EJED 2024 6(2):1–10
Ethiopian Journal of Environment and Development
http://www.du.edu.et/duj

Occurrence of External Injuries in Working Equines and associated risk factors, Around Alagie Districts, Southern Ethiopia

Wondewsen Bekele[1*] **and Mitike Abe**[2]

[1] *Department of Animal and Range Sciences, Dilla University, P.O.Box 419 Dilla, Ethiopia.*
[2] *Alagie districts Livestock and Fisher Resource, Alagie Ethiopia.*
Corresponding author; Email: wondewsen19@gmail.com

Received: 25th September 2023 *Accepted: 10th September 2024*

Article DOI: **10.20372/ejed.v06i2.01**

Abstract

Equine welfare issues are significant challenges in Ethiopia, threatening the health of the animals and the livelihoods of their owners. A cross-sectional study was conducted between November 2021 and May 2022 in districts around Alagae. The study aimed to assess the welfare status of working equines and the practices surrounding wound management in the region. Both direct (animal-based) and indirect (owner interviews via questionnaire) methods were employed. A total of 400 equines were examined, comprising 312 donkeys, 78 horses, and 10 mules, revealing an overall wound prevalence of 69.3%. The species-specific prevalence of wounds was 54.3% for donkeys, 13.5% for horses, and 1.5% for mules. The intensity of wounds was categorized as mild (46.8%), moderate (9.5%), and severe (3.0%) among donkeys, horses, and mules, respectively. Packed equines experienced a higher occurrence of wounds (56.5%) compared to cart animals (12.8%). Additionally, common equine problems included hoof overgrowth (16.5%), hoof deformity (0.8%), and gait and posture abnormalities (6.3%). The study indicated that among 277 equine wound cases, 14.1% were left untreated by either veterinary professionals or traditional healers. Significant differences ($p < 0.05$) were found in wound care conditions among donkey species based on management practices, showing a strong association between wound care management and conditions ($\chi^2 = 19.148$, $df = 3$, $p = 0.014$). Overall, external injuries represent major health and welfare concerns for working equines in the study area. Therefore, the development of a comprehensive equine health management and welfare improvement program is essential to address these issues effectively.

Keywords/Phrases: Equines, Hoof deformity, Posture, Welfare, Wound management

1 Introduction

Equines are essential to transport and farming systems in various developing countries, including Ethiopia. The country is home to approximately 2.14 million horses, 0.36 million mules, and 10 million donkeys (CSA, 2022). These animals play a fundamental role in the livelihoods of many rural communities, providing both financial and social capital. For both rural and urban poor communities, equines serve as a low-cost means of transport and can plow in areas where draft oxen are scarce.

Working equines in Ethiopia, particularly those pulling carts, often labor for 4 to 12 hours a day without rest, transporting people over long distances with an average load of 3 to 4 individuals (195–260 kg) in a single trip (Biffa and Woldemeskel, 2006; Nejash *et al.*, 2017). Donkeys are typically engaged in more diverse activities than horses, carrying goods between markets, farms, and shops. They often transport loads that are 3 to 4 times their body weight (Brooke, 2011).

Despite the significant contributions of equines to daily life and the livelihoods of their owners, their management is often inadequate. As a result, they suffer from poor health, malnutrition, and overall poor welfare (Guyo *et al.*, 2019). Furthermore, the government's livestock ministry and foreign aid agencies tend to focus on other livestock, neglecting equine production and productivity (Yoseph *et al.*, 2001).

Although equines significantly contribute to local communities and the national economy, research on equine welfare and health issues in Ethiopia is limited. There has been little attention given to the study of skin wounds and welfare problems affecting working equines, particularly in and around the Alage district of Central Ethiopia. More comprehensive studies are necessary to explore their welfare and health status, which will aid in implementing guidelines set forth by the "Prevention of Cruelty to Animals Act 1960." Therefore, the main objectives of this study were to assess the status of external injuries and welfare in working equines, along with their wound management practices in and around the Alage district.

2 Materials and Methods

2.1 Description of the Study Area

Alage is located between the Southern Nations, Nationalities, and Peoples' (SNNP) Regional State and the Oromia region of Ethiopia. It lies approximately 217 km south of Addis Ababa along the Rift Valley and is bordered by two Rift Valley lakes: Lake Abijata (10 km east) and Lake Shalla (8 km north). Alage is situated at $38o27$' east longitude and 7^o36' north latitude, with an altitude ranging from 1,580 to 1,650 meters above sea level (a.s.l.).

The region receives bimodal rainfall, with wet seasons occurring from June to September and from March to April, resulting in an average annual rainfall of 860 mm. Temperatures in Alage range from 16 to 29^oC, with a mean daily temperature of 21^oC (Agerie & Afework, 2013).

2.2 Study Animals

The study animals comprised randomly selected equines (donkeys, horses, and mules) from six kebeles: Arsi Negele (Negale Wadasha, Aje Kebele), special districts from SNNPR (Mito Dubela, Algie Dibulto Kebele), and Adami Tulu Jido Kombolcha districts from the Oromia region (Mudi, Arja, and Naka). These kebeles were chosen based on the concentration of equines in and around Alage. A total of 400 equines of varying sex, age, and body condition were included in this study.

2.3 Study Design and Sampling

A cross-sectional study was conducted on randomly selected equines (312 donkeys, 78 horses, and 10 mules) from November 2021 to May 2022 in the Alage district and its surroundings. The study collected information on species, sex, age, body condition, types of work, causes of back sore wounds, wound intensity, and wound management practices. The age of the selected equines was determined by dentition (Crane, 1997), and body condition scores were subjectively estimated based on guidelines published by Svendsen (1997).

Sample size determination

The sample size for this study was calculated using the formula provided by Thrusfield (2007). Given the absence of previous studies in the area, a 50% expected prevalence was assumed to determine the sample size, with a 95% confidence level and a 5% absolute precision. Consequently, the required sample size was 384; however, to enhance precision, the study included 400 animals.

$$n = \frac{1.962[Pexpe(1-Pexpe)]}{d2}$$

Where;
n = required sample size,
$Pexpe$ = expected prevalence and
d = desired absolute precision

Hence, a total of 384 animals were sampled from the site. In these work animals of different age group, sex and origin were included.

2.4 Study Methodology

Equine welfare status

Equines included in the study were physically examined for any visible wounds, with results recorded according to the wound sites. Representative photographs were taken when possible. The age of the selected equines was assessed by inspecting and estimating the incisor eruption times (Crane, 1997; Svendsen, 1997). Equines were categorized into two age groups: young (< 5 years) and adult (> 5 years). Body condition was scored as poor, medium, or good, following the criteria described by Carroll and Huntington (1988) and Svendsen (1997).

Common welfare challenges for equines include overworking and overloading, as well as improper harnessing (Kumar *et al.*, 2014). A poorly designed or ill-fitted harness can lead to fatigue, discomfort, or lesions on the animals (Pearson *et al.*, 2003).

Wound intensity was classified according to Biffa and Woldemeskel (2006). Severe wounds involved ulceration with pronounced contusion over wide areas, tissue hypertrophy, and severe complications. Moderate injuries consisted of clusters of small wounds with tissue sloughing but no complications or hypertrophy, and some with chronic courses. Mild wounds were defined as those involving only loss of the epidermis and superficial layers, with no further trauma.

Wounds (skin injuries) were also classified as abrasion, laceration, incision, and puncture (Feseha, 1997). Abrasions involved superficial denuding of the epidermis with minimal capillary bleeding and some serum/plasma exudation. Non-penetrating wounds from abrasion against rough surfaces, such as roads, were categorized as abrasions. Puncture wounds were defined as those caused by sharp objects like nails or glass shards, which create small skin tears or holes. Incision wounds were characterized by sharp, defined margins caused by sharp metal or glass, resulting in clean cuts with minimal tearing. Lacerations were described as traumatic tears of the skin occurring in an uncontrolled direction (Knottenbelt, 2003).

2.5 Welfare assessment protocol

Animal welfare is a multidimensional concept that encompasses good health, comfort, and the expression of natural behaviors (Botreau *et al.*, 2007). Therefore, it is essential to consider both health and behavior when assessing animal welfare. Observational assessments were conducted using direct (animal-based) methods with "The Hand Tool" (Galindo *et al.*, 2018). Additionally, a semi-structured, pre-tested questionnaire was prepared for interviews to collect data on welfare issues, such as harness type, wound intensity, causes of wounds, and owner responses regarding wound management.

Welfare assessments were carried out by veterinary students and agricultural experts, who underwent a three-day training course (described in Burn *et al.*, 2009). A welfare assessment trainer evaluated animals in each location to ensure consistency across sites. Assessments were tailored to the size of the equine population in each area.

Equine age and body condition scores (BCS) were determined using the method described by Svendsen (2008). Wound severity and classification were estimated according to the guidelines provided by Biffa and Woldemeskel (2006) and Knottenbelt (2003), respectively.

2.6 Data Analysis

The collected raw data were organized and arranged using Excel spreadsheets, with appropriate coding, and analyzed using SPSS version 25.0. The prevalence of wounds in equines was calculated, and associations between wound prevalence and each risk factor were tested for significance using Pearson's Chi-square analysis at a probability level of $p < 0.05$.

3 Results and Discussions

Among the 400 examined equines (312 donkeys, 78 horses, and 10 mules), the prevalence of wounds on various parts of the body was diagnosed. The results indicated that 277 equines (69.3%) had different types of wounds. Specifically, the prevalence of equine wounds was 54.3% in donkeys, 13.5% in horses, and 1.5% in mules. Based on sex, wound prevalence was 49.5% in males and 19.8% in females (Table 1).

The study found no significant association between the age of the animals and wound prevalence, although there was a higher numerical prevalence in adults (56.3%) compared to young equines (13.0%) ($p = 0.477$). This result aligns with findings by Birhan *et al.* (2014) and Fikru *et al.* (2015), which reported a relatively higher prevalence of wounds in adult equines, likely due to their exposure to heavy loads over long distances and extended working hours.

A high prevalence of wounds was also observed in equines with poor body condition (29.0%), compared to those with moderate (26.5%) and good body condition scores (13.8%) (p = 0.489). This finding is higher than the report by Tsega *et al.* (2016) in Northwest Ethiopia. Poor body condition can induce stress, potentially aggravating and prolonging the wound healing process. Similarly, Pearson *et al.* (2000) and Mekuria *et al.* (2013) indicated that physically poor-conditioned equines, often due to malnutrition, are more susceptible to wound complications.

Table 1. Prevalence of wound in relation to sex, age and body condition of equines in the study area

Risk related factors		No of examined	No of affected	prevalence	χ^2	P value
Species	Donkey	312	217	54.3	0.415	0.813
	Horse	78	54	13.5		
	Mule	10	6	1.5		
Age category	Young	71	52	13.0	1.482	0.477
	Adult	329	225	56.3		
Sex	Male	287	198	49.5	0.032	0.857
	Female	113	79	19.8		
Body condition	Poor	161	116	29.0	1.430	0.489
	Moderate	154	106	26.5		
	Good	85	55	13.8		
Total		400	277	69.3		

The proportion of identified wound types, intensity, type of work, lameness, and abnormalities is summarized in Table 2. The study found that the overall prevalence of wounds in equines was 69.3%, which is higher than the 37.9% prevalence reported by Usman *et al.* (2015) in Batu Town, East Shoa, but lower than the 72.15% prevalence indicated by Biffa and Woldemeskel (2006) in Hawassa, Southern Ethiopia. The differences may be attributed to variations in owners' management styles and husbandry practices across different production systems. Additionally, the incidence of wounds in equines could be influenced by variations in working conditions, owner awareness, and various seasonal factors (Pearson *et al.*, 2000).

Figure 1. Equines welfare and consequence of overloading

Table 2. Prevalence of equine wound, intensity, type of work and abnormalities among equine spp

Parameters	Donkey %	Horse %	Mule %	Total
Positive	217(69.6)	54(69.3)	6(60.0)	277(69.3)
Negative	95(29.7)	24(30.8)	4(40.0)	123(30.8)
Total	312	78	10	400
χ^2	1.321	4.301	5.131	
p-value	0.813	0.211	0.381	
		Intensity of identified wound		
Mild	148(47.4)	35(44.9)	4(40.0)	187(46.75)
Moderate	57(18.3)	19(24.4)	2(20.0)	78(19.5)
Sever	12(3.9)	0(0.0)	0(0.0)	12(3.0)
Total	217(40.7)	54(69.2)	6(60.0)	277(69.3)
χ^2	19.148	6.821	2.490	
p-value	0.323	0.152	0.476	
		Type of work		
Cart	41(13.1)	8(10.2)	2(20.0)	51(12.75)
Pack	176(56.4)	46(59.0)	4(40.0)	226(56.5)
Total	217(40.7)	54(69.2)	6(60.0)	217(69.3)
χ^2	18.602	7.383	4.321	
p-value	0.000	0.451	0.160	
		Lameness & movement		
Hoof overgrowth	51(16.4)	13(16.7)	2(20.0)	66(16.5)
Hoof deformity	2(0.6)	1(1.3)	0(0.0)	3(0.8)
Gait & posture Ab	21(6.7)	4(5.1)	0(0.0)	25(6.3)
Unaffected	143(45.8)	36 (46.2)	4 (40.0)	183(45.8)
Total	217	54	6	277
χ^2	1.346	3.321	1.012	
p-value	0.969	0.212	0.312	

Ab= Abnormality

The current study indicated that among the diagnosed equines, the prevalence of wound intensity was 46.8% for mild cases, 19.5% for moderate cases, and 3.0% for severe cases. Pack animals exhibited higher wound occurrences (56.5%) compared to cart animals (12.8%), providing strong evidence of a relationship between wound occurrence and the type of work performed (Figure 1). This difference may be attributed to variations in husbandry practices, working conditions, management knowledge, and seasonal factors (Pearson *et al*., 2000).

The highest prevalence of wounds based on location was found on the back (15.8%), while the least prevalence was noted in mixed wounds (4.8%). This finding is consistent with reports by Tesfaye and Curran (2005) and Biffa and Woldemeskel (2006), which indicated that the back is particularly susceptible to wounds. This vulnerability may stem from poorly designed or improperly fitted saddles and inappropriate load placement in relation to the straps used by owners.

