1	15
African yam bean	0	2	0	0	0	3
Marama bean	1	2	1	2	1	12
Eggplant	0	0	1	1	1	5
Spider plant	1	2	0	1	0	9
Finger millet	0	1	1	0	0	14
Nightshade	0	0	0	0	0	4
Cocoyam	1	2	1	2	2	20
Sunberry	0	1	0	1	1	7
Wild water melon	1	1	0	1	1	13
Wild mustard	1	1	0	1	0	13
Sorghum	2	3	2	1	2	30
Sesame	2	3	3	4	2	35
Total	19	35	15	32	18	344

Source: Developed by the researcher from a literature review, 2021

Among the cereal crops, maize landraces and sorghum were relatively the highest publications, however still these researches were not all rounded it specific one or two characters of the crops. With respect to root and tuber crops, sweet potato received the most research attention (42 publications) followed by taro and anchote (17 publications for each) (Table 1). In addition the result showed that for underutilized cereal crops maize and sorghum landrace (38 and 37 publications respectively (Table 1). As this study showed the rest of the other crops had very less studied publication which showed that they are much underutilized and didn't get research attention. The successful commercialization of taro in some African countries could be associated with the increased research outputs. Research on sweet potato has emerged recently, mostly due to promotion of orange-fleshed sweet potatoes as a source of beta carotene [34]. In general as this study showed all these crops were not developed, not promoted or they are underutilized in all perspectives, so they are considered as underutilized crops in Ethiopia as well may be in other Sub-Saharan countries. A major reason for the low investments in NUS research is the wrong perception that they offer less returns on investments compared to the major crops. The initial study by [35] proposed that this hurdle could be overcome by identifying a few specific NUS with traits that are useful such as drought and heat stress tolerance and nutrient density, that show certain advantages over major crops and that had prospects for success.

As this literature research showed the most common underutilized crops in the study area as well in the most part of this country as well in the east African countries were identified that included groundnut (Vignasubterranea (L.), amaranth (Amaranthus sp.), bottle gourd (Lagenariasiceraria), eggplant, African yam bean, maize landraces (Zea mays), cowpea (Vignaunguiculata (L.) Walp), sweet potato (Ipomoea batatas), taro (Colocasiaesculenta), sword bean (Canavalia gladiate), anchote (Cociniaabysinia), Oromo dinich (Plectranthus edulis), spider plant (Cleome gynandra), finger millet (Eleusinecoracana), sunberry (Solanumnigrum), wild water melon (Citrulluslanatus), wild mustard (Sinapisarvensis), sorghum (Sorghum bicolour), and sesame (Sesamumindicum L.) are the most common underutilized plant in the western part of our country especially in GutoGida district. These crops not get enough research or development and promotion programs, it didn't get enough funding for the development. Even though these crops were potential in nutrition and promising food security, they were not guided by policy and strategies for the development and promotion. Still these crops were restricted to a specific growing area or they were underutilized in Ethiopia.

Table 2. *Household population size and sampled households.*

Kebeles	Total households			Total Sampled size			Underutilized crop producers			Non-underutilized crop producers		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
Abdeta	720	270	990	38	10	48	18	6	24	20	4	24
Qitesa	513	170	683	24	6	30	11	4	15	13	2	15
Nagasa	629	210	839	28	14	42	13	8	21	15	6	21
Total	1862	650	2512	90	30	120	42	18	60	48	12	60

Source: Computed from authors' field survey, 2021

The survey study showed that the participant for underutilized crop producers and non-producers were similar and also the gender equality distribution for the producers and non-producers were almost similar (Table 2). The production land, educational level, age, family number and the cattle owning proportion were considered has no significance difference between the producers and non-producers (Tables 2 and 3).

The descriptive statistics of variables used in our analysis are shown in Table 2. The statistics are based on a sample of 120 farming households from GutoGida district, Ethiopia.

Table 3. *Summary statistics of variables used for analysis.*

Variable	Variable description	Underutilized crop producers				Non underutilized crop producers			
		Mean	SD	Min	Max	Mean	SD	Min	Max
Educational background	Educational level	8		3	Diplo	7		2	Diplo
Family numbers	Householdfamily number	6	7.76	1	12	6	7.76	1	12
Production land area	Productionlandin hectares	1.625	1.95	0.25	3	1.625	1.95	0.25	3
Socioeconomic contribution of underutilized crops	Total production (kg)	5653.33	95.04	5560	5750	2450.0	104.4	2380	2570
	Total consumption (kg)	3418.33	159.8	3021.1	3815.4	1136.0	54.61	1000.3	1271.6
	Total sale (kg)	2200.00	50.00	2150	2250	1312.3	90.22	1226	1406
	Total expenditure for food (birr)	5425.00	149.0	5265	5560	7371.0	254.0	7153	7650
	Total Income (birr)	6440.33	77.95	6358	6513	4372.3	217.5	4217	4621
FCS	Food Consumption Score of the household	29.87	15.8	12	43	22	12	10	33
CSI	Coping strategies index	8.00	2.000	6	10	12.33	2.517	10	15

