Heliyon 11 (2025) e42345

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

Underutilized and neglected crop species and their role in enhancing household food security amid climate change, Wolaita Zone, Ethiopia

Dessalegn Shiferaw Yesuph [a,*], Dabalke Dabala Dalka [b], Masresha Tadesse Baye [c]

[a] Department of Rural Development and Agricultural Extension, College of Agricultural Sciences, Wachemo University, Po. Box 667, Hossana, Ethiopia
[b] Department of Rural Development and Agricultural Extension, College of Agriculture, Wolaita Sodo University, Po. Box 138, Wolaita, Ethiopia
[c] Wolaita Sodo University College of Agriculture, Department of Rural Development and Agricultural Extension, 138, Wolaita, Ethiopia

ARTICLE INFO

Keywords:
Climate change
Biodiversity conservation
Food security
neglected crop underutilized crop

ABSTRACT

Neglected and underutilized crop species (NUCS) are those that have been largely overlooked in mainstream agriculture, despite their potential to contribute to food security, nutritional diversity, and resilience to climate change. These crops are often undervalued, resulting in limited research and underproduction, despite their significant potential for enhancing agricultural sustainability. The study addresses the need for crop and food diversification due to food insecurity, monotonous diets, and climate change. It focuses on NUCS, which are at risk of genetic loss or negative perceptions by growers and consumers. The research aimed to document these crops, assess farmers' opinion, identify challenges in their production and consumption, and analyse their contribution to household food security. Through a multi-stage sampling method, 246 households were interviewed, along with focus group discussions and key informant interviews. The study documented 32 NUCS, which are used as supplements to staple crops and help mitigate food crises caused by climate change. However, producing and consuming these crops is often associated with poverty. The analysis revealed that 50 % of respondents have poor food consumption, 30 % are at the borderline, and only 20 % are at an acceptable level. Factors such as age, sex, farming experience, household size, and farm size significantly impact the production and consumption of these crops. The study concludes that proper documentation and seed multiplication by research and extension institutions are crucial for preserving these crops as climate change threatens staple crop production.

1. Introduction

Climate change disrupts food systems, worsening existing problems and inequalities across regions and societies [1]. Developing climate-resilient food systems is essential for managing these challenges, which will enhance food security and sustainability [2]. The global dependence on a few major crops, such as rice, maize, and wheat, makes food systems more vulnerable to climate risks, with over 50 % of consumed calories coming from these three crops [3,4]. This reliance overlooks the diverse, nutrient-rich plants that have historically been part of human diets [5].

* Corresponding author.
E-mail addresses: dessuyusuf@gmail.com (D.S. Yesuph), ddebela9dalka@gmail.com (D.D. Dalka), masreshat57@gmail.com (M. Tadesse Baye).

https://doi.org/10.1016/j.heliyon.2025.e42345
Received 18 September 2024; Received in revised form 26 January 2025; Accepted 28 January 2025
Available online 1 February 2025

Hence, neglected and underutilized crop species (NUCS) are seen as a promising solution to meet the growing food and nutritional demands of the global population [6–8]. Recognized by the FAO as "future smart foods" (FSF), these crops are nutritionally superior, contain health-promoting bioactive components, and are more climate-resilient than common cereal crops [9]. However, several barriers hinder their efficient utilization, including a lack of knowledge about their nutritional value, minimal breeding and biotechnology efforts, low interest from researchers and producers, and insufficient scientific resources for evaluating and managing these crops post-harvest [10,11].

These crops, domesticated for centuries for food, fiber, fodder, oil, or medicinal use, have been marginalized due to their unrealized potential and limited competitiveness [8,11,12]. Primarily cultivated by local farmers using traditional knowledge, these neglected and underutilized crop species (NUCS) face the risk of genetic erosion and disappearance due to insufficient documentation and attention [8,13]. Overlooked by agricultural development, research, and policy, the knowledge of their use is gradually being lost [12, 14]. Most research has focused on a few species, leading to increasingly uniform farming landscapes and diets globally [15].

Many studies have explored the role of neglected and underutilized crop species (NUCS) in food production, nutrition security, income, and climate-smart agriculture, as well as the challenges and opportunities associated with them [7,8,10,16,17]. This study focuses on (i) documenting the status of locally neglected or underutilized NUCS, (ii) assessing rural households' opinions of these crops, (iii) identifying challenges in their production and consumption, (iv) analyzing their role to household food security, and (v) examining factors affecting their production and consumption. The study aims to promote the use and preservation of these valuable crop species, which are essential for local farmers' economies.