The prevalence of hoof overgrowth was 23.5%, 33.3%, and 33.3% for donkeys, horses, and mules, respectively. Hoof deformity was observed at rates of 0.9%, 1.9%, and 0.0%, while gait and posture abnormalities were noted at 9.2%, 7.4%, and 0.0% for donkeys, horses, and mules, respectively (see Table 2). Lameness was identified as a significant health problem among equines, caused by various conditions (Putnam *et al*., 2014). A high proportion of lameness was observed in cart horses (24.1%) and pack donkeys (23.5%), primarily due to hoof overgrowth. In contrast, the prevalence of lameness in cart-pulling donkeys was 1.6%, which is significantly lower than the 40.2% reported by Fekadu *et al*. (2015) for cart-pulling donkeys in Hawassa. This lower prevalence may be due to a lack of awareness, inadequate veterinary services, and poor equine management practices by owners. Overall, gait abnormalities were highly prevalent in the equine population, ranging from slight issues to significant weight-bearing difficulties.

Table 3. The welfare conditions of equines in the study area

Type of wound	Donkey %	Horse %	Mule %	Total
Abrasion	69(22.1)	14(17.9)	0(0.0)	83(20.75)
laceration	57(18.3)	19(24.4)	3(3.9)	79(19.75)
Puncture	33(10.6)	9(11.5)	1(1.3)	43(10.75)
Incision	39(12.5)	7(9.0)	1(1.3)	47(11.75)
Skin avulsion	19(6.1)	5(6.4)	1(1.3)	25(6.3)
χ^2	2.960	4.143	5.110	
P value	0.937	0.103	0.321	
Back	53(17.0)	8(9.0)	2(20.0)	63(15.8)
Wither	18(5.8)	7(9.0)	2(20.0)	27(6.8)
Neck	31(9.9)	7(9.0)	0(0.0)	38(9.5)
Abdomen part	39(12.5)	10(12.8)	0(0.0)	49(12.3)
Hing limb	36(11.5)	11(14.1)	0(0.0)	47(11.8)
For limb	24(7.7)	9(11.5)	1(10.0)	34(8.5)
Mixed	16(5.1)	2(2.6)	1(10.0)	19(4.8)
χ^2	12.151	9.521	7.314	
P value	0.389	0.531	0.621	

Among the sampled equines, the most frequently observed problems were abrasions (20.75%), followed by lacerations (19.8%), incisions (11.8%), punctures (10.8%), and skin avulsions (6.3%). The high incidence of abrasions in this study aligns with findings from Biffa and Woldemeskel (2006) and Pearson *et al*. (2000). This prevalence may be associated with poorly designed harnesses, improperly fitted saddles, inappropriate load placement, and the use of inadequately designed straps manufactured by unskilled individuals.

Wounds were frequently observed on different parts of the same animal, with the highest prevalence noted on the back (15.8%), followed by the abdomen (12.5%), hind limbs (11.8%), neck (9.5%), forelimbs (8.5%), withers (8.5%), and mixed regions (6.8% and 4.8%) (See appendix 1). However, no significant differences were observed between species regarding the distribution of wounds across various body parts, as summarized in Table 3. According to Mekuria *et al*. (2013), equines found in poor welfare situations, particularly during intense drought and packing conditions, are more susceptible to injuries and wounds on different body parts.

Table 4. Prevalence of wound in relation to the nature of harness in the study area

Species	harness	No. animal	Wound	prevalence	χ^2	p-value
Donkey	Plastic	140	102	32.7	1.041	0.903
	Grass	96	62	19.9		
	Leather	76	53	17.0		
Horse	Plastic	34	21	26.9	7.059	0.133
	Grass	26	19	24.4		
	Leather	18	14	18.0		
Mule	Plastic	3	2	20.0	5.011	0.212
	Grass	4	3	30.0		
	Leather	3	1	10.0		
Total		400	277	69.3		

The prevalence of wounds in relation to harness type was observed as follows: plastic (32.7%), grass rope (19.9%), and leather (17.0%) for donkeys, as summarized in Table 4. This study indicated that the majority of wounds in equines were caused by the improper application of harnesses, the types of harness used, and overloading. In contrast, a lower prevalence of wounds was attributed to falls.

Table 5. The percentages of each working equine species displaying the behaviors

Behavioral response	Donkey	Hors	Mule	Total
Responsive	164(52.6)	36(46.2)	8(80.0)	208(52.0)
Apathetic	128(41.0)	37(47.4)	1(10)	166(41.5)
Aggression	20(6.4)	5(6.4)	1(10)	26(6.5)
Total	312(78.0)	78(19.5)	10(2.5)	
χ^2	5.103	6.12	3.101	
p-value	0.258	0.191	0.13	

The prevalence of each behavioral response among the examined equines is presented in Table 5. Behaviors proposed to test aversion to humans were positively correlated across the tests. The study found that normal behaviors (alertness, responsiveness to surroundings, head and ears up) were observed in 52.6% of donkeys, 46.2% of horses, and 80% of mules. In contrast, abnormal behaviors (such as apathy or depression) were noted in 41.0% of donkeys, 47.4% of horses, and 10% of mules. The responsiveness of the observer's approach was evident in approximately 52.6% of donkeys, 46.2% of horses, and 80% of mules (Table 5). This may be attributed to the low level of owner awareness regarding proper approaches and the resulting changes in the behavior of their equines.

Overall, the primary causes of wounds in equines were improper harnessing (25.0%), followed by overloading (21.0%), multifactor causes (7.8%), biting (6.8%), unknown causes (5.3%), and skin infections (3.5%), as summarized in Table 6. These findings are consistent with the report by Pearson *et al.* (2000), which indicated that improper application of harnesses and overloading were major contributors to equine injuries. These issues may be related to poorly designed harnesses, improperly fitted saddles, inappropriate load placement, and the use of inadequately designed straps manufactured by unskilled individuals. Generally, working equines in several developing countries are already known to face extremely high welfare challenges (Burden *et al.*, 2010).

Table 6. Reason for the formation of wound and welfare condition of equines in the study area

Cause of wound	Donkey %	Horse %	Mule %	Total
Improper harness	80 (25.6)	18(23.1)	2(20.0)	100(25.0)
Overloading	65(20.8)	17(21.8)	2(20.0)	84(21.0)
Biting	19(6.1)	7(9.0)	1(10.0)	27(6.8)
Unknown cause	17(7.8)	4(5.1)	0(0.0)	21(5.3)
Skin infection	14(5.5)	0(0.0)	0(0.0)	14(3.5)
Multifactor	22(7.1)	8(10.3)	1(10.0)	31(7.8)
Total	217	54	6	277
χ^2	6.011	4.201	2.067	
p.value	0.814	0.301	0.735	

This study revealed that among the 400 sampled cases, 9.3% were left untreated by either veterinary professionals or traditional healers (Table 7). The results indicated that the percentages of untreated equines were 6.4% for horses, 15.1% for donkeys, and 20.0% for mules. Additionally, 31.5% of the equines in the study received treatment from traditional healers, while a surprising 25.8% of sick equines were treated by their owners using hot iron on the affected body parts. These management conditions may be attributed to the owners' economic status, a lack of veterinary service delivery, and gaps in knowledge regarding equine welfare issues. Overall, the study highlights several common welfare problems faced by working equines in the area.

Table 7. Equine owners' Responses to the Management of wound in the study area

Parameters	Donkey %	Horse %	Mule %	Total
Veterinary service	63(20.2)	14(17.9)	3(30.0)	80(20.0)
Traditional healers	84(26.9)	37(29.4)	5(50.0)	126(31.5)
Burning	87(27.9)	16(20.5)	0(0.0)	103(25.8)
Sulpheric acid treatment	31(9.9)	6(7.7)	0(0.0)	54(13.5)
No treatment	47(15.1)	5(6.4)	2(20.0)	37(9.3)
Total	312(78.0)	78(19.5)	10(2.5)	400(100.0)
χ^2	19.148	8.241	4.972	
p-value	0.014	0.371	0.154	

Traditional healers=include by local community using different medicinal plants

4 Conclusion and Recommendations

Although equines play a significant role in various transportation systems in the study area, they are often the most neglected among domestic animals. This lack of attention has led to compromised management and welfare conditions for these species. In the study area, equines face a range of welfare problems, including issues with harnessing, challenges in accessing veterinary services, overloading, poor management, and a high prevalence of wounds.

The risk factors associated with wound incidence in equines include sex, age, and body condition, with abrasions being the most prevalent type of wound. Improper placement and types of harnesses used are major contributors to these injuries.

To address these equine welfare problems, significant efforts are needed to raise awareness among equine owners about proper management and handling practices. Improving equine welfare and health status can enhance management conditions, ultimately benefiting the livelihoods of the community. Furthermore, equine welfare policies and protocols should be endorsed to ensure animal welfare issues are addressed in Ethiopia, particularly in the study area.

Conflicts of Interest

The authors have not declared any conflict of interests.

Acknowledgments

The authors would like to acknowledge the equine owners, animal health workers, and agricultural extension workers for their consent, invaluable responses, and support. Special thanks are extended to Dilla University for providing the necessary facilities.

Availability Statement

The authors declare that all data supporting the findings of this study area available.

References

Agerie A. and Afework B.(2013): Habitat preferences, seasonal abundance and diets ofrodents in Alage, Southern Ethiopia 2013. *Afr. J. Ecol.*, 52, 284–291.

Biffa, D. and Woldemeskel, M. (2006): Causes and Factors Associated with Occurrence of External Injuries in Working Equines in Ethiopia. *Int'l J. Applied Res. Vet. Med.*, 4, 1-7.

Birhan G, Chanie M, Tesfaye T, Kassa A, Mekonnen B, Wagaw N (2014): Incidence of wound and associated risk factors in working donkeys in YilmanaDensa District. Glob. Vet. 13(1):133-140.

Brooke (2011) Bearing heavy burden Available online at http://www.fao.org/ file admin / user –upload/ animal welfare /Brooke report.pdf [Accessed g April 2023].

Burden, F. A., Du Toit, N., Hernandez-Gil, M., Prado-Ortiz, O., & Trawford, A. F. (2010). Selected health and management issues facing working donkeys presented for veterinary treatment in rural Mexico: some possible risk factors and potential intervention strategies. Tropical Animal Health and Production, 42, 597-605.

Burn, C.C., Pritchard, J.C., Whay, H.R., 2009. Observer reliability for working equine welfare assessment: problems with high prevalences of certain results. Anim. Welf. 18, 177–187

Carroll CL, Huntington PJ (1988). Body condition scoring and weight estimation of horses. *Equine Vet. J.* 20(1):41-45

Central Statistical Authority (CSA, 2022): Agricultural sample survey report on livestock and livestock characteristics, volume II, Addis Ababa, Ethiopia

Crane, M. (1997): Medical. In: The professional Hand book of the Donkey (3^{rd} edn) Whittet Books limited, 18 Anley Road, London Pp: 19-36

Fekadu A, Teshome H, Worku T (2015). Epidemiology of lameness among cart pulling donkeys in Hawassa City Administration, Southern Ethiopia. Academic Journal of Animal Diseases 4(2):52-59.

FAO (2003): FAO statistical data base website. Food and agriculture organization, Rome, Italy (FAO STATS:http://apps.fao.org).

Feseha G.A., 1997. In: Elisabeth DS (ed.) Diseases and health problems of donkeys abroad. Professional Hand Book of the Donkeys (3^{rd} edn) White Books imited, London.

Fikru A, Tadese A, Gebreegziabher Z (2015): Prevalence of Equine Wound and Associated Risk Factors in and around Kombolcha Town, North Ethiopia. *J. Vet. Sci. Technol.* 6:234.

Galindo F, de Aluja A, Cagigas R, Huerta LA, Tadich TA (2018). Application of the Hands-On Donkey Tool for Assessing the Welfare of Working Equids at Tuliman, Mexico. *Journal of Applied Animal Welfare Science* 21(1):93-100.

Guyo, S., Legesse, S., & Tonamo, A. (2015). A review on welfare and management practices of working equines. *Glob J Anim Sc Livers Prod Anim Breed,* 3, 203-209.

Herago T, Megersa M, Niguse A, Fayera T(2015). Assessment on Working donkey welfare issue in Wolaita Soddo Zuria District, Southern Ethiopia. *Glob.Vet*. 14:867-875.

Knottenbelt, D. (2003): Handbook of equine wound management. London:Saunders.

Kumar, N., K. Fisseha, N. *Shishay and Y. Hagos, 2014. Welfare Assessment of Working Donkeys in Mekelle City, Ethiopia. Global Veterinaria*, 12: 314-319.

Mekuria, S., M. Mulachew and R. Abebe, 2013. Management practices and welfare problems encountered on working equids in Hawassa town, Southern Ethiopia. *J. Vet. Med. Anim. Health*, 5: 243-250.

Nejash A., Endale T., Abdi H. and Feyissa B.(2017). Prevalence and associated risk factors of equine wound in and around Asella town, South Eastern Ethiopia. *J. Vet. Med. Anim. Health*, Vol. 9(4), 63-71

Pearson R, Mengistu A, Agajie T, Eleanor F, David G, Mesfin A (2000): Use and management of donkeys in peri-urban areas of Ethiopia, Draught Animal Power Technical Report 5, Scotland, University of Edinburgh: Centre Trop. *Vet. Med*. 4:260-275.

Pritchard, J.C., A.C. Lindberg, D.C. Main and H.R. Whay, 2005. Assessment of the welfare of working horses, mules and donkeys, using health and behavior parameters. *Prev. Vet. Med*., 69: 265-283 behavior parameters. Preventive Veterinary. Medicine, 69: 265-283.Putnam JR, Holesmes CLM, Green MJ, Freeman SL (2014). Incidence,cause and outcome of lameness cases in working military horse population: Field study. *Equine Veterinary Journal* 46:194-197.

Solomon M and Rahmeto A (2010): Observation on major welfare problems of equine in Meskan district, southern Ethiopia. *Livest. Res. Rular Dev*., 22(3): 1-6.

Svendsen E. (1997): Parasites Abroad. the professional hand book of the donkey, (3^{rd} edn) Whittet Books limited, 18 Anley Road, London, Pp: 166-182.