Source: Computed from authors' field survey, 2021 *Significant at 5%

The result implies that high crop diversification with underutilized crops of the sampled households in the GutoGida district of nearly the same production area of land, the same other economic back ground of the respondents, the diversified producers had showed more level of crop production (22.48%), consumption (11.73%), total annual sale (19.32%) and total income generation (26.67%) than the non-producers of diversification with underutilized crops or the mono cereal crop producers (Figure 3). On the other hand the non-producers of diversified crops expend (31.43%) more money than the crop diversified with the underutilized crops (Figure 3). This survey showed that, in terms of non-underutilized crops producers from the sampled households had a very poor ratio of production, consumption, total annual sale and income generation. On average, only 21% of the households produce underutilized crop with other cereal or diversification at the physical year of the survey. Household sizes at the time of the survey were found to be moderate, about six to eight family members per household. The minimum household size recorded was 1 and maximum of 13 members. There is no significant difference on age, educational level, household members and area of cultivation land and other economic activities among the underutilized crop producers and non-producers (Table 3).

The income generation from the production differences of these crops was vary in the group of smallholder farmers sampled as per the producer house number in GutoGida district of the study area (Table 3). The household number has positive effect on the production amount of the crops because most of these crops were produced in the garden of the households, in small area of the land and it give the opportunities for the whole family member participation in the whole agricultural activities. More than 60% of the respondents or the producers had generated more amount of income from the production of these underutilized crops. On the other hand these of non-producers of underutilized crops were not relatively producing enough income per year of these producers (Table 3).

This survey showed that the amount of production, consumption, income generation, of the underutilized crop producer was averagely earn 30% greater than of these non-producers (Figure 3). From this study one can conclude that the non-diversified producers were expend more amount of money per year for food than the diversified crop producers (Table 3). This study also showed that the productivity and yield of the diversification with underutilized crops were more productive than the non-diversified crops in the same area of land. Education wise, about 86% of household heads had attained at least primary education at the time of the survey. The result implies that the level of education in the study area is good which makes extension messages and any other production- and marketing-related information from various sources easily understood by the smallholder farmers. In addition, the group of farmers was found not to be very old with an average age of 46 years. Minimum and maximum age for the group of the household was found to be 19 and 82, respectively. Another characteristic researched on was whether the households own or rent a production or farm land. Results show that about 99% of the sampled smallholders had access to their own land for the production.

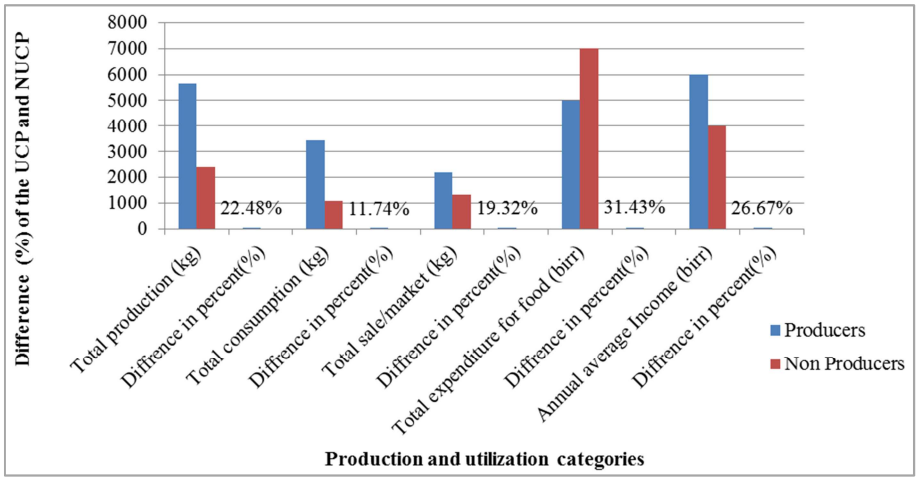

Figure 3. *Socioeconomic contribution of underutilized crops (source: computed from the authors' field survey, 2021).*