2. Materials and methods

2.1. Description of the study area

This study was conducted in the Wolaita Zone, specifically in the Damot Gale and Offa districts. Damot Gale is located 350 km south of Addis Ababa, covering an area of about 24,185.9 ha. It is bordered by several districts and falls between latitudes 6°55′00″ and 7°10′00"N and longitudes 37°45′00″ and 38°00′00"E. The district is administratively divided into 31 villages and various agro-climatic regions based on temperature and altitude. The mean monthly temperatures range from 16 °C during the coldest months to 20 °C during the warmest months, with an average annual rainfall of 1250 mm.

The altitude of Damot Gale district ranges between 1500 and 3500 m above sea level [18]. The district has a population of 151,079, with 74,227 males and 76,852 females, and a population density of 664 persons per square kilometer [19]. Agriculture is the primary economic activity, making up about 90 % of the area's economy and serving as the main resource for rural households.

Offa district, one of 16 districts in the Wolaita Zone, is located 383 km south of Addis Ababa along the Sodo Gofa main road. The district covers an area of 37,356 ha and is divided into 21 villages, with Gasuba as its administrative center. In 2007, the population was estimated at 127,387, with women making up 51.5 % of the total [19]. The district's altitude ranges from 1200 m near the Gogara River in the south to 2800 m above sea level in the north [20]. Geographically, Offa is situated at 6°44′59.99″ N latitude and 37°29′59.99″ E longitude.

2.2. Research design

The study used a multi-method design, including descriptive statistics to describe socio-economic aspects of smallholder farmers, a Likert scale to assess their perception of NUCS utilization, and an econometric model to quantify factors affecting NUCS consumption and production. It relied on both primary and secondary data sources, collected at a single point in time through a questionnaire, making it cross-sectional.

2.3. Data types, sources and method of data collection

The study gathered both quantitative and qualitative data on income, consumption, and socio-economic, demographic, and environmental aspects of farm households. A semi-structured questionnaire was pre-tested in sampled villages, and trained enumerators familiar with the area collected the data. Checklists were used to guide discussions and ensure understanding of research objectives. Focus group discussions were held separately with women, men, and joint groups at farmers' training centers to gather

Table 1
Study populations.

Name of District		Total households	No. of Samples
Damot Gale	Wandara Gale	628	42
	Ade Sibaye	740	49
	Fate	489	33
Offa	Dekaya	961	64
	Mancha	876	58
		3694	246

Source: Own Computation, 2024

relevant information on NUCS crop production systems and their impact on household food security.

2.4. Sampling technique and sample size

A multi-stage sampling procedure was used to select respondents from the study area. First, the Damot Gale and Offa districts were purposively chosen based on their NUCS production potential and consumption patterns. Next, five crop-producing villages such as *Wandara Gale, Ade Sibaye*, and *Fate* villages from *Damot Gale* whereas *Dekaya* and *Mancha* villages from *Offa* were randomly selected. Finally, from a total of 3694 households in these villages, 246 household heads were interviewed (see Table 1). The sample size was determined by considering resource constraints and the need for representativeness, using various sampling approaches as references [21,22].

Accordingly, for this study, the sample size was determined by using the minimum sample size and then adjusted for the total population by Cochran's sample size formula (Cochran [23], as shown below:

$$n = \frac{Z^2(p)(q)}{d^2} \tag{3.1}$$

Where: n = the total desired minimum sample size; N = total population = is the abscissa of the standard curve that passes an area α at the tails (1 - α equals the 95 % confidence level); d = allowable error which is equal to .06; p = is the estimated proportion of the population (.5) q = is 1-p.

In order to calculate the final sample size, the researchers considered the total population of the study area. Therefore, Cochran's [23] correct formula were used to calculate the final sample size in the study area.

$$no = \frac{n}{1 + \left(\frac{n}{N}\right)} \tag{3.2}$$

Where; no = the new sample size that to be considered to this study; n = the old sample size; and N = the total households in the study area.