Svendsen E. (2008): Parasites Abroad. the professional hand book of the donkey, (3^{rd} edn) Whittet Books limited, 18 Anley Road, London, Pp: 166-182.

Tesfaye, A., Curran, M.M., 2005. A longitudinal survey of market donkeys in Ethiopia. *Trop. Anim. Health Prod*. 37, 87–100.

Thrusfield, M., 2007. Veterinary Epidemiology (3^{rd} edn) Blackwell science Ltd London, UK, pp: 228-246.

Tsega AM, Worku Y, Tesfaye T, Nazir S (2016). Prevalence of Wound and Associated Risk Factors of Donkeys in Merawi.

Usman S, Haim anotDTK, Kebede TZG (2015): Health and Welfare Related Assessment of Working Equine in and Around BatuTown, East Shoa, Central Ethiopia. *Nat. Sci*. 13(10):1-8.

EJED 2024 6(2):11–28

Ethiopian Journal of Environment and Development

http://www.du.edu.et/duj

E J E D

Smallholder Farmers' Climate Change Adaptation Practices and their Determinants in Negelle Arsi District, Central Rift Valley of Ethiopia

Hurgesa Hundera[1], **Adinet Bekele**[1], **Shimelis Sishah**[1], **Tesfaye Ganamo**[1], **and Abdulkadir Hussein**[1]

[1] *Department of Geography and Environmental Studies, College of Humanities and Social Sciences, Arsi University, P O Box 09, Bekoji, Ethiopia*

**Corresponding author; Email: gadaurgesa@gmail.com*

Received: 15th December 2023 *Accepted: 06th November 2024*

Article DOI: **10.20372/ejed.v06i2.02**

Abstract

Climate change presents an unavoidable challenge that disproportionately affects developing nations. In Ethiopia, the livelihoods of smallholder farmers heavily depend on rain-fed agriculture, making them particularly vulnerable to recurrent droughts and unpredictable rainfall patterns. Therefore, adaptation mechanisms are crucial for addressing the impacts of climate change. This study aims to assess the climate change adaptation practices of smallholder farmers and their determinants in the Negelle Arsi district. A cross-sectional survey design with a mixed-methods approach was employed. Both primary and secondary data were collected, utilizing systematic random sampling to identify the sampled households. Primary data were gathered through a survey questionnaire involving 184 households, supplemented by four focus group discussions and four key informant interviews. Secondary data relevant to the study were obtained from both published and unpublished sources. Data analysis involved descriptive statistics, chi-square tests, and a multivariate probit model. The results revealed that the dominant adaptation strategies employed by smallholder farmers in the study area included improved crop varieties, adjusting planting dates, crop diversification, terracing, and reserving crop residues. The maximum likelihood estimates from the multivariate probit model indicated that the probabilities of households adopting these adaptation measures were 93% for improved crop varieties, 85% for adjusting planting dates, 57% for crop diversification, 90% for practicing terracing, and 91% for reserving crop residues. The implementation of these strategies varied by agro-ecological location. Significant factors influencing the choice of climate adaptation strategies included education, family size, access to communication devices, farm size, extension services, membership in social organizations, and agro-ecological location. Consequently, future policy should focus on raising awareness among farmers and extension workers regarding the determinants of climate change adaptation. Additionally, it is essential to implement location-specific measures that are appropriate for both current and projected climate conditions.

Keywords/Phrases: Adaptation strategies, Climate change, Negelle Arsi, Smallholder farmers'

1 Introduction

Almost all nations worldwide are affected by climate change, though its magnitude varies depending on specific national contexts. Climate change has adverse, multidimensional effects on life systems as a whole. According to the United Nations Framework Convention on Climate Change (UNFCCC) (2011), climate change refers to alterations in the composition of the Earth's atmosphere, driven by human activities and, to some extent, natural climate variability observed over comparable time periods.

Low-income countries in Asia and Africa are already under significant stress, and the impacts of climate change are expected to exacerbate this situation. The Intergovernmental Panel on Climate Change (IPCC) (2007) warns that unless effective adaptation strategies are implemented promptly, some African countries could lose up to 50% of their yields from rain-fed agriculture by 2020, severely compromising food access in many regions across the continent.

The climate change adaptation mechanisms in the African context have a long history and occur within dynamic socio-economic, technological, biophysical, and political environments that vary by time, place, and sector (Bewuketu, 2017). According to Gbetibouo *et al.* (2010), farmers in the Limpopo Basin of South Africa have already observed long-term climate changes and are responding through strategies such as crop diversification, adjusting planting dates, using irrigation, and supplementing livestock feed.

In Ethiopia, smallholder farmers are particularly vulnerable to the impacts of climate change due to their heavy reliance on rainfall and exposure to non-climatic stressors such as poverty, inadequate infrastructure, a rapidly growing population, low adaptive capacity, and inefficient institutional support (Seid and Tamiru, 2016; FAO, 2018b).

These farmers possess valuable indigenous knowledge and long-standing experience that are essential for coping with hazardous environmental conditions, including climate change and variability (Haileab, 2018). For Ethiopia, adaptation is crucial to mitigating the effects of climate change. Common adaptation measures include the use of improved crop varieties, crop diversification, adjusting planting dates, irrigation, livelihood diversification, water harvesting, and soil water conservation (FAO, 2015; Solomon *et al.*, 2016).

However, the choices of adaptation strategies among farmers vary based on access to resources, infrastructure, education, technology, location, biophysical conditions, social structures, financial capacity, and institutional mechanisms (Nhemachena & Hassan, 2008; Tamiru, 2020). Numerous studies have been conducted in Ethiopia on climate change and adaptation techniques, particularly focusing on basin and drought-affected areas. Nonetheless, the impacts of climate change are increasingly becoming a threat across various environmental conditions and agro-ecological settings (Nhemachena & Hassen, 2008; Pickson and He, 2021). Therefore, analyzing climate change adaptation requires specific attention to the socio-economic and institutional characteristics of different locations (Jha and Gupta, 2021).

Negelle Arsi district is situated in the Central Rift Valley region of Ethiopia, characterized by three distinct agro-ecological zones. The majority of farmers in this area are smallholders who rely on rain-fed agriculture. Repeated episodes of drought have become a common challenge, leading to reduced crop yields and livestock mortality (Zenebe *et al.*, 2018; Tewodros, 2021). Furthermore, many residents in the district's lowland agro-ecology face severe and chronic food insecurity, along with widespread malnutrition.

Previous studies by researchers such as Yoseph *et al.* (2015) and Abreham *et al.* (2017) have explored similar topics in specific areas. However, none of these studies addressed climate change adaptation practices in relation to agro-ecological settings. Given that each agro-ecological zone necessitates specific adaptation measures, understanding these requirements is essential for identifying effective strategies. Additionally, other researchers, including Abreham (2017) and Tewodros (2018), employed binary logistic regression models to analyze factors influencing farmers' choices of adaptation strategies against climate change. A limitation of this model is that it considers only a single adaptation choice made by farmers, assuming that they can select only one strategy at a time, without accounting for potential correlations or interdependencies between various adaptation practices (Yu *et al.*, 2008).

In reality, farmers often adopt multiple adaptation strategies simultaneously, and these strategies may be interconnected (Nhemachena and Hassen, 2008). Adoption decisions can vary based on cultural factors, resource endowments, objectives, preferences, and different socio-economic backgrounds. Therefore, this study aims to examine the climate change adaptation practices of smallholder farmers and their determinants in Negelle Arsi district, Central Rift Valley, Ethiopia.

2 Material and Methods

The study was conducted in the Negelle Arsi district, located within the West Arsi zone of the Oromiya regional state in Ethiopia. The district shares borders with Adamitulu Jido Kombolcha district to the northwest, Shashemene district to the southeast, Heben Arsi district to the east, and Shalla district to the west. It is situated 225 km south of the national capital, Addis Ababa, with geographical coordinates ranging from 7^o10'N to 7^o40'N latitude and 38^o20'E to 38^o50'E longitude (Figure 1).

The altitude of the district varies from 1,500 to 2,800 meters above sea level, and annual rainfall ranges between 500 and 1,200 mm. The district is home to three major Rift Valley lakes: Lake Langano, Lake Abijata, and Lake Shalla, as well as the Abijata-Shalla National Park.

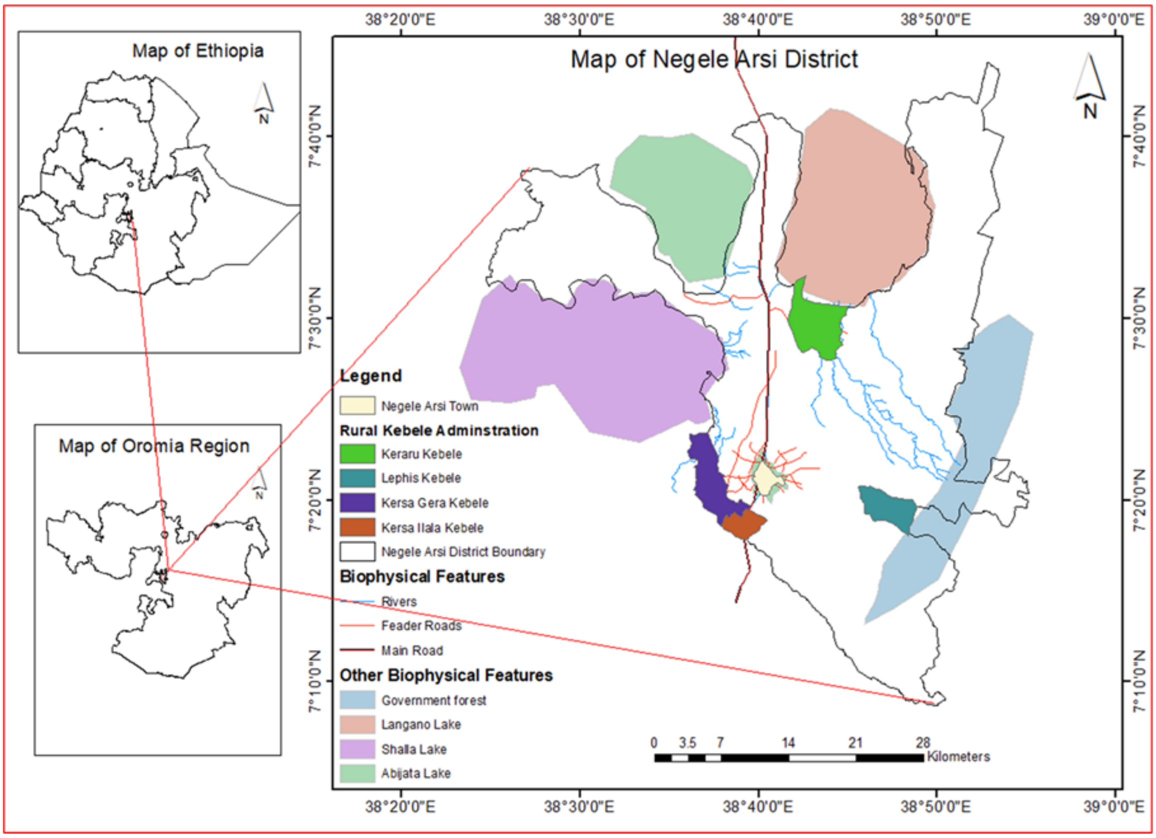

Figure 1. Location Maps of Negelle Arsi District.
Source: Developed from CSA 2007 using ArcMap 10.7 software

The major crop cultivation occurs during the main rainy season. Of the total agricultural land, which covers 48,479 hectares, approximately 41,749.6 hectares were dedicated to various crops during the 2022 production year of the main rainy season. Additionally, a short rainy season planting was conducted on 8,652.5 hectares from March to May of the same year.

The primary crops grown in the district include wheat, maize, Eragrostis teff, barley, sorghum, beans, and various vegetables such as potatoes, cabbage, and onions. The average farm size per household is about 1.5 hectares (FAO, 2015). Common crop pests include stalk borers, cutworms, bollworms, aphids, and armyworms, while prevalent crop diseases consist of rust, leaf virus, wilt, leaf blight, bacterial blight, and bean chocolate spot.

Livestock farming in the area includes cattle, sheep, goats, horses, donkeys, and poultry. The district serves as a key trade route for beef and dairy farming, which are commercialized in various locations.

3 Research Design and Data Sources

The research design utilized a cross-sectional survey, with data collection occurring at a single point in time during the study period. This technique is advantageous as it allows researchers to gather information about the current status or recent past of the cases under investigation (Rani, 2003). Additionally, a mixed-methods approach was employed to triangulate qualitative and quantitative data.

This research drew on both primary and secondary data sources to meet its objectives. Primary data were collected from households of smallholder farmers through face-to-face surveys, interviews, and group discussions. Secondary data were obtained from both published and unpublished sources by reviewing relevant documents, research reports, journals, and online resources.

3.1 Sample Size Determination and Sampling Technique

Multi-stage sampling techniques were employed to identify the study kebeles and respondent households. In the first stage, Negelle Arsi district was purposefully selected due to its vulnerability to the impacts of climate change, stemming from its geographical location in the Central Rift Valley. According to the agro-ecological classification by Temesgen *et al.* (2009), the study area is categorized as hot to warm sub-moist lowlands, characterized by erratic rainfall and shallow soils. The FAO (2015) reported that rainfall patterns in Ethiopia are generally influenced by altitude; for example, middle and higher altitudes (above 1,500 meters) receive significantly more rainfall than lowland areas. Additionally, Akilu and Alebachew (2009) and the Negelle Arsi District Agricultural Office (2021) found that the study area has experienced extreme climate events, including recurrent droughts and floods.

In the second stage, the study area was divided into three major agro-ecological zones (AEZs) using a stratified sampling technique. Farmers from different agro-ecological settings have varying vulnerabilities to the impacts of climate change and different experiences with adaptation strategies (Kothari, 2004). These strategies are influenced by various factors, including the biophysical, socioeconomic, and institutional contexts of the study population. Accordingly, of the thirty-six rural kebele administrations, seven kebeles belong to the highland zone, eighteen to the midland zone, and eleven to the lowland zone.