This study was agreed with the study on taro and other underutilized crops; underutilized crop food has a considerable economic importance as additional crop in many large islands in the Pacific region such as Samoa, Fiji as a cash crop and foreign exchange earner [36] [Akwee, E. P., Netondo, G., Kataka, J. A. and Palapala, J. A., 2014. A critical review of the role of taro Colocasia esculenta L. (Schott) to food security: A comparative analysis of Kenya and Pacific Island taro germplasm.]. Some underutilized crops such as taro, sweet potatoes can be exported; its production not only provides cash to the farmers but is also a valuable foreign exchange to the country. These Pacific islands countries have been able to earn substantial revenue from the underutilized crops like taro export trade, mainly to Australia and New Zealand. Many other countries would like to participate in taro exportation. People of Pacific Island origin continue to consume taro wherever they may live in the world, not so much because there are no substitute food items, but mainly as a means of maintaining links with their culture. This cultural attachment to taro has spawned a lucrative taro export market to ethnic Pacific Islanders living in Australia, New Zealand and western North America [37]. Various parts of the taro plant are used in traditional medical practice. Taro corms and leaves are used in traditional medicine, evidence of the long association of the people with the plant.

According to Farm Concern International and The World Vegetable Center study, consumption of African leafy vegetables in Eastern Africa was only 31 tons valued at USD 6,000 in 2003, but by 2006, consumption increased almost 20 times to 600 tons with a farm gate value of USD 142,860. A yield and profitability analysis indicated that mono-cropping on about 1,000 m^2 could produce 3,409 kg of spider plant; 7,500 kg of amaranth; 2,841 kg of cowpea (Vigna species); 2,841 kg of African nightshade (S. scabrum); and 2,273 kg of Jew's mallow, which has a total of 18,864 kg amounting to a market value of USD 2,515, with net profitability of USD 1,539 [38]. In the past, leafy vegetables may have been considered only as food for the poor, unclean, and, therefore, not safe to eat.

Drawing from Baa-Poku [41] description of a resource being valuable and able to present opportunities, NUCS constitute a valuable plant resource with several benefits and traits that make them relevant and useful to the easy of production, income generation and environment health. NUCS are able to flourish under harsh conditions where previously other plants may not survive and this make them valuable in climate change mitigation and sustainable food production [39]. NUCS also contribute essentially to the maintenance of cultural diversity among indigenous communities due to the cultural value they place on them [40]. Several studies in remote areas of developing economies have shown that NUCS play important roles in the enhancement of local livelihood, nutrition and food security among indigenous communities [41]. In countries such as India, Nepal, Malaysia and Philippines in Asia and the Pacific, NUCS have been reported to serve as source of food and medicine. The use of NUCS is also common among Sub Saharan countries such as Malawi, Nigeria, Cote d' Ivoire, Uganda, and Zimbabwe [42].

NUCS therefore present a unique opportunity for agricultural sector to exploit for the purposes of addressing the food insecurity among indigenous or rural communities. Several studies including [43] have confirmed NUCS contribution to addressing the food insufficiency challenge. In terms of resources being rare and offering competitive advantages, NUCS possess some unique agronomic properties that make them thrive in diverse ecological niches and under unfavorable environments such as poor soils and drought [44]. While NUCS occur in both tropical and temperate areas, their use and importance are not clearly evident in many countries [45]. It is imperative from the foregoing discussions that NUCS as plant resource has not been fully exploited by the agricultural sector in Ethiopia and therefore must be given the urgent attention it deserves.

4.2. Households' Food Security Status of Underutilized Crops Producers and Non-Producers in GutoGida District

The two measures of food security portray almost a similar

trend. The two measures show that at least 78% of the households are moderate to food secure. In trying to relate the two measures of food security, FCS and CSI, to crop diversification with underutilized crops were showed that proportions of crop diversification are higher among borderline food secure to food secure households. One notable thing is that average indices by food security status category (high FCS and less CSI) are above 55% indicating high crop diversification and relative food secured than with non-diversification with underutilized crops (Figures 4 and 5).

Table 4. *Food security status of households and intensity of crop diversification.*

Food security/insecurity indicator	Underutilized crop producers		Non underutilized crop producers	
	% of households in category	Average CDI index by category	% of households in category	Average CDI index by category
FCS				
Poor FCS	10	0.56	14	0.38
Borderline FCS	16	0.6	25	0.43
Acceptable FCS	34	0.63	21	0.41
CSI				
Food secure	32	0.58	15	0.49
Mild to moderate food insecure	20	0.58	25	0.45
Severely food insecure	8	0.55	20	0.41

Source: Computed from authors' field survey, 2021

Crop diversification as measured by the index was found to have a positive influence on FCS and a negative influence on CSI (Table 5). The coefficient of CDI is significant at 5% and shows a positive influence on household FCS. 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 food consumption in GutoGida district, which means the underutilized crop producers with the other crops were more food secured than the non-producers. In addition the more crop diversified households had used low level of CSI (Table 4). On the other hand, the coefficient of CDI is significant at 5% and shows a negative influence on CSI (Table 5). This means that household with higher crop diversification intensities is less food insecure as compared to those with relatively lower crop diversification intensities. The result implies that crop diversification with underutilized crops reduces the severity of food insecurity or low uses of CSI (Table 4). Households which have relatively higher number of crop species are less likely to adopt more desperate food insecurity coping strategies.