Purposive sampling was used to select respondents for focus group discussions (FGDs) based on their awareness, production, and consumption of NUCS. Five FGDs, each including 10 to 12 men and women farmers aged 30 to 70, were conducted in different villages across the study districts to complement the quantitative data collected.

2.5. Methods of data analysis

Descriptive statistics, such as frequency and percentage, were used to present the demographic and socio-economic characteristics of the respondents. The first objective was analyzed qualitatively, mainly using data from focus group discussions and key informants. A 5-point Likert scale was employed to assess households' perceptions of NUCS based on various criteria. The contribution of these crops to household food security was analyzed using the Food Consumption Score (FCS) method, which considers dietary diversity, food frequency, and the nutritional importance of different food groups. The FCS was calculated using a weighted score formula based on the consumption of eight standard food groups (see Table 2).

The Food Consumption Score (FCS) was used to categorize households into low, borderline, and acceptable food security levels. Descriptive statistics were applied to analyse challenges in NUCS production and consumption. Additionally, a Logit regression model was used to examine factors affecting NUCS production and consumption, as it is suitable for analyzing ordinal dependent variables with natural ordering but unknown or unequal distances between categories.

Table 2
Food groups and their weights.

Food groups	Food groups Weight
Cereals and Tubers	2
Pulses	3
Vegetables	1
Fruit	1
Meat (poultry)	4
Milk	4
Sugar	.5
Oil	.5

Source: WFP [24].

3. Results and discussion

3.1. General demographic characteristics of the respondents

Out of 246 survey responses, 192 (79 %) were male. About 41 % of respondents had a family size of 5–10 members, 39 % were aged 35–45, and 43 % had a primary level of education (see Table 3).

3.2. The status of the neglected and underutilized crop species in the study area

NUCS (Neglected and Underutilized Crop Species) include cereals, vegetables, roots and tubers, pulses, and fruits. Examples from literature include crops like taro, yam, sorghum, and sweet potato. This study explored various NUCS in these categories, identifying 32 crops with local names in the study area (see Table 4). However, many traditional crops have genetically disappeared, making seeds difficult to find, and some have even been forgotten. Focus group discussions and key informant interviews revealed that some traditional crops are neglected, while others are underutilized. The study highlights the importance of identifying, documenting, and conserving these crops to prevent further genetic loss [25].

3.3. Opinion of rural households to neglected and underutilized crop species

A 5-point Likert scale was used to gauge respondents' opinions on various crops. The results showed that 41 % strongly disagreed with the statement that they had never heard of NUCS, indicating that most were aware of them. However, only 14 % had a negative perception of NUCS's importance in local consumption and production. Additionally, 85 % agreed that while NUCS are important, they face significant production challenges, and 47 % strongly agreed that NUCS have been replaced by new, improved crop varieties. Moreover, 32 % moderately agreed on the nutritional value of NUCS (see Table 5).

3.4. Challenges confronting the production and consumption of NUCS in the study area

The study revealed that traditional crops play great role in livelihood of the people and they have uncountable other extra purposes. But currently those crops are not documented and are facing the threat of extinction. As seen in the table below, there are different challenges on production and consumption of NUCS in study area (see Table 6). Among reasons and challenges the respondents mentioned, about 33 % is related with NUCs were already replaced with new varieties and improved crops and loss of local seeds for production. About 28 % is related with changing diet and preference of the users and the 14 % is related with loss of indigenous knowledge. This is also supported with [26,27] who described that the most frequently given reasons for reduction in the use of traditional food species include local perceptions of these food as food for the poor, loss of traditional knowledge, the complexity of cooking methods and integration into market economies and globalization. *In addition, discussion with key informant interviews and FGDs strongly indicated that lack of policy and institutional* support*, characterization and breeding on conservation and use of NUCS are also big problem. In the context of study area, except few non-government organization (Send caw and terepeza development association), there is no institutional and policy* support *on NUCS.*

3.5. Contribution of NUCS to households' food security

Neglected and underutilized crops have great potential to support smallholder farmers and rural communities by improving their incomes and food security. In study area, people have different opinion to importance and contribution of NUCS. As focus group discussion with old age groups on diversity and importance of NUCS shows that there is different diversity of NUCS in the study area

Table 3
The general demographic information of the respondents.