In the third stage, four administrative kebeles (two from the lowland zone, one from the midland zone, and one from the highland zone) were selected using simple random sampling techniques. This approach ensures that each agro-ecological zone is represented and that communities within the same AEZs are likely homogeneous regarding socio-economic, cultural, ecological, and other relevant factors.

Lastly, in the fourth stage, the list of the study population (sample frame) was obtained from the respective kebele administrations. The sample size was determined using the formula provided by Yamane (1967), which is widely applicable, easy to calculate, and effective for survey studies, resulting in a minimal error term. The required sample size was calculated at a 93% confidence level with a 7% margin of error, as an error of less than 10% is considered acceptable (Kothari, 2004; Tewodros, 2018).

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

Where "n" is the sample size, "N" is the population size (sample frame), and "e" (0.07) is the margin of error.

$n = \frac{[}{1}801][1+1801(0.07)^2] = 184$

Hence, the questionnaire was completed by 184 household heads. After determining the sample size, the respondent household heads were selected and contacted using a systematic random sampling technique. A key advantage of systematic random sampling is its simplicity in implementation; it encourages diversity, minimizes inclusion or exclusion errors, and is particularly effective when the population has homogeneous characteristics (Zinger, 1980).

3.2 Methods of Data Collection

The study employed four data collection tools to gather quantitative and qualitative data relevant to the research objectives. The main tools used for data collection are as follows:

Questionnaire Survey: A structured questionnaire, comprising both close-ended and open-ended questions, was developed to address the research questions. To ensure clarity and facilitate meaningful conversation, the questionnaire was crafted using straightforward and understandable language. The completeness, readability, and language construction of the questionnaire were reviewed by an individual with expertise in the subject matter. The questionnaire included detailed items regarding smallholder farmers' views on climate change and the response mechanisms they employ to mitigate its negative effects. Additionally, it captured the demographic, socioeconomic, and institutional characteristics of the study area to provide a comprehensive understanding of the research questions. The survey was conducted by enumerators familiar with the study area and the local language, who received appropriate training and orientation prior to data collection. All activities were closely supervised by the researchers, and face-to-face interviews were conducted with 184 sampled respondents.

Focus Group Discussion (FGD): A checklist was prepared to explore smallholder farmers' perceptions of climate change over the past 20 years (2001 to 2021) and the existing adaptation strategies. This approach allowed the researchers to triangulate data obtained from the questionnaire survey and key informant interviews. Four focus group discussions, each consisting of eight individuals, were organized in Kersa Ilala, Kersa Gera, Lephis, and Keraru kebeles. FGD participants were purposefully selected with the assistance of the kebele chairpersons and included delegates, elders, model farmers, and youth representatives who had lived in the study area for at least 20 years. Participation was based on individual interest.

Key Informant Interview (KII): The third technique utilized for primary data collection was key informant interviews, which helped cross-check and substantiate data gathered through quantitative methods (Elder, 2009). Relevant data were collected through interviews with experts in climate change and related fields, involving four KIIs at the district level. Interviews were conducted with extension and natural resource experts from the Agriculture Office, an early warning expert from the Disaster Risk Management Office, and an irrigation expert from the Water and Irrigation Office of Negelle Arsi district. The selection of these sectors was based on their sensitivity to the impacts of climate change and their efforts to address these issues through institutional mechanisms. The interview checklist focused on smallholder farmers' perceptions, adaptation practices, and the socioeconomic characteristics affecting their choices of adaptation strategies. Each interview session was conducted separately and lasted on average for one hour, with the researchers managing the process and documenting the findings accordingly.

3.3 Methods of Data Analysis

Descriptive statistics were utilized to analyze the demographic, socioeconomic, and institutional characteristics of the study area. This analysis included measures such as percentages, maximum and minimum values, means, frequencies, standard deviations, and other metrics of central tendency. The data were summarized and presented using SPSS version 21 software.

Additionally, the Pearson chi-square test was employed to compare variations in adaptation strategies practiced across different agro-ecological zones in response to climate change. A multivariate probit model was also applied (using STATA version 12) to analyze the factors influencing farmers' choices of adaptation strategies.

Both dependent and independent variables were considered to examine the factors affecting smallholder farmers' adaptation decisions regarding climate change impacts. Independent variables are explanatory variables that influence the values of the dependent variables. The relationships among these variables, which address the research objectives, are summarized in Table 1.

The dependent variables, identified from the literature review and various climate change adaptation methods used by farmers in the study area, include Improved Crop Varieties (ICV), Adjusting Plantation Dates (APD), Crop Diversification (CD), Water and Soil Conservation (WSC), and Reservation of Crop Residues (RCR). The identified independent variables are also presented in Table 1 below.

Table 1. Description of variables and measurement

Definition of Variable	Measurement of Variable	Expected Effect				
		ICV	APD	CD	WSC	RCR
Sex of HH head	1= Male; 2= Female	+/-	+/-	+/-	+/-	+/-
Age of HH Head	Years	+/-	+/-	+/-	+/-	+/-
Education level	Years	+	+	+	+	+
Family size	Number	+/-	+/-	+/-	+	+
Communication Device	Yes=1, No=2	+	+	+	+	+
Farm size	Hectare	+	+	+	+	+
Extension Access	Yes=1, No=2	+	+	+	+	+
Social Support System	Yes=1, No=2	+	+	+	+	+
Credit Access	Yes=1, No=2	+	+	+	+	+
Agro-ecology Setting	Yes =1, No =0	+/-	+/-	+/-	+/-	+/-

The multivariate probit technique (MVP) is appropriate to study smallholder farmers who employ more than one adaptation strategy based on the complementarity and substitutability approach (Yu *et al.*, 2008; Nhemachena *et al.*, 2014). Farmers' conditions to practice or not practice for any adaptation strategy can be determined using the relative benefit of each practice. Let U_j be the benefit in the state of choosing j as an adaptation measure and, whereas, U_0 be the benefit in the state of not choosing j as an adaptation measure. Therefore, the farmer "f" decides to use "j" adaptation option if the perceived benefit from option "j" is greater than not being chosen by the farmer, which is given by:

$$U_j(x'_{fj}\beta_j + e_{fj}) > U_0(x'_{fj}\beta_j + e_{fj}),\ j \neq k$$

Based on the above information, S^*_{fj} is unobserved net benefit of using or not using j adaptation measure and determined by:

$$S^*_{fj}\ (\text{strategy}) = x'_{fj}\beta_j + e_{fj} \quad j = 1, 2, \ldots, n$$

S*fj represents practicing or not practicing an adaptation strategy by farmers, x'_{fj} is a predictor that determines farmer f who practices j^{th} adaptation strategy (where j= 1, 2, ..., n and denotes any climate change adaptation strategies). $\beta_1, \beta_2, ..., \beta_n$ are a vector parameters to be estimated for j^{th} strategies, and random error terms $\varepsilon_1, \varepsilon_2, ..., \varepsilon_n$ are distributed as multivariate normal distribution with zero means, unitary variance. The relationship across the error terms of several latent equations can be explained with a non-zero off-diagonal n x n contemporaneous correlation matrix $R = \rho_{fj}$, with density $\emptyset$ ($\varepsilon_1, \varepsilon_2, ..., \varepsilon_n; R$). The unobserved characteristics of farmers' which affect the choice of adaptation strategies may be a source of error term. The state of unobserved preferences of farmers (S^*_{fj}) related to the j^{th} choice of adaptation strategy described in equation 11 is transformable into an observable binary outcome, which is stated by:

$$S_{fj} = 1 \text{ if } S^*_{fj} > 0$$
$$S_{fj} = 0 \text{ if } S^*_{fj} \leq 0$$

$S_{fj} = 1$ if $U_j > U_0$ and $S_{fj} = 0$ if $U_j < U_0$, state that, S is a binary dependent variable taking the value of 1 if the farmer f chooses the j adaptation strategy of interest; and otherwise 0, if the farmer failed to choose it (Hassen, 2015). This study considered five adaptation strategies to be analyzed the influences of deriving factors on each of these strategies.

These include: S_1 = Uses of improved crop varieties, S_2 = Adjusting planting dates, S_3 = Crop diversification, S_4 = Terracing, and S_5 = Reserving crop residues. The maximum likelihood estimation maximizes the sample likelihood function is a product of 5-variate integration of standard normal probability ($\emptyset$) which is given by:

$$\Pr(S1,\ S2,\ \ldots,\ S5/x) = \int_{-\infty}^{(2s-1)x'\beta_1} \text{x}\int_{-\infty}^{(2s-1)x'\beta_2} \ldots \text{x}\int_{-\infty}^{(2s-1)x'\beta_5} \emptyset\ \varepsilon_1, \varepsilon_2, \ldots, \varepsilon_n; Z'RZ\ d\varepsilon_2 d\varepsilon_1$$

Where, $Z = diag\ 2y\ 1–1, \ldots, 2y\ 5\text{-}1$.

4 Results And Discussion

4.1 Climate Change Adaptation Strategies

There is no one-size-fits-all adaptation to climate-related risks; adaptation strategies vary contextually and spatially among communities and individuals. Frequency statistics were used to assess the adaptation measures practiced by household heads. Farmers in the study area have developed various mechanisms to mitigate the negative impacts of climate change, with the most commonly practiced strategies summarized in Table 2. The response values from household heads reflect multiple answers for a single adaptation option since farmers may implement more than one adaptation strategy simultaneously.

Table 2. Summary of adaptation strategies utilized by smallholder farmers

Adaptation strategies	Number of Respondents (n=184)	Percent (%)
Improved crop varieties	171	92.9
Adjusting plantation dates	157	85.3
Crop diversification	104	56.5
Terracing	166	90.2
Irrigation	8	4.3
Reserving crop residues	169	91.8
Emergency Support	54	29.3

Source: computed from survey result (February, 2022).

Table 2 shows that the most important adaptation strategies practiced by respondent household heads include using improved crop varieties (92.9%), adjusting planting dates (85.3%), crop diversification (56.5%), terracing (90.2%), and reserving crop residues (91.8%). In contrast, irrigation was the least commonly used adaptation strategy among the respondents.

Although various factors—such as agro-ecological specifics, cultural influences, and the effectiveness of the measures—affect the choice and implementation of these adaptation strategies, most of them are relatively easy to implement and affordable for many smallholder farmers. Focus group discussion (FGD) participants noted that irrigation requires significant investment and skills, making it unaffordable for most smallholder farmers.

The MVP regression model was applied to analyze the types of adaptation strategies used by respondents and the effects of driving factors on their choices. Before running the model, the data were checked for multicollinearity to determine whether inter-correlation existed among the independent variables, using the variance inflation factor (VIF) as a measure (Nhemachena *et al*., 2014). The VIF value was found to be 1.31, indicating that there were no issues with multicollinearity.

The probability of smallholder farmers selecting any adaptation strategy in response to climate change is influenced by demographic, socioeconomic, and institutional characteristics. These variables were analyzed to assess their significant impact on household heads' choices of adaptation strategies. According to Table 3, the probabilities of households choosing and implementing improved crop varieties, adjusting planting dates, diversifying crops, terracing, and reserving crop residues as forage are 93%, 85%, 57%, 90%, and 91%, respectively. These findings align closely with the summary of adaptation strategies used by farmers presented earlier in Table 2.

It was hypothesized that smallholder farmers would jointly employ two or more adaptation strategies. Consequently, there is a 46% likelihood of respondents choosing all five adaptation strategies together, while the likelihood of choosing none of them jointly is only 0.12%. The likelihood ratio test for the model ($\chi^2(10) = 28.12$, p = 0.0017) and Rho = 0 at a 5% significance level indicate that at least one combination of strategies is statistically different from zero. The correlation matrix revealed significant joint correlations among the non-mutually exclusive adaptation strategies practiced by respondents (Table 3).

Thus, the error term arises from the interdependence of these adaptation strategies, based on the relative benefits they provide to farmers when implemented together. The Stimulated Maximum Likelihood (SML) estimation indicated that the probability of farmers selecting any adaptation strategy depends on whether the overall benefit of the typical climate adaptation strategies being used exceeds that of other strategies.

Table 3. Correlation Matrix of Adaptation Strategies

Matrix category	Use of improved crop varieties ($\rho 1$)	Adjusting planting dates ($\rho 2$)	Crop diversification ($\rho 3$)	Terracing ($\rho 4$)	Reserving crop residues ($\rho 5$)
$\rho 2$	-0.237				
	-0.253				
$\rho 3$	0.268	0.197			
	-0.172	-0.146			
$\rho 4$	0.51***	0.117	0.459***		
	-0.17	-0.191	-0.152		
$\rho 5$	0.127	0.037	0.42**	0.597***	
	-0.3	-0.203	-0.179	-0.162	
Predicted probability	0.93	0.854	0.566	0.901	0.92
Joint success probability = 46%			Pro. Failure = 0.12%		
Likelihood ratio test of $\rho 21 = \rho 31 = \rho 41 = \rho 51 = \rho 32 = \rho 42 = \rho 52 = \rho 43 = \rho = 53 = \rho 54 = \rho 65 = 0$:					
χ^2 (10)= 28.1171; prob > χ^2 = 0.0017					

***, ** and * significant at 1%, 5% and 10% probability level, respectively.

Source: computed from survey result (February, 2022).

Table 3 illustrates the results of possible combinations of five adaptation strategies practiced by farmers. The correlation coefficients for these combinations were determined at significant levels of 1% and 5%. This indicates that the choice of climate change adaptation strategies is interdependent (Table 3). The relationships among the latent variables can exhibit either positive correlation (complementarity) or negative correlation (substitutability) between different adaptation options utilized by farmers. Consequently, due to the interdependency of these strategies, smallholder farmers may implement more than two adaptation strategies simultaneously.

There is a positive and significant relationship between the adoption of improved crop varieties and terracing, crop diversification and terracing, crop diversification and reserving crop residues, and reserving crop residues and terracing, with significance levels of 1%, 1%, 5%, and 1%, respectively. In contrast, the relationship between the use of improved crop varieties and adjusting planting dates is negatively correlated, though this relationship is not statistically significant. Farmers often utilize adjusting planting dates and improved crop varieties interchangeably due to liquidity issues, which help them save on additional costs. When farmers face shortages of improved crop varieties, adjusting the planting date becomes a priority measure to adapt to changing climate conditions.