Table 5. *OLS regression of underutilized crop production effect on food security and livelihoods of the households.*

Variables	Food security and livelihood indicators			
	FCS		CSI	
	Coef.	P > t	Coef.	P > t
Education of-HH	0.097	0.086*	− 0.435	0.002***
Age of –HH	0.001	0.68	− 0.004	0.39
Household size	-0.012	0.51	0.007	0.83
Crop diversification with underutilized Crops	0.5	0.057**	− 1.028	0.005*
Non crop diversification with underutilized Crop	− 1.048	0.067	0.29	0.053
Income	0.35	0.068	− 1.085	0.95
Other properties ownership	0.175	0.014**	− 1.064	0.98
R2	18.50%		19%	
Adjusted R2	16%		16.80%	
F	3.65***		3.45***	
N	120		120	

*Significant at 10%; ** significant at 5%; ***significant at 1%, HH is household head

Therefore, farmers who intensify crop diversification with underutilized crops are better off than their counterparts as diversification is positively related to food consumption and negatively related to food insecurity mainly due to the benefits of crop diversification to include, raising farm productivity, income, and reducing production and price risks. Similar studies have found crop diversification to impact positively on food security of the household [46, 47]. More so, the merits of crop diversification in improving food security can manifest through better management of price and production risk [48]. This is possible since growing more than one crop species in a single season gives the farmer options which can ensure him/her manage price and production risks better as compared to less diversified farming enterprises.

Considering that Ethiopia has a variable climate, crop diversification helps farmers insure against disasters such as floods and drought. Statistics report more than 45 weather-related disasters that occurred in Ethiopia between 1973 and 2009, including about 12 droughts and flood events [49]. These present serious problems to the smallholder farmer in Ethiopia since he/she can find difficulties in adopting modern

coping strategies to the problem of crop diversification. Furthermore, if smallholder farmers continue to increase acreage of the traditional maize and sorghum at the expense of more drought- and flood-tolerant crops could exacerbate the impact of drought and floods on food security [50]. This therefore justifies the positive influence of crop diversification on FCS and negative influence on CSI [51].

4.3. Contribution of Crop Diversification with Underutilized Crops in Improving Food Security and Livelihoods of the Households

Food Consumption Score (FCS) and Coping Strategy Index (CSI) statistics show that household FCS on average was at 36% indicating acceptable food consumption level for the underutilized crop produces whereas 22% of the non-diversification producers of underutilized crops can only reach the acceptable level of food consumption. Minimum score 12% was observed in the non-underutilized crop produces households whereas the maximum FCS (39%) was found in the households that produce diversified crops with underutilized crops. The distribution of households based on the FCS was shown in Figure 4. Based on FCS, the distribution shows that the majority of the household (57%) are food secure, 36% have borderline food consumption, and only 26% have poor food consumption. In terms of CSI, results show that 32% of the UCP households and 15% of the NUCP households were food secured or they used low CSI, and 20% of UCP and 25% of NUCP households were used medium CSI while 8% of UCP and 20% of NUCP households used high level CSI in Figure 5.