Variable	Category	Frequency	Percent
Age	20–35	82	33
	35–45	96	39
	45–55	43	17
	>55	25	11
Sex of the respondents	Male	192	79
	Female	54	21
Family Size	1–4	89	36
	5–10	102	41
	>10	55	23
Education	Illiterate	70	28
	Primary level	105	43
	Secondary level	55	22
	Above diploma	16	7

Source: Survey result, 2024

Table 4
List of neglected and underutilized species in study area.

No.	Local name of NUCs	English name	Status	
Cereal			Neglected	Underutilized
1.	Sutale badala	Local Maize	X	
2.	Moshore badala	Local Maize	X	
3.	Borante badala	Local Maize	X	
4.	Gawgaa badala	Local Maize	X	
5.	Malduwa/zengada	Ethiopian millet	X	
6.	Harasusuwa mashila/malldo	Local Sorghum	X	
7.	Phil'owa mashila/malldo	Local Sorghum	X	
8.	Hama mashila/malldo	Local Sorghum	X	
9.	Fesele mashila/malldo	Local Sorghum	X	
10.	Wogumuwa mashila/malldo	Local Sorghum	X	
11.	Zo'o Gaashe	Red teff	X	
12.	Kareta banga	black barley	X	
Vegetables				
13.	Lelehe	Pumpkin		X
14.	Chumadhe	Amaranthus	X	
15.	Aina	Makoi or black nightshade	X	
16.	Santa bulo	solanum nigrin	X	
17.	Argama	Local onion	X	
Root and tuber crops				
18.	Boliboye/bundubuche	Local Trifoliate yam	X	
19.	Wolaita donuwa/shukariya	Local Sweet potato	X	
20.	Bokicha boyna/yitre boyna	Local Taro type	X	
21.	Dolka	Local Taro type	X	
22.	Mole	Local Taro type	X	
23.	Mitaboye	Cassava		X
24.	Tura boye	Yam		X
25.	Hal'a/ciice uuta	Local Enset type	X	
26.	Gefetenuwa	Local Enset type	X	
27.	Nakaka	Local Enset type	X	
28.	Tuzuma	Local Enset type	X	
29.	Silkantiya	Local Enset type	X	
Pulses				
30.	Rigib Atariya	Pigeon pea		X
31.	Lokoma/Boloke	Haricot Bean		X
32.	Gagifisa	Unknown	X	

Source: Survey result, 2024

Table 5
Perception of rural households to NUCS.

Perception Statements on NUCS	1. Strongly disagree		2. Disagree		3.Moderately agree		2. Agree		3. Strongly agree	
	Fre	%	Fre	%	Fre	%	Fre	%	Fre	%
Never heard and awareness about NUCS	100	41	56	23	32	13	41	17	17	6
Heard and aware about NUCs	14	6	20	8	55	22	117	48	40	16
NUCS are important in local consumption and production systems currently	35	14	45	18	102	41	21	85	43	17
NUCS are not available in our community	45	18	81	32	70	28	25	11	25	11
People know them but face bottlenecks to their production system.	10	4	21	9	40	16	75	30	100	41
I Know them but they are replaced with new varieties and Improved crops	11	5	16	6	40	16	64	26	115	47
People have adequate awareness of their nutritional value	30	12	15	7	79	32	62	25	60	24

Source: Survey result, 2024

and people use them for different purposes traditionally. Traditionally they play role for diversify the human diet, for medicinal value, special dishes for women during child birth, circumcision and when people injured and during ceremonies. *Additionally, FGD results and key informant interviews shows that NUCS have more than consumption purposes. This because many NUCS can also thrive in marginal areas, in arid soil or on land considered unsuitable for other purposes and they have remarkable tolerance of marginal agricultural lands, and can bloom in low-input conditions and economically viable for small-holder farmers.* The findings of various scientific studies have also suggested that NUCS can tolerate extreme conditions, and a variety of biotic, and abiotic stresses [16,28]. Other studies also confirm this importance's of NUCS are locally available/adaptable, are accessible and affordable for the local population and therefore contribute to food security and nutrition, livelihood improvements, and cultural diversity [29].

Table 6
Related challenges on production and consumption of NUCS in the Study Area.