On the other hand, the effects of climate change and variability are intensifying and becoming increasingly unpredictable. As a result, farmers are compelled to adopt a flexible approach to adapt to fluctuating climate conditions. Institutional support, including timely technical assistance and climate information services, is critical in shaping farmers' choices of adaptation measures and enhancing their effectiveness in addressing climate-related stresses.

4.2 Comparison of Climate Change Adaptation Strategies based on AEZS

A specific approach tailored to the agro-ecological setting is essential for overcoming the risks and impacts associated with climate change (Wondmagegn and Lemma, 2016). In this context, farmers in the study area were asked for their views on the adaptation strategies they practice in response to climate change. The Pearson chi-square test (χ^2) was used to compare the adaptation strategies employed by smallholder farmers based on the agro-ecological zones (AEZs). The results indicate that a majority of smallholder farmers implement one or more adaptation strategies simultaneously (Table 4). These strategies include the use of improved crop varieties, adjusting planting dates, crop diversification (including crop rotation), terracing, irrigation, reserving crop residues, and emergency assistance for food-insecure households. Findings from focus group discussions (FGDs) and key informant interviews (KIIs) were compared with household interviews and empirical evidence from various scholars, aligning with the farmers' responses.

Improved Crop Varieties: This strategy is already being utilized by smallholder farmers across all AEZs in the study area. Specifically, approximately 92.5%, 93.8%, and 92.7% of respondents in the highland, midland, and lowland AEZs, respectively, practice agronomy through the use of improved crop varieties as climate change adaptation strategies (Table 4). The variation in the use of improved crop varieties across the three AEZs is statistically insignificant (χ^2 = 0.68, p = 0.967). This suggests that the practice is widespread among respondent households in all AEZs and is effective in addressing climate-related impacts.

Historically, the effects of climate change were most pronounced in lowland areas, but these issues have now extended to midland and highland AEZs. According to participants in the FGDs, production in the midland and lowland areas during the short rainy season (belg) has become increasingly unproductive. Similarly, one participant from the highland area shared their experiences regarding long-term rainfall patterns, comparing them to the current situation in 2022.

"*So far, the area is known to have a bimodal rainfall distribution with a timely and sufficient amount. In particular, the short rainy season, which is locally named as the belg season, starts in early March and ends in May of the normal time. Adequate rainfall during the spring season is required for easy land preparation at the beginning of June. The main sources of our income and food security (wheat, potatoes, cabbage, and maize) are determined by production during a short rainy season. However, since 2000, crop production during the short rainy season has been challenging due to the insufficient amount of rainfall and unpredictability of the rainfall conditions. This interview testified that the effect of climate change imposed a significant decline in rainfall and socio-economic challenges on the respondents in the study area.*"

The views of key informants indicated that rainfall during the 'Arfasa' (short rainy season) has been interrupted for 15 to 45 consecutive days, depending on the agro-ecological zone (15 days in highland areas and 45 days in lowland areas). As a result, many farmers in the lowland regions have shifted their practices to include measures such as transitioning from agriculture to livestock production, selling forest products, and relying on emergency aid. Radio, television, and institutions (such as the Disaster Risk Management office, Agricultural office, NGOs, and farmer cooperatives) play a crucial role in providing smallholder farmers with information about rainfall and temperature.

The use of multiple adaptation mechanisms across all AEZs is particularly important for addressing the negative impacts of climate change. According to the FGDs, farmers are utilizing specialized crop varieties, including short-growing and drought-tolerant crops.

Taddese *et al.* (2018) also found that climate change has altered land use patterns, leading to the introduction of short-growing crops such as maize, haricot beans, peppers, and sugarcane in areas where they were not traditionally cultivated. All FGD participants noted that these specialized crop varieties are capable of withstanding drought, excessive rainfall, and disease infestations, thereby making farming systems more resilient.

However, survey respondents and FGD participants expressed concerns regarding supply challenges. Additionally, many agricultural inputs currently used by farmers are ecologically unsuitable. A similar study conducted by Kabir *et al.* (2021) found that the majority of farmers in the southwestern coastal regions of Bangladesh were using improved crop varieties that require less water and can tolerate higher temperatures and salinity.

Adjusting Plantation Dates: Adjusting planting dates is the second most common adaptation strategy, utilized by 70%, 89.5%, and 89.5% of sampled households in the highland, midland, and lowland areas of the study region, respectively (Table 4). There was a statistically significant difference in the practice of adjusting planting dates among AEZs (χ^2 = 9.59, p = 0.008), with the strategy being more prevalent in the midland and lowland areas compared to the highland area.

Unpredictable and variable rainfall patterns have compelled farmers to actively utilize weather information and indigenous knowledge to adjust their planting dates. Radio, television, and institutions (such as the Disaster Risk Management office, Agricultural office, NGOs, and farmer cooperatives) play a critical role in providing smallholder farmers with essential rainfall and temperature information.

Key informants reported that rainfall during the 'Arfasa' (short rainy season) has been interrupted for 15 to 45 consecutive days, depending on the agro-ecological zone (15 days in highland areas and 45 days in lowland areas). According to evidence from FGDs, over the past two decades, the area typically received reliable spring rainfall from March to May. Unfortunately, this pattern has changed, leading to late onset and early cessation of rains. Temesgen *et al.* (2011) noted that farmers in lowland AEZs have observed these changes more acutely than those living in midland and highland areas.

Farmers in lowland regions, having long experience with climate variability, are already adapting to these challenges. However, Urgessa and Amsalu (2014) found that the likelihood of smallholder farmers in the highland AEZ adjusting their planting dates has increased by 16.19%.

Crop Diversification: Crop diversification is widely practiced in the study area as a strategy to mitigate the risks of crop failure rather than simply maximizing yields. The results indicate that 79.2% and 60.4% of respondents in the midland and lowland AEZs, respectively, engage in crop diversification through intercropping or crop rotation (Table 5). In contrast, this practice is less common among highland farmers, with only 20% of interviewed households utilizing it as a climate adaptation strategy. The chi-square test results show a significant difference in the practice of crop diversification among farmers in different AEZs, with χ^2 = 32.3 and p = 0.000 (Table 4).

A similar study by Taddesse *et al.* (2018) reported that 37.7%, 57.6%, and 68.6% of respondents from highland, midland, and lowland areas, respectively, utilized crop diversification to mitigate the impacts of climate change. According to FGDs, the most commonly grown field crops for intercropping that enhance soil management include Eragrostis teff paired with sorghum, maize with potatoes, and sorghum with chickpeas. The researcher also observed these practices during field visits. Participants in the FGDs emphasized their extensive practical experience with the benefits of mixing crops with varying attributes, such as maturity periods, drought tolerance, input requirements, and end uses of the products.

Irrigation: Irrigation serves as another climate change adaptation strategy, particularly reliable in conditions of unpredictable rainfall and prolonged dry seasons. Table 4 shows that 8% of respondents in the lowland area practice irrigation, primarily using small rivers such as the Lephis and Gedemso Rivers. There is a statistically significant variation in irrigation practices among smallholder farmers across different agro-ecological settings (χ^2 = 7.67, p = 0.022). However, despite the river's potential, existing irrigation practices serve only a limited number of farmers located near watershed areas and are mostly implemented in a traditional manner. No respondents reported using irrigation in the midland and highland parts of the study area.

FGDs and KIIs indicated that poor irrigation practices in the region stem from a lack of investment, inadequate technology, and insufficient attention from local government. The overall decline in rainfall across all seasons has heightened the need for irrigation to mitigate the negative impacts on agricultural production during dry periods. Additionally, limited rainfall reduces the availability of water sources for irrigation, underscoring the importance of local government efforts to implement water harvesting systems and advance irrigation technologies.

Terracing: During field observations, the researcher noted various structural measures for soil and water conservation, including the construction of terraces and bunds aimed at minimizing soil erosion and maintaining soil fertility. Farmers reported that terracing not only improves groundwater recharge but also reduces soil erosion. As a result, terracing is widely adopted by farmers in the region. According to Abreham (2017), terracing is one of the primary soil and water conservation practices used in hilly areas where soil erosion is a significant issue, and it is also beneficial in moisture-deficit regions.

Data from Table 4 reveal that 75%, 91.7%, and 95.8% of respondents reported practicing terracing in the highland, midland, and lowland AEZs, respectively. There is a significant variation in terracing practices among farmers in different locations, with $\chi^2 = 16$ and p = 0.001. The study found that terracing and other soil conservation activities are more commonly implemented in the lowland and midland areas than in the highland regions. This trend is partly due to the severe destruction of vegetation in the hill areas of the lowland and midland AEZs, driven by local farmers' search for farmland, construction materials, and firewood. This degradation has led to extensive soil erosion in the downhill areas of the farmlands.

Additionally, incentives provided by the Productive Safety Net Program (PSNP) and humanitarian organizations have encouraged communities to engage in soil and water conservation activities in the project area. According to key informant interviews, more attention has been given to lowland areas due to their heightened moisture deficits and fragile landscapes compared to other regions. This finding aligns with Megerse (2018), which reported that approximately three-fourths (74.8%) of households in the study practiced terracing as an adaptation strategy, enhancing water infiltration and reducing soil erosion.

Entitlement for Relief Aid: The evidence presented in Table 4 indicates a significant difference in entitlement to emergency aid among respondent households across the highland (0%), midland (16.7%), and lowland (47%) zones of the study area ($\chi^2 =$ 11.74, p = 0.000). This finding aligns with the studies by Yoseph *et al.* (2015) and Abreham *et al.* (2017), which report that the productivity of major crops has been progressively declining over the last two decades in arid and semi-arid regions of the central rift valley, exposing farmers to food insecurity. Similarly, Eyasu (2020) identified food aid as a coping mechanism for climate extremes and variability in Ethiopia.

According to a report from the district's Disaster Risk Management (DRM) office (2022), a significant portion of the lowland areas, along with some midland regions, has experienced low rainfall distribution, leading to total production losses. In response, emergency relief efforts have been implemented through close collaboration between local governments and various humanitarian organizations.

Table 4. The variation of adaptation practices based on AEZs

Adaptation option	Status	Highland		Midland		Lowland		χ^2 value	P-value	Observed count	Phi value
		Count	%	Count	%	Count	%				
Use improved crop variety	Practiced	34	92.5	45	93.8	89	92.7	0.68	0.967	2.83	0.019
	Not practice	3	7.5	3	6.2	7	7.3				
Adjusting Planting Dates	Practice	28	70	43	89.6	86	89.6	9.59	0.008***	5.87	0.228
	Not practice	12	30	5	10.4	10	10.4				
Crop Diversification	Practice	8	20	38	79.2	58	60.4	32.3	0.000***	17.39	0.419
	Not practice	32	80	10	20.8	38	39.6				
Terracing	Practice	30	75	44	91.7	92	95.8	14	0.001***	3.91	0.276
	Not practice	10	25	4	8.3	4	4.2				
Irrigation	Practice	0	0	0	0	8	8.3	7.67	0.022**	1.74	0.204
	Not-practice	40	100	48	100	88	91.7				
Store crop residues	Practiced	37	92.5	47	97.9	85	88.5	3.79	0.151	3.26	0.143
	Not practice	3	7.5	1	2.1	11	11.5				
Entitled Relief support	Receive	0	0	8	16.7	46	47.9	36.3	0.000***	11.74	0.444
	Not receive	40	100	40	83.3	50	52.1				

*, **, and *** indicate 10%, 5%, and 1% level of significance respectively.

Source: from survey result (February, 2022).

4.3 Determinants of Climate Change Adaptation Strategies

Table 5 presents the estimated results of the MVP model. The likelihood ratio, indicated by the Wald test (Wald $\chi^2(55) = 91.69$, p = 0.0014), suggests that the model fits the data reasonably well, demonstrating strong explanatory power and rejecting the null hypothesis at the 1% significance level.

Table 5. MVP Analysis result for the determinants of adaptation strategies

Independent variables		Dependent variables				
		Improved crop variety	Adjusting planting dates	Crop diversification	Terracing	Store crop
Age	Coefficient	0.006462	-0.00946	-0.00349	-0.02354	-0.03077
	Std. Error	-0.02344	-0.01935	-0.01509	-0.02114	-0.02308
Sex	Coefficient	-0.17139	-0.31474	-0.06982	0.33225	0.3742
	Std. Error	-0.55465	-0.42573	-0.34647	-0.43419	-0.5809
Family Size	Coefficient	0.124411	0.24101***	-0.00262	0.13531*	0.12786
	Std. Error	-0.09597	-0.08915	-0.05507	-0.08099	-0.10331
Education Level	Coefficient	0.423602**	-0.0045	-0.01433	0.15231	-0.11444
	Std. Error	-0.2087	-0.14777	-0.11465	-0.16689	-0.20361
Communication device	Coefficient	0.486143	0.85703***	0.335434	-0.11206	1.25225***
	Std. Error	-0.38587	-0.29122	-0.25934	-0.37352	-0.36706
Farmland Size	Coefficient	-0.26095	-0.40891	-0.32378	1.0721*	3.41595
	Std. Error	-0.44666	-0.3963	-0.30856	-0.61301	-100.362
Extension	Coefficient	0.77357**	0.40262	0.265204	0.41057	-0.06495
	Std. Error	-0.36511	-0.3174	-0.25489	-0.35299	-0.44864
Credit Access	Coefficient	0.45945	0.06366	-0.12621	-0.3145	-0.01327
	Std. Error	-0.45167	-0.31056	-0.22701	-0.3235	-0.35902
Membership in SSS	Coefficient	-0.36492	0.45116	0.62073**	0.26521	0.00259
	Std. Error	-0.46541	-0.30011	-0.24336	-0.36884	-0.4149
Agro-ecology	Coefficient	-0.00186	0.41595***	0.41793***	0.66514***	-0.41334*
	Std. Error	-0.19543	-0.15405	-0.12713	-0.17782	-0.23501
Cons		-0.18801	-1.13461	-0.62703	-1.1186	-2.21008
		-1.23387	(0.94305)*	-0.79983	-1.18204	-100.366

Multivariate probit (SML, # draws =5, Log likelihood= -280.41228, Number of observation & Simulation = 184, Wald χ^2 (55) = 91.69, Prob. > χ^2 = 0.0014.