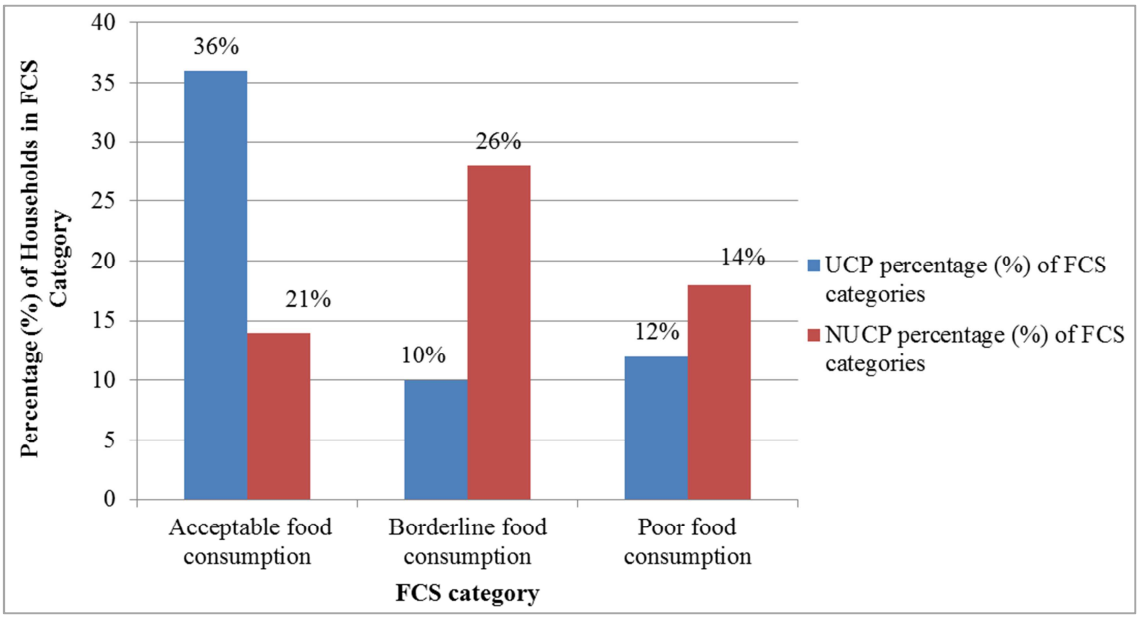

Figure 4. *Distribution of households in GutoGida district based on food consumption score (FCS) (Source: Computed from authors' field survey, 2021).*

This result showed that diversification with underutilized in GutoGida district or in Ethiopia was found to significantly contribute to the FCS (Figure 4). The coefficient of production is significant at 5% and positively related to food consumption score. Producers of underutilized crop are important in improving household food consumption in several ways. The results show that households that crop diversification have higher FCSs than those that do not produce diversification (Figures 4 and 5). This survey showed that underutilized crops were produced by local materials, it easily cultivated in small area of production land.

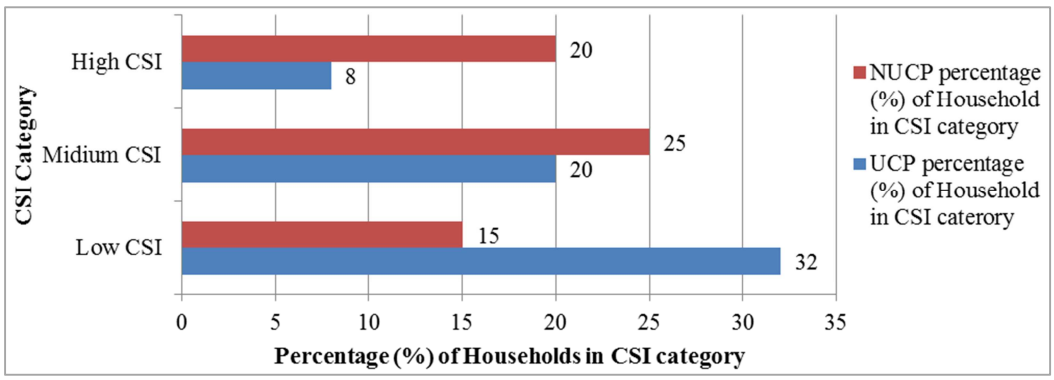

Figure 5. *Distribution of households in GutoGida district based on Copying Strategies Index (CSI) (Source: Computed from authors' field survey, 2021).*

Secondly, these production or farming system are play a vital role as a productivity enhancing input in farming activities as they can provide organic matter and composts, enhance the recycling of different organic materials [52]. In addition these crops are very nutritious and serve as a source of food for the household by producing important nutrients [53]. It provides good chance of work opportunities for whole the households and also it generate source of income for the household members. To support this finding [53], found that crop diversification with underutilized are an important factor that contributes to food security mainly because: it contributes to subsistence household needs, income and nutritional requirements with the other food sources.

5. Conclusion

This study has examined the contribution of crop diversification on household food security and increasing livelihoods in GutoGida district. The study used two measures of household food security, the FCS and the CSI. The OLS results showed that crop diversification is positively correlated with the FCS and negatively correlated with the CSI. This means that households with higher crop diversification with the underutilized crops are more likely to have a diverse diet slightly more livelihoods and they are also less likely to use copying strategies to desperate food insecurity conditions. Farming households with more than one crop grown tend to be more secure in terms of food supplies and income and hence are able to provide for the food requirement of their households than the less crop diversified producers. Crop diversification with underutilized crops hence improves food security and livelihoods through improving food stocks in terms of quantity and variety and also in improving income through sale of crop produced from a variety of grown crop species which then is used to further improve consumption patterns.