Challenges	Freq	%
Replaced with new varieties and improved crops and loss of local seeds for production	82	33
Changing diet and preference	68	28
Loss of indigenous knowledge	35	14
Inadequate awareness of the nutritional value	25	10
Social Stigma	16	6
lack of policy and institutional support on conservation and use of NUCS	20	9

Source: Survey result, 2024

3.6. NUCS consumption pattern and HHs food security

As discussed in above sections, neglected and underutilized crops can have huge potential for addressing the food and income needs of the farmers. However, the consumption pattern of NUCS by farm households in study area is at poor level. This is inherently associated with various reasons and their current availability and accessibility of NUCS. In this regard, to analyse consumption pattern and level of NUCS by respondents' food consumption score (FCS) method were applied. Accordingly, the result of food consumption score (FCS) analysis revealed that 52 % of the respondents are at low consumption level, 28 % are at borderline and only 20 % are at acceptable level (see Table 7).

3.7. Factors affecting consumption of NUCS for food security

The model is fitted and significant at 1 % probably level. Also, there has been 15.7 % improvement in prediction of outcome variable based on predictor variables.

Table 8 describes factors affecting consumption of NUCS for Food security. The major significantly determining factors include age, family size, sex, farming experience, perception towards NUCs, access to irrigation, frequency of extension contact, and slope of the land. So, the interpretation of the model result is as follows.

Age of households: In this study, age of the farmers is found to positively determine consumption of NUCS for food security and significant at 5 %. This indicates that the older the household head, the higher the probability that the household would incline in these crop species along with other major staples. On top of that the productivity of old household heads will increase, as they get older and older. Since as age of the household head increase will increase the awareness to complement these crop species in their production systems and serve as a common dishes. To this end, older people are more likely to have more farming experience and more output resulting in their families have a better probability of being food and nutrition secure and risk reduction than households who are dependent on single production system. This result is consistent with the findings of [30] who reported that older people are more likely food insecure than the younger ages and whereas in contrast with former authors [31], reported that older people are more food secure than their counterpart.

Sex: Other variables being constant, female farmers relatively were found more dependent on NUCs for their source of food and income compared to their male counterparts and statistically significant at 1 %. This might be because female-headed households are generally resource-poor and more interested in low-cost resources, which are less capital-intensive and easily accessible. Another important thing might be men, usually show less interest in producing and consuming NUCs because of the perception that these crop species is less contribute to their routine diets and household income. The finding of this is in agreement with [32] which revealed that being a female increases the tendency of NUCS production and income. *As data collected through FGD female, headed households (widowed and divorced) were mostly engaging inside the house, which is tedious with less participation in outside activities due to cultural factors. As data collected KII most of the female-headed households culturally consider themselves mediocre compared with male-headed households. Also, males see themselves better than female-headed households.*

Household size: is measured in the number of the household members who shared commonly every aspect with the household head. The result indicated that the total number of the household has positively related to household food security improvement and it is statistically significant at the 5 % probability level. A farmer having more families may have the opportunity to their families with enhanced food security status because their production reliance not only on major crops but also from NUCS production which helps them to reduces risk of loss by changing climate. So, the existence of large number of family size in the household affects their wealth and tends to be food secure as compared to households with small family size. This result is in agreement with the study in food security

Table 7
Result of food consumption score analysis.

Consumption category	Profile	Frequency	Percent
Low	<28	128	52
At borderline	28–42	70	28
At acceptance level	>42	48	20
Total		246	100

Source: Food Consumption Score Analysis, 2024

Table 8
Ordered Logit model result on factor affecting production and consumption of NUCS.

Variables		Estimate	Std. Error	Wald	Sig.
1	Age	.036	.016	4.872	.027
2	Famsiz	.409	.184	4.920	.027
3	Nlvtlu	−.254	.158	2.578	.108
4	Farmsz	2.252	1.07426	2.09	.034
5	Frmexprc	.028	.015	3.287	.070
6	Mktdistc	.051	.041	1.516	.218
7	Educ	.830	.298	7.165	.06
8	Sex	−.971	.308	9.938	.002
9	Percep	1.032	.397	6.758	.009
10	Acstrng	.266	.381	.487	.485
11	Acsirgn	−1.9034	.5723	10.752	.001
12	Extcnt	1.426	.789	3.261	.071
13	Hhprfrnc	1.728	1.269	1.854	.173
14	Slope	−1.521	.198	22.25	.000

Observation = 246, Chi-Square = 71.047(P = 0.000), −2 Log Likelihood = 518.448, Pseudo R-Square Cox and Snell = .236, Nagelkerke = .274, McFadden = .157.
Source: Model result, 2024

by Ref. [33] concludes that more family size helps to provide more labor for production and has a positive association with the food security status of a household but in contrast with the findings of [30] who reported inverse association between household size and food security.