***, ** and * significant at 1%, 5% and 10% probability level, respectively.

Source: from survey result (February, 2022).

According to Table 5, smallholder farmers' choices of adaptation strategies to climate change are evaluated based on various driving factors, including household characteristics, economic conditions, social capital, institutional commitments, and agro-ecological settings (highland, midland, and lowland). These factors significantly influence farmers' adaptation decisions in response to climate change. The effects of 13 explanatory variables on the choices of climate change adaptation strategies by respondent household heads are discussed below.

Age of Household Heads: The results from the MVP model indicate that the age of the household head is positively associated with the use of improved crop varieties but negatively associated with adjusting planting dates, crop diversification, terracing, and reserving crop residues (Table 5). However, these relationships are statistically insignificant. Older household heads are less likely to adjust planting dates, as this requires updated weather information and evidence-based decision-making, areas in which older farmers may have less exposure to new information and technology compared to their younger counterparts.

Similarly, older farmers are less likely to engage in crop diversification, terracing, and reserving crop residues, likely due to the physical demands of these activities. This finding aligns with the work of Abebe (2019), which found a negative correlation between the age of the household head and the practice of irrigation. Haftu *et al.* (2016) also reported that older individuals are less likely to engage in soil and water conservation practices. Conversely, Abreham *et al.* (2017) found that a unit increase in the age of the household head resulted in a 9% and 12% increase in the likelihood of practicing soil and water conservation and changing crop varieties as climate change adaptation strategies, respectively.

Sex of Household Heads: The gender of the household head negatively influences the use of improved crop varieties, timing of planting, and crop diversification. Women tend to prefer adaptation strategies that require less labor, avoiding labor-intensive activities such as soil and water conservation and tree planting (Wendmagegn and Lema, 2016). Conversely, gender is positively related to the practice of terracing and reserving crop residues; however, these relationships are not statistically significant (Table 5).

A study by Bewuketu (2017) found that the gender of the household head significantly and negatively affects the use of agroforestry. Similarly, Abebe (2019) reported that male-headed households are more likely to plant different crop varieties and engage in crop diversification as climate change adaptation measures. In contrast, Paulos and Belay (2018) noted that male-headed households are more inclined to adopt new agricultural technologies, largely because female-headed households often have less access to resources, information, and agricultural technologies compared to their male counterparts.

Family Size: The size of the household is an important factor positively affecting the adjustment of planting dates and terracing, with significance levels of 1% and 10%, respectively (Table 6). A larger number of individuals in a household enhances the sharing of weather information regarding past and future trends, which helps determine the best times for agronomic activities. More family members increase exposure to various public media, facilitating access to weather-related information.

Similarly, Tamiru (2020) found that household size significantly and positively influences farmers' decisions to choose improved crop varieties and irrigation. A larger family size also contributes to labor-intensive activities such as soil conservation practices. According to the data in Table 5, each additional household member increases the probability of choosing terracing as a climate change adaptation strategy. This finding aligns with the work of Hurgesa *et al.* (2020), which indicated that a greater number of economically active household members support the adoption of labor-intensive farming technologies.

Education: The education level of the household head positively and significantly influences the likelihood of choosing improved crop varieties at a 5% significance level (Table 5). Smallholder farmers with additional years of schooling are more likely to adopt improved crop varieties compared to those with lower educational attainment. Education enables farmers to acquire new information and farming technologies that enhance their agricultural practices and mitigate the effects of climate change. This finding is consistent with the studies by Abebe (2019), Helen *et al.* (2021), and Girma *et al.* (2022), which report that educated farmers are better equipped to understand and utilize scientific knowledge in selecting appropriate crop varieties, including drought- and disease-tolerant options.

Farmland Size: The size of farmland owned by farmers is a crucial determinant of their livelihoods. According to Table 5, farmland size positively and significantly affects the practice of terracing at a 10% significance level. Farmers with larger plots can implement a greater variety of soil conservation practices (such as soil bunds, terraces, and cut-off drains), which help stabilize soil nutrients and increase moisture retention. Additionally, Nhemachena and Hassan (2008) noted that larger landholdings increase the likelihood of applying irrigation as a response to climate change. Similarly, Abreham *et al.* (2017) asserted that increased farmland ownership enhances the likelihood of planting fodder trees.

Communication Device: The use of cell phones provides substantial benefits to farmers by offering updated information and enabling evidence-based decisions regarding adaptation strategies (FAO, 2015). Table 5 shows that the use of communication devices, such as mobile phones, is positively and significantly related to adjusting planting dates and storing crop residues at a 1% significance level. Farmers can access timely early warning messages from local Disaster Risk Management Offices and extension workers through phone conversations, allowing them to take proactive measures against climate-related risks. Additionally, communication devices facilitate low-cost, efficient communication with extension workers or others who can provide relevant information.

Extension Advice: Extension visits have a positive effect on the use of improved crop varieties, significant at a 5% level (Table 5). This suggests that extension services increase the likelihood of farmers adopting improved crop varieties, particularly short-growing and drought-tolerant crops. Extension advice helps farmers enhance their agricultural practices and supports evidence-based decision-making. Similar studies by Temesgen *et al.* (2009) and Solomon *et al.* (2016) confirmed that extension visits improve the likelihood of using improved crop varieties. However, key informant responses indicate that extension services in most parts of the study area are often fragmented, typically occurring once every quarter or even less frequently. Moreover, many extension services lack support from farm demonstrations.

Access to Credit Services: Farmers' access to affordable credit influences the likelihood of using improved crop varieties and adjusting planting dates, although it is negatively related to crop diversification, terracing, and reserving crop residues as climate change adaptation mechanisms (Table 5). However, these relationships are statistically insignificant. Access to credit can alleviate financial difficulties, enabling farmers to purchase essential farm inputs, new technologies, and other resources that help mitigate the negative impacts of climate change (Hassen and Nemachena, 2014). The negative relationship suggests that practices like terracing and reserving crop residues do not require credit, as they primarily depend on labor rather than financial investment.

Social Support System: Membership in farmers' organizations, such as cooperatives and informal groups like Idir and Ikub, positively and significantly influences respondent household heads' choices regarding crop diversification as a climate change adaptation strategy, at a 5% significance level (Table 5). Being part of a social organization increases the likelihood of adopting crop diversification to counteract the negative effects of climate change. Meetings among group members facilitate training and experience-sharing on adaptation strategies. A study by Ayele (2008) on rural farmers in Walayita supports this finding, highlighting that social support during ceremonial events and risk-sharing can help prevent food shortages and protect vital assets.

Agro-Ecological Setting: Different agro-ecological settings are characterized by varying climate regimes and climate-related risks, necessitating specific adaptation responses tailored to each area. The results indicate that farmers' locations within different agro-ecological zones significantly affect their practices, including adjusting planting dates, crop diversification, and terracing (all at a 1% significance level), as well as the storage of crop residues for livestock feed (at a 10% significance level) (Table 5). Farmers in low-rainfall areas (lowlands) are more likely to adopt short-duration and diverse crops compared to those in high-rainfall areas, such as the highlands. A similar study by Gutu *et al.* (2012) found that households in lowland (Kolla) areas are more inclined to use drought- and pest-tolerant crop varieties than those living in highland and midland zones. Additionally, participants in FGDs from various agro-ecological zones reported that many farmers have experience in storing crop residues, which helps feed their cattle during prolonged dry periods.

Limitation of the Study

The study was conducted in a spatially limited area, specifically the Negelle Arsi district, using a cross-sectional survey design. The population studied consisted solely of smallholder farmers and did not include other community groups, such as pastoral communities or state farms.

5 Conclusion and Implication of the Research

Smallholder farmers are already suffering from the impacts of changing and unpredictable climate conditions. In response to these challenges, they have adopted various adaptation strategies, including the use of improved crop varieties, adjusting (shifting) planting dates, crop diversification, terracing, and reserving (piling) crop residues. There are significant differences in the implementation of these strategies across agro-ecological zones (highland, midland, and lowland), reflecting the specific climate risks encountered in each area. The capacity of farmers to choose effective adaptation methods is influenced by various driving factors.

These findings are valuable for smallholder farmers and local government institutions, such as the agricultural office and the disaster risk management office of the district. They provide insights into the determinants of climate change adaptation strategies and help identify gaps related to socio-economic and institutional dimensions. Furthermore, these insights should be incorporated into the long-term development plans of institutions at various levels.

Overall, the measures currently practiced to mitigate the adverse effects of climate change are insufficient to address the existing and projected impacts. Vulnerability to climate change also varies across agro-ecological zones and between individual farmers. Consequently, local government and non-governmental institutions (such as the Agricultural Office, Disaster Risk Management Office (DRMO), Farmers' Cooperatives, NGOs, and other partners) need to address these gaps and build the resilience of smallholder farmers in the study area.

Contribution of Authors: The authors of this article contributed to the study design, material preparation, data collection, analysis, and manuscript preparation.

Conflict of Interest: The authors declare that there are no conflicts of interest.

Availability of Data and Materials: All data processed and utilized in this work are available within the manuscript.

Ethics Statement: The study complies with all relevant regulations, and informed consent was obtained from all participants involved in data collection.

Acknowledgments: The authors would like to thank the institutions and all participants in this study for their contributions.

References

Abebe Tilahun (2019). The role of small scale irrigation in climate change adaptation: The case of East Belesa district, Amhara Region, Ethiopia. MA Thesis Awasa University, Awasa, Ethiopia.

Abreham Belay, Recha, J. W., Teshale Weldeamanuel, and Morton, J. F. (2017). Smallholder farmers' adaptation to climate change and determinants of their adaptation decisions in the central rift valley of Ethiopia; *Agriculture and Food Security*: 6(1): 1-13p.

Abreham Chernet (2017). Community perception on climate change, its impacts and adaptation strategies: the Case of Ensaro Woreda, North Shewa Zone, Amhara Regional State, Ethiopia; MA, Thesis, Addis Abeba University, Addis Abeba, Ethiopia.

Ayele Tessema (2008). Livelihood Adaptation, Risks and Vulnerability in Rural Wolaita, Ethiopia: Department of International Environment and Development Studies, Norwegian University of Life Sciences, Norway.

Bewuketu Minwuye (2017). Studied on farmers' perception and adaptation strategies to climate change the case of Woreillu district of Amhara Region, Northeastern Ethiopia: Haramaya University, Haramaya.

Elder, S. (2009). Sampling methodology and methodological guide module 3: International Labor Organization, Geneva.

Eyasu Melkammeri (2020). "Farmers' perception and adaptation strategies to climate change: implications to household food security in Lay

Gayint district, Amhara region, Ethiopia": College of development studies, Addis Ababa university Addis Ababa, Ethiopia.

FAO (Food and Agriculture Organization of the United Nation) (2018b). Climate changes on farming system and livelihoods in near East and North Africa, Food and Agriculture Organization of the United Nations, Cairo.

FAO (Food and Agriculture Organization of the United Nations) (2015). The economic lives of smallholder farmers analysis based on household data from nine countries: Food and Agriculture Organization of the United Nations, Rome.

Gbetibouo G. A., Hassan, R. M., and Ringler, C. (2010). Modelling farmers' adaptation strategies for climate change and variability: The case of the Limpopo Basin, South Africa. *Agrekan*, 49(2): 217-234.

Girma Geleta, Moti Jaleta, Kindie Tesfaye, Mezegebu Getnet, Tamado Tana, and Berhane Lakew (2022). Perceived climate change and determinants of adaptation responses by smallholder farmers in central Ethiopia: Department of Plant Sciences, College of Agriculture and Natural Resources, Salale University, Fiche, Ethiopia.

Gutu Teso, Bezabih Emana, and Mengistu Ketama (2012). Econometric analysis of local level perception, adaptation and coping strategies to climate change induced shocks in North Shewa, Ethiopia: *International Research Journal of Agricultural Science and Soil Science*, 2(8): 347-363.

Haftu Kelelew, Jema Haji, & Abbadi Girmay (2016). Determinants of smallholder farmers' adaptation strategies against climate change stresses in Raya Azebo District: Abergelle Agricultural Research Center, Northern Ethiopia.

Hassan, R., and Nhemachena, C. (2008). Determinants of climate adaptation strategies of African farmers: Multinomial choice analysis; *African Journal of Agricultural and Resource Economics*.

Helen Teshome, Kindie Tesfaye, Nigussie Dechassa, Tana Temado, and Huber, M. (2021). Smallholder Farmers' perceptions of climate change and adaptation practices for maize production in Eastern Ethiopia: African center of excellence for climate smart agriculture and biodiversity conservation, Haramaya University, Ethiopia.

Hurgessa Hundera, Sylvester, M., and Amare Bantider (2020). Determinants of adaptation strategies to climate change among the smallholder farmers in Adama district: *International Journal of Climate Change Strategies and Management* Vol. 12 No. 4, pp. 463-476.

IPCC (Intergovernmental Panel on Climate Change) (2007). Climate change synthesis report on the contribution of working groups I, II and III to the fourth assessment report of the intergovernmental Panel on climate change: IPCC, Geneva, Switzerland.

Jha, Ch., and Gupta, V. (2021). Farmer's perception and factors determining the adaptation decisions to cope with climate change; Evidence from National Institute of Industrial Engineering: Vihar Lake, Powai, Mumbai, Mahrashtra, 400087, India.

Kabir, A., Amin, N., Roy, K., and Hossain, S. (2021). Determinants of climate change adaptation strategies in coastal zone of Bangladesh; Implications for Adaptation to climate change in developing country: Bangladesh University of Professionals: Dhaka, Bangladesh.

Kothari, C. R. (2004). Research methodology; methods and techniques: second revised edition.

Megerse Hundera (2018). Smallholder farmers' adaptation strategies to climate change in Adama District, Oromia Region, Ethiopia: MA Thesis in Agricultural Economics and Agribusiness and Value Chain Management, Jima University, Jima, Ethiopia.

Nhemachena, C., and Hassan, R. (2008). Determinants of African farmers' strategies for adapting to climate change: Multinomial choice; Analysis Centre for Environmental Economics and Policy in Africa (CEEPA), University of Pretoria.