Declarations

Author Contribution Statement

Dhaba Mengesha Adula: Conceived and designed the experiments; Performed the survey; Analyzed and interpreted the data; wrote the paper.

Messay Mulugeta Tefera: Analyzed and interpreted the data; wrote the paper.

Bogale Ayana: Analyzed and interpreted the data; wrote the paper.

Funding Statement

The present research has been supported by the Addis Ababa University and Ethiopian Agricultural Research Institute.

Data Availability Statement

Data will be made available on request.

Conflict of Interest

The authors have no conflict of interest.

Acknowledgments

Authors are grateful to center for food security studies of Addis Ababa university for facilitating all the activities of this research work and Dr. KassayeTolessa, and Dr. Diriba Geleti from the Food Science and Nutrition Research Program of the Ethiopian Institute of Agricultural Research are acknowledged for their initiating, funding and directing this survey or project for developing a research agenda for promoting underutilized, indigenous and traditional crops.

References

[1] Mabhaudhi, T., Chimonyo, V. G., Chibarabada, T. P. and Modi, A. T., 2017. Developing a roadmap for improving neglected and underutilized crops: A case study of South Africa. *Frontiers in plant science*, *8*, p. 2143.

[2] Burchi, F., Fanzo, J. and Frison, E., 2011. The role of food and nutrition system approaches in tackling hidden hunger. *International journal of environmental research and public health*, *8* (2), pp. 358-373.

[3] Frison, E. A., Cherfas, J. and Hodgkin, T., 2011. Agricultural biodiversity is essential for a sustainable improvement in food and nutrition security. *Sustainability*, *3* (1), pp. 238-253.

[4] Norman, D. W., 2002, November. The farming systems approach: A historical perspective. In *Presentation held at the 17th Symposium of the International Farming Systems Association in Lake Buena Vista, Florida, USA* (pp. 17-20).

[5] Weber, C., Hametner, C., Tuchscherer, A., Losand, B., Kanitz, E., Otten, W., Singh, S. P., Bruckmaier, R. M., Becker, F., Kanitz, W. and Hammon, H. M., 2013. Variation in fat mobilization during early lactation differently affects feed intake, body condition, and lipid and glucose metabolism in high-yielding dairy cows. *Journal of dairy science*, *96* (1), pp. 165-180.

[6] Mabhaudhi, T., V. G. Chimonyo, and A. T. J. S. Modi, *Status of underutilised crops in South Africa: Opportunities for developing research capacity.* 2017. 9 (9): p. 1569.

[7] Yusa, A., Berry, P., Cheng, J. J., Ogden, N., Bonsal, B., Stewart, R. and Waldick, R., 2015. Climate change, drought and human health in Canada. *International journal of environmental research and public health*, *12* (7), pp. 8359-8412.

[8] Newton, A. C., Flavell, A. J., George, T. S., Leat, P., Mullholland, B., Ramsay, L., Revoredo-Giha, C., Russell, J., Steffenson, B. J., Swanston, J. S. and Thomas, W. T., 2011. Crops that feed the world 4. Barley: a resilient crop? Strengths and weaknesses in the context of food security. *Food security*, *3*, pp. 141-178.

[9] Chivenge, P., Mabhaudhi, T., Modi, A. T. and Mafongoya, P., 2015. The potential role of neglected and underutilised crop species as future crops under water scarce conditions in Sub-Saharan Africa. *International journal of environmental.*

[10] Sohaib, M. and Jamil, F., 2017. An insight of meat industry in Pakistan with special reference to halal meat: a comprehensive review. *Korean journal for food science of animal resources*, *37* (3), p. 329.

[11] Cosgrove, W. J. and Loucks, D. P., 2015. Water management: Current and future challenges and research directions. *Water Resources Research*, *51* (6), pp. 4823-4839.

[12] Popkin, B. M. and Reardon, T., 2018. Obesity and the food system transformation in Latin America. *Obesity Reviews*, *19* (8), pp. 1028-1064.

[13] Panuju, D. R., Mizuno, K. and Trisasongko, B. H., 2013. The dynamics of rice production in Indonesia 1961–2009. *Journal of the Saudi Society of Agricultural Sciences*, *12* (1), pp. 27-37.

[14] Peter, K. V. ed., 2008. *Underutilized and Underexploited Horticultural Crops: Vol. 04* (Vol. 4). New India Publishing.

[15] Ebert, A. W., 2014. Potential of underutilized traditional vegetables and legume crops to contribute to food and nutritional security, income and more sustainable production systems. *Sustainability*, *6* (1), pp. 319-335.

[16] Ingram, J., 2011. A food systems approach to researching food security and its interactions with global environmental change. *Food security*, *3*, pp. 417-431.