Farming experience: It was measured by the number of years in the production and utilization of NUCS. As it expected this variable affected the production and utilization of NUCS positively and significantly at 10 %. This might be because those households who have produced and utilized for a long period of time and complement these crops with their common staples will help to ensure daily caloric requirements and diversify their income sources in relative with those who underestimated these crop species for their consumption.

Education: It is measured number of grades attended in school. As expected the level of education of household heads is significant at a 5 % level of significance. Level of education increases farmers' ability to obtain, process, and use information relevant to utilize different climate resilient crops. This implies that as the level of education of the farmer increases, the probability of a household to understand the risks of reliance on certain major crops and underestimating the production and utilization of NUCS will become lower. This result is in agreement with [30,31] who revealed that educated farmers obtain knowledge and skills on how to effectively utilize NUCS to improve household consumption and income generation.

Farm size is a total area of land a household cultivates measured in hectare. It influences households' decision to utilize NUCS. The cultivation land is considered as critical agricultural production unit, which determines the food security status of the smallholder farmers under the subsistence agriculture. This is supported by the previous study done by Refs. [30,31,34]; reported that under subsistence agriculture, the cultivation land size would affect households' food security. Hence, large farm size was positive and significant relationship with production of NUCS and consumption of for food security.

Slope of the land: It refers to the slope of the plot as perceived by the farmers and grouped in to flat, gentle slope, moderate slope and steep slope. The slope of land has negatively and significantly influence on the production of NUCS and food security status of household at 1 % due to farmer's slope of land become flat, they will tend to produce major crops. This might be farmers prefer to produce major crops in a flat space and allow marginal, unproductive land and eroded area for NUCS production.

Contact with extension agent: It is the contact between farmers and development agents on various aspects of crop production and climate change effects. And as expected, result shows frequency of extension contact has positive and significant influence for production and consumption of NUCS at 10 %. This might be extension agents provide training and influence the mind of farmers on the relevance of production diversification and climate change resilience. This result is in support of [30,31] reported extension agents have positive and significant contribution for household welfare.

Access to Irrigation: The result shows that access to irrigation has negative determination on production and consumption of NUCS to food security. This is due to that if farmers have access to irrigation they give more attention on more commercial crops than NUCS.

4. Conclusion

This study tried to document diversity of 32 NUCS and of them some are falling into disuse due to various factors and some are underutilized in study area. The NUCS have multi-dimensional roles to play for food security and resilient food systems in face of emerging food crisis and the on-going climate changes. The result of food consumption score analysis revealed that 50 % of the respondents are poor consumption level, 30 % are at borderline and only 20 % are at acceptable level. And also, more than 50 % of respondent's have wrongly perceived NUCS production and consumption as they relate with inferior food groups preferred by the poorest people and having no nutritional values. On the other hand, the analysis of ordinal logit model revealed that various factors with different significant level affecting consumption and production system of NUCS by the farmers. Accordingly, the following

recommendations are suggested to be consider by any concerned stakeholders such as documenting NUCS of specific localities and related indigenous knowledge should be strengthened by researchers, NGOs/association and governing bodies, capacitating and changing the perception of younger age groups on production and importance of NUCs, and promoting and characterizing these crops to reach wider producers and consumers for future consideration in the production, research and extension organizations.

CRediT authorship contribution statement

Dessalegn Shiferaw Yesuph: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Dabalke Dabala Dalka:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Masresha Tadesse Baye:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization.

Data availability statement

No data sets were generated and if any pertinent data is needed to consider in the article, it will be made available on request.

Funding

No funding has been received from any organization for this study.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

The authors would like to express sincere gratitude to all officials, sample respondents, and experts who participated in providing relevant information and data collection.