Nhemachena, C., Hassan, R., and Chakwizira, J. (2014). Analysis of determinants of farm level adaptation measures to climate change in southern Africa: Human sciences research council, 134 Pretorius Street, south Africa. Page: 232–240.

Paulos Asrat, and Belay Simane (2018). Farmers' perception of climate change and adaptation strategies in the Dabus watershed, North-West Ethiopia: Center for Environment and Development Studies, Addis Ababa University, Ethiopia.

Pickson, R., and He, G. (2021). Smallholder farmers' perception, adaptation constraints, and determinants of Adaptive capacity to climate change in Chengdu: Sichuan Agricultural University, China.

Rani, M. (2003). Tobacco use in India: prevalence and predictors of smoking and chewing in a national cross sectional household survey 12(4): 8p.

Seid Sani, and Tamiru Chalchisa (2016). Farmers' perception, impact and adaptation strategies to climate change among smallholder farmers in Sub-Saharan Africa: department of Agricultural Economics, College of Agriculture and Natural Resource, Assosa University, Ethiopia.

Solomon Addissu, Getachew Fisseha, Birhanu Gediff, and Yemaneh Asmelash (2016). Perception and adaptation models of climate change by the rural people of Lake Tana Sub-Basin, Ethiopia.

Taddesse Badada, Mustefa Sultan, & Teyiba Amno (2018). Farmers' Perception and Adaptation Strategies to Climate Change and Variability in Arsi Negelle District, Oromia, Ethiopia: Oromia Urban planning Institute, Addis Abeba, Ethiopia.

Tamiru Bezabih (2020). Smallholder farmers' perceptions and adaptation strategies to climate change in Ethiopia: Debre Tabor University, Ethiopia.

Temesgen Deresse, Hassan, R.M., & Ringler, C. (2009). Determinants of farmers' choice of adaptation methods to climate change in the Nile basin of Ethiopia article in global environmental change: George Washington International Food Policy Research Institute, USA.

Temesgen Deresse., Hassan, R.M., Ringler, C. (2011). Perception and adaptation to climate change by farmers in the Nile basin of Ethiopia: *J.Agric. Sci.* 149:23-31.

Tewodros Beyene (2018). MA Thesis on adoption of climate smart agricultural practices: determinants and challenges in Gerar Jarso Woreda of Oromia Regional State, Ethiopia: submitted in partial fulfillment of the requirement for the degree of Master of Arts, Addis Abebba University, Addis Abebba.

Tewodros Tefera (2021). Farmers' perceptions and their implications to climate-proof food security programs: Wageningen Research (SWR) an international NGO that operates in support of agricultural sector transformation.

UNFCCC (United Nation Framework Convention on Climate Change) (2011). Climate Change, Impacts, Vulnerabilities and Adaptation in Developing Countries.

Urgessa Tilahin, and Amsalu Bedamo (2014). Farmers' perception and adaptation to climate change; Heckman's two stage sample selection model: Haro Sabu Agricultural Research Center, Kellem Wollega, Ethiopia.

Wondimagegn Tesfaye, & Lemma Seifu (2016). Climate change perception and choice of adaptation strategies: *International Journal of Climate Change Strategies and Management*, Vol. 8 Iss 2 pp. 253–270, Permanent link to this document: http://dx.doi.org/10.1108/IJCCSM-01-2014-0017.

Yamane, T. (1967). Statistics and introductory analysis, second edition: Harper and Row, New York.

Yoseph Melka, Habtemariam Kasa, Mengistu Ketema, Degnet Abebaw, and Ute S. (2015). The effect of drought risk perception on local people coping decisions in the central rift valley of Ethiopia: Haramaya University, Ethiopia.

Zenebe Mekonin, Teshale Woldeamanuel, and Kasa, Hebtemariam (2018). Analysis of observed and perceived climate change and Variability in Arsi Negele district, Ethioipia: Ethiopian Forestry Development, Addis Abebba, Ethiopia.

Zinger, A. (1980). Variance estimation in partially systematic sampling: *Journal of the American Statistical Association*, 75, 206-211.

EJED 2024 6(2):29–48
Ethiopian Journal of Environment and Development
http://www.du.edu.et/duj

Household Resilience to Food Insecurity: the case of Chencha Zuriya District, Southern Ethiopia

Desta Dereje Dado [1*], **Temesgen Tilahun Teshome**[2], **and Teshome Yirgu Yayu**[3]

[1]*Center for Food Security Studies, College of Development Studies, Addis Ababa University*
[2]*Center for Food Security, college of Development Studies, Addis Ababa University*
[3]*Department of Geography and Environmental Studies, College of Social Sciences, Arba Minch University*
[*]*Corresponding author; Email: derejedesta0@gmail.com*

Received: 29th April 2023 *Accepted: 10th August 2024*

Article DOI: **10.20372/ejed.v06i2.03**

Abstract

Fragmented landholding, recurring drought, food price inflation, and continued conflicts in the northern parts of Ethiopia have increased incidences of food insecurity shocks in the highland areas of the country. This study investigated food insecurity shocks and major sources of household resilience in southern Ethiopia. Using a resilience strategy, the study employed a cross-sectional design that included a household survey of 303 rural households in the wake of COVID-19 and related shocks, corroborated with focus group discussions and key informant interviews. Descriptive statistics and multivariate analytical methods, such as principal component analysis, were used to analyze the data. The findings reveal that food insecurity in the area is caused by factors like inflation, family illness, low farm production, and drought. A resilience analysis identifies six dimensions that significantly contribute to household resilience, with access to Social Safety Net, basic services, and non-agricultural assets being crucial. All but the stability dimension positively and significantly contributed to resilience. The multivariate analysis showed that 59.7% of households were non-resilient, while 40.3% were resilient at various levels. Based on factor loading and beta coefficient, access to Social Safety Net, basic services, and non-agricultural assets are crucial for promoting household resilience against food insecurity. The study suggests strengthening and improving the targeting system and quality of social safety services, increasing access to basic public services, and supporting agricultural intensification to enhance household resilience to food insecurity. Furthermore, policymakers should also prioritize the strengthening of key resilience dimensions and address frequently encountered shocks and stresses to enhance household resilience in the area.

Keywords/Phrases: Chencha, Food insecurity, Household resilience, Livelihood, Shock, Stress

1 Background

Food security is a global concern that originated in the 1970s during the global food crisis (FAO, 1996). The concept has evolved over time, with over 200 definitions (Maxwell *et al*., 2013). Food security is defined as having access to adequate food for all people, at all times, for an active and healthy life (FAO, 1996; El Bilali *et al*., 2019). However, hunger and undernourishment remain pressing issues, with 820 million hungry people worldwide and an estimated 670 million still expected to be hungry by 2030, putting the Sustainable Development Goal 2030 (SDG) agenda of eliminating poverty and malnutrition at risk (Boliko, 2019; WFP, 2022).

Food security exists when everyone has physical, social, and economic access to enough, safe, and nourishing food that satisfies their dietary needs and food choices for an active and healthy life. When this requirement is not met, food insecurity results (Camire, 2021). Food insecurity is disproportionately distributed, with Africa comprising 28.05% of the food insecure population globally, and Sub-Saharan Africa (SSA) and Asia alone accounting for 95% of the global food insecure populations (Zereyesus *et al*., 2022). Climate change, COVID-19, and wars have exacerbated this issue in Sub-Saharan Africa (Baptista *et al*., 2022). Conflict, climate change, and global market failure are major contributors to hunger and malnutrition (Degefa, 2015; Caroline & Kristina, 2022), with 70% of food insecurity occurring in conflict areas.

Ethiopia is grappling with humanitarian emergencies and food insecurity due to factors such as conflict, recurring droughts every 3-5 years, rain-fed agriculture, population pressure, limited infrastructure, irregular rainfall, and seasonal fluctuations (Devereux, 2000; MoARD, 2009; Meskerem & Degefa, 2015; Anantharam *et al*., 2021). The major causes of food shortage in Ethiopia are associated with its traditional backward farm practices (lack of adopting improved seed and animal breeds, low adoption of chemical fertilizers, lack of farming technology adoption), rain-fed dependence, and lack of large-scale irrigation practices (Mulugeta, 2009). Recent reviews reveal that despite a decrease in food insecurity in Ethiopia, 32.7% of the population still suffers from food insecurity, and the food gap is higher than in other African countries due to several factors (Ayele, 2020). In Ethiopia, food insecurity is primarily caused by factors such as recurring drought risk, environmental degradation, demographic pressure, rural-urban migration, and conflict.

Chencha Zuria district in Gamo zone, with 82% highland ecology, experiences 3-6 months of food insecurity particularly during the periods of April to May and September to November (Hassen, 2019; Tadesse *et al*., 2021). This is primarily due to fragmented landholdings and seasonal food shortages. To cope, people in the district use risk management measures like livelihood diversification, cultivation of drought-resistant crops (*Enset* and *Qoltso*), weaving, and outmigration (Abera, 2014; Utallo *et al*., 2019). However, empirical evidence on household resilience remains limited.

Food insecurity remains a significant challenge for many individuals, as highlighted in the previous paragraphs, necessitating ongoing research. Food security analysis has long aimed to enhance analytical techniques for predicting vulnerability to food insecurity (Løvendahl *et al*., 2004). However, resilience, a cohesive academic and policy concept, encourages collaboration among various disciplines, policymakers, and practitioners to address food insecurity issues (Alinovi *et al*., 2008; Schipper & Langston, 2015). Resilience measures a system's ability to handle the negative effects of unpredictable shocks, rather than predicting a crisis. According to Bahadur *et al*. (2015) and Winderl (2014), resilience indicators are used as a measure of program success. Resilience refers to a system's ability to maintain a specific standard of living, such as food security, despite shocks and stresses, based on available means of subsistence and risk-taking.

Resilience and vulnerability share two common elements: the shocks and stresses, and the adaptive capacity (Alinovi *et al*, 2010). Resilience concerns examining, investing, and taking actions on existing capacities as a new normal towards attaining food security (Frankenberger & Nelson, 2013). The conventional risk management approach is disjointed, while resilience promotes cooperation in analysis, planning, and implementation (Constas and Barrett, 2013), linking short-term humanitarian efforts with long-term development activities for better outcomes (Fan *et al*., 2014). Resilience provides a fresh perspective on the factors and dynamics of resilience to food insecurity, enabling individuals to utilize their existing strengths (Adane, 2018).

Resilience is context-specific (FAO, 2014), but food security studies in general are rare in Chencha (Eshetu & Mekonnen, 2016; Tadesse, Y. *et al*., 2019). However, there are no previous studies on the subject of resilience in the area. Eshetu and Mekonnen's (2016) study found that off-farm participation reduces household poverty, while Essa's (2019) study revealed significant differences in food security between adopters and non-adopters of soil and water conservation practices. Yenenesh *et al*. (2019) discovered that the adoption of improved potato varieties enhances households' livelihoods, but no studies have explored resilience to food insecurity.

The resilience approach is a long-term development strategy that analyzes shocks and stresses, plans, and evaluates food security programs to achieve sustained progress (Constas *et al.*, 2014). The analysis of resilience studies in Ethiopia is limited in number and broad in scope, considering diverse livelihood contexts and different measurement approaches. This study aims to narrow the focus on weaving-based households, exploring the multidimensional nature of household resilience sources and the factors determining the capacity to withstand, recover, and respond to food insecurity.

The literature suggests that integrated assessment approaches at national, local, and household levels are necessary for context-specific vulnerability and resilience studies to address specific geographic problems (Adane, 2018; Shibru *et al.*, 2024). It is against this background that the present study aims to assess rural households' resilience to food insecurity shocks in Chencha Zuriya district, Gamo zone, identifying sources, magnitudes, and determinants. The findings can then guide policymakers in determining effective investments in resilience.

2 Materials and Methods

2.1 Description of the Study Area

The study examined household resilience to food insecurity in Chencha Zuriya district, a Gamo zone in Southern Ethiopia. The district is located between 6^o8'55" and 6^o25'30" North latitude and 37^o29'57" to 37^o39'36" East longitude. It is situated at an elevation of 1,600-2,732 meters above sea level, with mean annual rainfall ranging from 750mm to 1,000mm. The district is 521 km south of Addis Ababa and 37 km from Arba Minch town.

Chencha Zuriya district has a predominantly highland (Dega) (82%) agro-ecology, with the remaining 18% being midland (Woyna-Dega) (Hassen, 2019). The district comprises 33 kebeles (the smallest administrative unit) and 3 transition towns, with 65% of the area having a mountainous topography (CSA, 2011; Hassen, 2019).

The district experiences a 3-6 months food shortage due to population growth, land degradation, unpredictable rainfall, crop diseases, and limited market access, primarily due to rain-fed subsistence agriculture (CWARDO, 2014). The study evaluates household resilience to food insecurity in Chencha Zuriya district, focusing on weaving-based livelihood groups. Limited livestock ownership and coping strategies, such as Enset production, are explored. Empirical studies on sources and magnitudes of household resilience to food insecurity shocks have not been conducted in the area.

2.2 Data Sources and Sampling Techniques

This study utilized both qualitative and quantitative data to understand livelihood conditions, food security, external shocks, and household resilience to food insecurity. The primary data sources were households, key informants, and focus group discussants, while secondary data was collected from national statistical reports, documents, and literature.

To obtain representative and reliable information and draw sound conclusions, a multistage sampling method was employed. In the first stage, Chencha Zuriya district was selected due to the high concentration of weaving activities in the region and throughout the nation (Waktole, 2016; Alyahat, 2018). Weaving is the primary source of income to supplement the highly dispersed subsistence farming in the area.

In the second stage, four kebeles with relatively dominant weaving households were purposively selected based on a preliminary survey and key informant interviews. The selected kebeles were Doko Danbo, Doko Loosha, Lakana Maldo, and Setena Borcha.

The sample respondents were chosen in the third stage using systematic random sampling techniques. The sample size of respondents was determined using the formula proposed by Yemane (1967):

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

Where:
n = the sample size
N = the total population size (2,485 households)
e = the level of precision (0.05)

Applying this formula, the sample size (n) was calculated to be 303 households. The representative sample respondents were then identified based on probability proportion to the population from the four selected kebeles using a systematic random sampling technique, with every 8^{th} household being selected.