[17] Loos, J., Abson, D. J., Chappell, M. J., Hanspach, J., Mikulcak, F., Tichit, M. and Fischer, J., 2014. Putting meaning back into "sustainable intensification". *Frontiers in Ecology and the Environment*, *12* (6), pp. 356-361.

[18] Tontisirin, K., Nantel, G. and Bhattacharjee, L., 2002. Food-based strategies to meet the challenges of micronutrient malnutrition in the developing world. *Proceedings of the Nutrition Society*, *61* (2). pp. 243-250.

[19] Keatinge, J. D., Waliyar, F., Jamnadas, R. H., Moustafa, A., Andrade, M., Drechsel, P., Hughes, J. D. A., Kadirvel, P. and Luther, K., 2010. Relearning old lessons for the future of food—by bread alone no longer: diversifying diets with fruit and vegetables. *Crop Science*, *50*, pp. S-51.

[20] Gómez, M. I. and Ricketts, K. D., 2013. Food value chain transformations in developing countries: Selected hypotheses on nutritional implications. *Food Policy*, *42*, pp. 139-150.

[21] Lemoine, A. and Tounian, P., 2020. Childhood anemia and iron deficiency in sub-Saharan Africa–risk factors and prevention: A review. *Archives de Pédiatrie*, *27* (8), pp. 490-496.

[22] Ghose, B., 2014. Food security and food self-sufficiency in China: from past to 2050. *Food and Energy Security*, *3* (2), pp. 86-95.

[23] Bakhtsiyarava, M. and Grace, K., 2021. Agricultural production diversity and child nutrition in Ethiopia. *Food Security*, *13* (6), pp. 1407-1422.

[24] Démurger, S., Fournier, M. and Yang, W., 2010. Rural households' decisions towards income diversification: Evidence from a township in northern China. *China Economic Review*, *21*, pp. S32-S44.

[25] Baldermann, S., Blagojević, L., Frede, K., Klopsch, R., Neugart, S., Neumann, A., Ngwene, B., Norkeweit, J., Schröter, D., Schröter, A. and Schweigert, F. J., 2016. Are neglected plants the food for the future?. *Critical Reviews in Plant Sciences*, *35* (2), pp. 106-119.

[26] Evans, L. T., 1980. The natural history of crop yield: A combination of improved varieties of crop plants and technological innovations continues to increase productivity, but the highest yields are approaching limits set by biological constraints. *American Scientist*, *68* (4), pp. 388-397.

[27] Liavoga, B. A., Kathumo, V. M., Onwonga, R. N., Karuku, G. N. and Onyango, C. M., 2014. Assessment of trends in land cover and crop type change over two decades in Yatta sub county, Kenya. *Int. J. Agric. For. Fish*, *2*, pp. 46-52.

[28] [Kuyu, C. G. and Bereka, T. Y., 2020. Review on contribution of indigenous food preparation and preservation techniques to attainment of food security in Ethiopian. *Food science & nutrition*, *8* (1), pp. 3-15.

[29] West Shewa and East Wollega Zones, E. (2019). Inputs-outputs Marketing System Efficiencies of Maize and Tomato Production of Bako Tibe and Guto Gida Districts of. Adaptation and Generation of Agricultural Technologie, 26, 195.

[30] Borelli, T., Hunter, D., Padulosi, S., Amaya, N., Meldrum, G., de Oliveira Beltrame, D. M., Samarasinghe, G., Wasike, V. W., Güner, B., Tan, A. and Koreissi Dembélé, Y., 2020. Local solutions for sustainable food systems: The contribution of orphan crops and wild edible species. *Agronomy*, *10* (2), p. 231.

[31] Cafiero, C., Melgar-Quiñonez, H. R., Ballard, T. J. and Kepple, A. W., 2014. Validity and reliability of food security measures. *Annals of the New York Academy of Sciences*, *1331* (1), pp. 230-248.

[32] IPGRI, I. BAMNET (2000) Descriptors for bambara groundnut (Vigna subterranea), International Plant Genetic Resources Institute, Rome, Italy; International Institute of Tropical Agriculture, Ibadan, Nigeria. The International Bambara Groundnut Network, Germany.

[33] Sokal, R. R. and Braumann, C. A., 1980. Significance tests for coefficients of variation and variability profiles. *Systematic Biology*, *29* (1), pp. 50-66.

[34] Mbosso, C., Boulay, B., Padulosi, S., Meldrum, G., Mohamadou, Y., Berthe Niang, A., Coulibaly, H., Koreissi, Y. and Sidibé, A., 2020. Fonio and bambara groundnut value chains in mali: issues, needs, and opportunities for their sustainable promotion. *Sustainability*, *12* (11), p. 4766.