References

[1] A. Mirzabaev, L. Olsson, R.B. Kerr, P. Pradhan, M.G.R. Ferre, H. Lotze-Campen, Climate change and food systems, in: J. von Braun, K. Afsana, L.O. Fresco, M.H. A. Hassan (Eds.), Science and Innovations for Food Systems Transformation, Springer, Cham, 2023, https://doi.org/10.1007/978-3-031-15703-5_27.
[2] G.A.S. Ginigaddara, A.N. Kodithuwakku, Building climate-resilient food systems in Sri Lanka through site-specific agricultural management, Eur. J. Agron. 156 (May 2024) (2024) 127148, https://doi.org/10.1016/j.eja.2024.127148.
[3] M.A. Mustafa, S. Mayes, F. Massawe, Crop diversification through a wider use of underutilised crops: a strategy to ensure food and nutrition security in the face of climate change, in: A. Sarkar, S. Sensarma, G. vanLoon (Eds.), Sustainable Solutions for Food Security, Springer, Cham, 2019, https://doi.org/10.1007/978-3-319-77878-5_7.
[4] A. Hossain, S. Maitra, Neglected and underutilized crop species: are they future smart crops in fighting poverty, hunger, and malnutrition under changing climate?, in: Neglected and Underutilized Crops - towards Nutritional Security and Sustainability Springer, 2021, pp. 1–50, https://doi.org/10.1007/978-981-16-3876-3_1.
[5] D. Hunter, T. Borelli, D.M. Beltrame, C.N. Oliveira, L. Coradin, V.W. Wasike, et al., The potential of neglected and underutilized species for improving diets and nutrition, Planta 250 (2019) 709–729, https://doi.org/10.1007/s00425-019-03169-4.
[6] P. Chivenge, T. Mabhaudhi, A.T. Modi, P. Mafongoya, The potential role of neglected and underutilized crop species as future crops under water scarce conditions in Sub-Saharan Africa. Int, J. Environ. Res. Public Health 12 (2015) 5685–5711, https://doi.org/10.3390/ijerph120605685.
[7] A.S. Karunaratne, E.M. Wimalasiri, M. Esham, T. Mabhaudhi, E. Jahanshiri, Editorial: crop modelling - underutilized crops for climate-smart agrifood systems, Front. Sustain. Food Syst. 8 (2024) 1305909, https://doi.org/10.3389/fsufs.2024.1305909.
[8] Samuel Imathiu, Neglected and underutilized cultivated crops with respect to indigenous African leafy vegetables for food and nutrition security, Journal of Food Security 9 (No. 3) (2021) 115–125. DOI:10.12691/jfs-9-3-4.
[9] FAO, The future of food and agriculture. Trends and challenges. Rome, Italy, 2018.
[10] R.K. Naresh, M.S. Chandra, N.C. Mahajan, P.K. Singh, A. Baliyan, P. Ahlawat, et al., Neglected and underutilized crop species the key to improving soil nutritional security for fighting poverty, hunger and malnutrition in north-western IGP: a review, Pharma Innov J. 10 (8) (2021) 1833–1839.
[11] A. Ali, B. Bhattacharjee, Nutrition security, constraints, and agro-diversification strategies of neglected and underutilized crops to fight global hidden hunger, Front. Nutr. 10 (2023) 1144439, https://doi.org/10.3389/fnut.2023.1144439.
[12] Stefano Padulosi, Bhag Mal, Oliver I. King, Elisabetta Gotor, Minor millets as a central element for sustainably enhanced incomes, empowerment, and nutrition in rural India, Sustainability 7 (7) (2015) 8904–8933, https://doi.org/10.3390/su7078904, 2015.
[13] J.A.O. Magbagbeola, J.A. Adetoso, O.A. Owolabi, Neglected and underutilized species (NUS): a panacea for community focused development to poverty alleviation/poverty, J. Econ. Int. Finance 2 (10) (2010) 208–211. http://www.academicjournals.org/JEIF.
[14] G.R. Lule, et al., Loss of traditional crop knowledge in Uganda: implications for food security and climate resilience, Afr. J. Agric. Res. 18 (6) (2023) 189–200.
[15] M.I. Gómez, et al., Global agricultural landscapes: the diminishing role of biodiversity in food systems, Glob. Environ. Change 74 (2022) 102400.
[16] Zerihun Tadele, African orphan crops under abiotic stresses: challenges and opportunities, Scientifica (2018) 1–19, https://doi.org/10.1155/2018/1451894, 2018.
[17] B.K. Joshi, R. Shrestha, D. Gauchan, A. Shrestha, Neglected, underutilized, and future smart crop species in Nepal, J. Crop Improv. 34 (3) (2019) 291–313, https://doi.org/10.1080/15427528.2019.1703230.
[18] E. Le Gal, N. Molinier, Agricultural and Economic Analysis-Diagnosis of Obe Jage (Damot Gale, Wolayta), Institut National Agronomique Paris- Grignon, 2008.
[19] CSA, Central Statistical Agency, Addis Ababa, Ethiopia Population Profile, Eastern Commission, 2007.