[35] Tumwegamire, S., Kapinga, R., Zhang, D., Crissman, C. and Agili, S., 2004. Opportunities for promoting orange-fleshed sweetpotato as a mechanism for combat vitamin-A deficiency in Sub-Saharan Africa. *African Crop Science Journal*, *12* (3), pp. 241-252.

[36] Baekelandt, A., Saltenis, V. L., Nacry, P., Malyska, A., Cornelissen, M., Nanda, A. K., Nair, A., Rogowsky, P., Pauwels, L., Muller, B. and Collén, J., 2023. Paving the way towards future-proofing our crops. *Food and Energy Security*, *12* (3), p. e441.

[37] Akwee, E. P., Netondo, G., Kataka, J. A. and Palapala, J. A., 2014. A critical review of the role of taro Colocasia esculenta L. (Schott) to food security: A comparative analysis of Kenya and Pacific Island taro germplasm.

[38] Lobell, D., G. Bala, and P. J. G. R. L. Duffy, *Biogeophysical impacts of cropland management changes on climate.* 2006. 33 (6).

[39] Baa-Poku, F., *Application of the Resource-based Theory (RBT) to Neglected and Underutilized Crop Species (NUCS) and the opportunities they present for rural household food security: The Ghana context*. International Journal of Technology and Management Research, 2020. 5 (1): p. 45-54.

[40] Baa-Poku, F. J. I. J. o. T. and M. Research, *Application of the Resource-based Theory (RBT) to Neglected and Underutilized Crop Species (NUCS) and the opportunities they present for rural household food security: The Ghana context.* 2020. 5 (1): p. 45-54.

[41] Baa-Poku, F., *Neglected and Underutilized Crop Species (NUCS) and Household Food Security in Central Ghana*. 2019, University Of Ghana.

[42] Baa-Poku, F., J. Ayivor, and B. J. G. J. o. A. S. Ofori, *Changing Agricultural Practices and Indigenous Food Crops in the Upper Afram Basin of Ghana.* 2020. 55 (1): p. 65-74.

[43] Fallahi, J., Moghaddam, P. R., Mahallati, M. N. and Behdani, M. A., 2013. The use of diversity indices to assess the effect of restoration and conservation on plant diversity of a rangeland in South Khorasan Province, Iran. *Journal of Agricultural Technology*, *9* (2), pp. 395-412.

[44] Ismail, S., N. K. Rao, and J. C. Dagar, *Identification, evaluation, and domestication of alternative crops for saline environments*, in *Research developments in saline agriculture*. 2019, Springer. p. 505-536.

[45] Mango, N., Makate, C., Mapemba, L. and Sopo, M., 2018. The role of crop diversification in improving household food security in central Malawi. *Agriculture & Food Security*, *7* (1), pp. 1-10.

[46] Adjimoti, G. O., G. T.-M. J. A. Kwadzo, and F. Security, *Crop diversification and household food security status: Evidence from rural Benin.* 2018. 7 (1): p. 1-12.

[47] Frison, E. A., J. Cherfas, and T. J. S. Hodgkin, *Agricultural biodiversity is essential for a sustainable improvement in food and nutrition security.* 2011. 3 (1): p. 238-253.

[48] Mohamed, A. A., *Food security situation in Ethiopia: a review study.* International journal of health economics and policy, 2017. 2 (3): p. 86-96.

[49] Umar, D. U. A., Ramli, M. F., Aris, A. Z., Sulaiman, W. N. A., Zaudi, M. A. and Tukur, A. I., 2019. An overview of climate change and variability impact studies in Nigeria. *Arabian Journal of Geosciences*, *12*, pp. 1-11.

[50] Mango, N., Siziba, S. and Makate, C., 2017. The impact of adoption of conservation agriculture on smallholder farmers' food security in semi-arid zones of southern Africa. *Agriculture & Food Security*, *6*, pp. 1-8.

[51] Chibarabada, T. P., A. T. Modi, and T. J. S. Mabhaudhi, *Expounding the value of grain legumes in the semi-and arid tropics.* 2017. 9 (1): p. 60.

[52] Hawkesworth, S., Dangour, A. D., Johnston, D., Lock, K., Poole, N., Rushton, J., Uauy, R. and Waage, J., 2010. Feeding the world healthily: the challenge of measuring the effects of agriculture on health. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *365* (1554), pp. 3083-3097.

[53] Bandula, A., Jayaweera, C., De Silva, A., Oreiley, P., Karunarathne, A. and Malkanthi, S. H. P., 2016. Role of underutilized crop value chains in rural food and income security in Sri Lanka. *Procedia food science*, *6*, pp. 267-270.