[20] Offa District Office of Agriculture and Rural Development (ODOARD), Physical and Socio-Economic Description of the Offa District of Wolaita Zone, Offa, South Ethiopia Regional State, 2024. *Unpublished Report*.
[21] D. Glenn, Israel, Determining sample size. A Series of the Program Evaluation and Organizational Development, University of Florida. Publication date: November, 1992.
[22] Thomas R. Knapp, Nancy Campbell-Heider, Numbers of observations and variables in multivariate analyses.", West. J. Nurs. Res. 11 (5) (1989) 634–641.
[23] W.G. Cochran, Sampling Techniques, third ed., John Wiley& Sons, New York, 1977.
[24] World Food Program (WFP), Food Consumption Analysis: Calculation and Use of the Food Consumption Score in Food Consumption and Food Security Analysis. Technical Guidance Sheet, Prepared by VAM HQ. Rome, 2008. www.wfp.org/odan/senac.
[25] Rajib Khanal, Arbindra Timilsina, Chandra P. Pokhrel, Ram Kailash P. Yadav, Documenting abundance and use of underutilized plant species in the mid hill region of Nepal, Int. J. Ecol. 21 (2014) (2014) 63–71, https://doi.org/10.3126/eco.v21i0.11906.
[26] Zareen Bharucha, Jules Pretty, The roles and values of wild foods in agricultural systems, Phil. Trans. Biol. Sci. 365 (1554) (2010) 2913–2926.
[27] Julia Boedecker, Céline Termote, Achille Ephrem Assogbadjo, Patrick Van Damme, Carl Lachat, Dietary contribution of Wild Edible Plants to women's diets in the buffer zone around the Lama forest, Benin – an underutilized potential, Food Sec (6) (2014) 833–849, https://doi.org/10.1007/s12571-014-0396-7.
[28] Mehanathan Muthamilarasan, Nagendra Kumar Singh, Manoj Prasad, Multi-omics approaches for strategic improvement of stress tolerance in underutilized crop species: a climate change perspective, Adv. Genet. 103 (2019) 1–38.
[29] I.F.A.D. Fao, UNICEF, WFP and WHO, the State of Food Security and Nutrition in the World 2022. Repurposing Food and Agricultural Policies to Make Healthy Diets More Affordable, FAO, Rome, 2022.
[30] Wondim Awoke, Kefale Eniyew, Genenew Agitew, Belete Meseret, Determinants of food security status of household in central and north gondar zone, Ethiopia, Cogent Social Sciences 8 (1) (2022) 2040138, https://doi.org/10.1080/23311886.2022.2040138.
[31] Tsidkineh Assefa, Ermias Beyene Abide, Determinants of food insecurity in rural households: a case of lemo district, southern Ethiopia, Heliyon 9 (2023) e12764, https://doi.org/10.1016/j.heliyon.2022.e12764.
[32] M. Elias, H. Zaremba, K. Tavenner, C. Ragasa, A.M. Paez Valencia, A. Choudhury, N. de Haan, Beyond crops: toward gender equality in forestry, fisheries, aquaculture and livestock development. CGIAR GENDER Impact Platform Working Paper #012, CGIAR GENDER Impact Platform, Nairobi, Kenya, 2023. https://hdl.handle.net/10568/129708.
[33] M.S. Faustine, The role of neglected and underutilized crop species in improving food security and nutrition, Int. J. Agric. Sustain. 14 (4) (2016) 331–340, https://doi.org/10.1080/14735903.2016.1142219.
[34] Jubril Olayinka Animashaun, et al., Determinants of the Neglected and Underutilized Species' Cultivation by Small-Scale Farmers in Nigerian Guinea Savannah, 2016.