The study utilized cross-sectional data collection methods, including quantitative and qualitative techniques such as household surveys, focus group discussions (FGDs), key informant interviews (KIIs), field observations, and secondary source analysis. Before conducting the data collection activities, an official letter of consent and approval concerning ethical matters and the primary objective of the research was obtained from the Institutional Review Board (IRB) of Addis Ababa University's College of Development Studies. Informed written consent was also obtained from the respondents for interviews, focus groups, and surveys. Ethical approval (approval number: 029/01/2023) was granted by the Addis Ababa University's Academic Commission and the Institutional Review Board on October 20, 2023.

2.3 Data Analysis

This study aimed to explore livelihood-threatening shocks and stresses, as well as sources of household resilience to food insecurity in the Chencha district. However, amid the emerging research and development use of resilience (Constas & Barrett, 2013), many aspects remain unclear regarding how the concept can be measured (Vaitla *et al.*, 2012). There is a lack of consensus on the indicators to be used and how they can be combined (Maxwell *et al.*, 2013; Mulat & Negussie, 2013; Mulugeta, 2014; Guyu & Muluneh, 2015; Adane, 2018; Gebrerufael, 2019; Debebe, 2021).

Resilience is a latent variable that cannot be directly observed. It was determined in this study by adopting the Resilience Index Measurement and Analysis-II (RIMA-II) approach (WFP, 2022), which consists of eight components: access to basic services (ABS), agricultural assets (AA), income and food access (IFA), non-agricultural assets (NAA), adaptive capacity (AC), social safety nets (SSN), and stability (S). The RIMA-II approach involves theoretical concept development, variable identification, standardization, weighting, and uncertainty metrics assessment (Dhraief *et al.*, 2019; WFP, 2022). The mathematical model for measuring household resilience can be expressed as:

$$RI = f(ABS, IFA, NA, ATP, AC, SC, S)$$

Where, RI is the resilience index, IFA is income and food access, ABS is access to basic services, AA is agricultural asset possession, NA is non-agricultural assets, ATP is agricultural technological and practices adoption, AC is adaptive capacity, SC is social capital, and S refers to household exposure to shocks or stability.

The study determined the resilience index (RI) using multivariate techniques, specifically principal component analysis (PCA), considering the lack of consensus among researchers on this approach (Dhraief *et al.*, 2019; Maxwell *et al.*, 2013). Some studies have employed qualitative techniques of measurement (Niemistö, 2011), while others have used quantitative statistical methods. This study used quantitative methods to estimate household resilience to food insecurity, transforming qualitative scales into standard ones using optimal scaling for easier principal component analysis.

The analysis followed a two-stage factor analysis strategy. First, each component was estimated individually using PCA. In the second stage, the interacting components were used as covariates, and the resilience index was calculated as a weighted sum of factors using Bartlett's scoring method (Bartlett, 1937), with the weights being the proportions of variance explained by each factor:

$$RIn = Wj_1Fi_1 + Wj_2Fj_2 + Wj_3Fj_4 + ... + Wj_nFj_n$$

Where, RI is the resilience index of the nth household, Wj is the variance explained by factor j, and Fn is the factor retained based on an eigenvalue greater than 1.

Data compatibility for PCA analysis, including singularity and sampling adequacy, was checked using Bartlett's Sphericity test and the Kaiser-Meyer-Olkin (KMO) criteria of sampling adequacy (Field, 2005). Bartlett's test of Sphericity should generally be less than 0.05, and the KMO test of sampling adequacy should be above the recommended cutting point of 0.5. However, the cutting points to categorize households into different resilience levels may vary across studies.

The resilience index (RI) score ranges from negative to positive values. However, there is a lack of consensus in the resilience literature on the use of cutting points to categorize households. Some studies have categorized households into two groups: resilient (RI > 0.00) and non-resilient (RI < 0) (Cheber, 2021a; Gebrerufael, 2019). Others have used a four-level categorization: non-resilient, moderately resilient, resilient, and highly resilient (Adane, 2018; Beyene, 2016; Dhraief *et al.*, 2019).

Rather than making a rough division into two groups, this study is inclined to use a more descriptive four-category classification: non-resilient (RI < 0), moderately resilient ($0 < RI \leq 0.50$), resilient ($0.50 < RI \leq 1.0$), and highly resilient (RI > 1.0) (Adane, 2018; Beyene, 2016).

The determination of the final household resilience index has employed directly observed variables to determine the different pillars of the household resilience index, such as the Household Food Insecurity Access Scale (HFIAS) and the Food Consumption Score (FCS). Each of these variables was derived through the use of different data analysis techniques.

The HFIAS is a food security analysis tool used to measure the access component of household food insecurity. It was developed between 2001 and 2006 by the USAID-funded Food and Nutrition Technical Assistance (FANTA) project. The data is collected through nine occurrences and nine frequencies of occurrence questions that capture the behavioral and psychological experiences of households regarding food access over the past 30 days (Coates *et al.*, 2007).

The Food Consumption Score (FCS) used in the principal component analysis is a composite measure used to assess household food security by evaluating dietary diversity, food frequency, and the nutritional importance of different food groups. The FCS is calculated based on the frequency of consumption of various food groups over the past seven days. Each food group is assigned a weight reflecting its nutritional value, with foods high in energy and protein receiving higher weights. The total score is derived by summing the weighted frequencies of consumption across all food groups (Coates *et al.*, 2007). These scores of the HFIAS and FCS indicators were then used as directly observed variables to determine the pillars of resilience, particularly the Income and Food Access (IFA) component.

3 Results and Discussions

3.1 Descriptive Statistics

Households in Chencha face significant chronic and seasonal food deficits due to low agricultural production on fragmented landholdings (Abera *et al.*, 2019). The current study found very small average land (1.1 ha) and livestock (2.95 TLU) holdings. The households rely on weaving as an essential income source, with 90.75% using diverse income sources and an average annual income of 44,474.63 ETB. Formal employment (75,025.66 ETB), weaving (38,162 ETB), and barber services (24,500 ETB) have higher average annual income returns. However, external shocks threaten these livelihoods. Government-designed Productive Safety Net Program (PSNP) support helps address the food shortage, providing food for work and free aid access.

Rural households in developing countries face challenges from environmental, socio-economic, and ecological shocks (Tefera & Kayitakire, 2015) requiring resilience to recover from food insecurity (Folke, 2006; Walker *et al.*, 2004). Understanding the capacity of the food system is crucial for humanitarian development planning interventions (Holling, 1973; Diamond & Morlino, 2004).

The household survey, key informant interviews, and focus group discussions concurrently identified climate, demographic, and market-related stressors as the primary causes of food insecurity in the study area in the last 5 years since 2022. Factors such as population pressure, food price inflation, the COVID-19 pandemic; drought, crop pests, and livestock deaths contribute to the issue. Health extension services have reduced health problems, but poor individuals still face health issues. Long-term threats include low technology adoption, soil erosion, and over-reliance on rain-fed agriculture (Figure 1).

As to 2022 Early warning office report of Chencha Zuria district experiences 3-6 months of food shortages annually, primarily in April, May, June, September, and October. Coping strategies include transitory food aid, PSNP, soil and water conservations, and weaving activities.

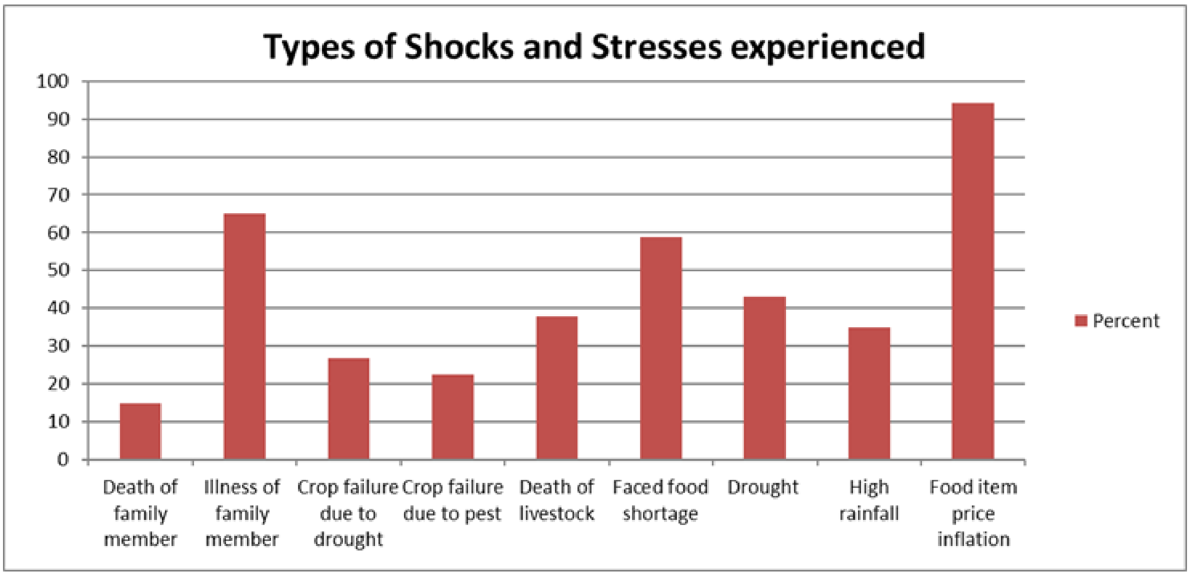

Figure 1. Major shock challenges faced by the surveyed households

70% of respondents believe their current food consumption levels cannot be maintained during a drought, highlighting the need for identifying sources of resilience and determining the key factors in development planning and intervention.

3.2 Estimation of the Latent Indicators

This section examines household resilience to food insecurity using the principal component analysis method. Eight resilience building blocks are identified, and latent variables are computed using multivariate analysis (Alinovi *et al*., 2009), factor loadings, eigenvalue criteria, and Kaiser-Meyer-Olkin (KMO) statistics (Field, 2005). The final aggregate resilience index is then computed.

3.2.1 Income and Food Access (IFA)

Income and food access (IFA) are crucial for a household's resilience against external livelihood shocks and food insecurity. The IFA component is computed from 9 variables (Table 1). The PCA analysis retained four factors based on the eigenvalue criteria greater than 1.0.

Factor 1 is determined by the Food Consumption Score (FCS), the Household Food Insecurity Access Scale (HFIAS), and household food worry. Factor 2 is defined by household food expenditure and food consumed from own production. Factor 3 is defined by food consumed from credit and assistance. Factor 4 is determined by the contribution of annual per capita household income and the percentage of total household income spent on food for consumption.

Based on the factor loading and Beta coefficient size, the IFA index is primarily influenced by household per capita income, with negative correlations with the HFIAS score and the percentage of income spent on food consumption. The KMO test of sampling adequacy (0.559) and Bartlett's test of Sphericity ($p<0.0001$, chi-square=215.785) showed that the variance defined is 60.46%, which indicates significant variance contributions from the four factors. This suggests that the principal component analysis technique is suitable for dimension reduction.

The IFA index is calculated as:

IFA = 0.3364factor1 + 0.25769factor2 + 0.2202factor3 + 0.1857factor4 ... Equ(4)

Table 1. Component Factor Loading for Income and Food Access (IFA)

Variables	Comp1	Comp2	Comp3	Comp4
FCS	0.5493			
HFIAS	-0.6369			
Worried to feed family	0.5278			
Food Expenditure		0.6498		
Food consumed from neighbor		0.6749		
Food from credit			0.6897	
Food from Gift			0.6812	
Per capita income				0.8366
Income spent on food (%)				-0.4351
Eigenvalues	1.83104	1.40214	1.19751	1.01052
Variances	0.2034	0.1558	0.1331	0.1123
Cumulative variance	0.2034	0.3592	0.4923	0.6046

Variance (%) =60.46%
KMO test of sampling adequacy=0.559
Determinant of correlation matrix Det=0.485
Bartlett's test of Sphericity is significant at p=0.0001; chi-square=215.785
Degree of freedom=26
Extraction method: Principal Component Analysis

Source: Own survey, 2022

3.2.2. Social Safety Net or Social Capital (SSN)

The Social Safety Net (SSN) is a crucial resource for the poor (WFP, 2016), providing access to assistance from both formal and informal sources (Ciani & Romano, 2014; Guyu & Muluneh, 2015). It is often the last resort for those facing food insecurity. Ten variables were used for the index determination (Table 2), with insignificant variables dropped out. Variables in dummy and categorical forms were converted into standard forms using optimal scaling for easier principal component analysis.

The data set meets the KMO and Bartlett's tests for sampling adequacy and Sphericity (Table 3), and the index for the Social Safety Net variable is estimated as follows:

SSN = (0.1678factor1 + 0.1589factor2 + 0.1177factor3 + 0.1065factor4) ... Equ(5)

The PCA approach identified four latent variables (factors 1, 2, 3, and 4) that accounted for 55.09% of the variance in the estimation of the latent variable SSN.

The study uses factor rotation to identify important variables, retaining loading values larger than 0.4 (James, 2002). Most variables are positively correlated with the Social Safety Net (SSN), except for community supportiveness and lending (Table 2). Support from safety nets and other organizations are more crucial than other forms in determining Factor 1. Membership in religious associations, social support from neighbors, and support from nongovernmental organizations are important variables.

Table 2. Principal Component factor loadings of Social Safety Nets (SSN)

Variables	Components			
	Comp1	Comp2	Comp3	Comp 4
Supportiveness of people	-0.4812			
Safety net Gov't	0.5567			
Other supports NGO	0.6202			
No. Close friends		0.5828		
Neighbors to feed children		0.5758		
Edir membership			0.6175	
Church membership			0.7501	
No. individuals lend 100 birr				-0.5999
Supportive neighbor				0.6892
Eigenvalues	1.67755	1.58876	1.17745	1.06496
Variances	0.1678	0.1589	0.1177	0.1065
Cumulative variance	0.1678	0.3266	0.4444	0.5509

Variance (%) =55.09%

KMO test of sampling adequacy=0.554

Bartlett's test of Sphericity is significant at p=0.0001; chi-square=194.638

Degree of freedom=45

Extraction method: Principal Component Analysis

Source: Own survey, 2022

3.2.3. Access to Agricultural Assets (AA)

Access to agricultural assets (AA), including land, livestock, and labor, is crucial for rural households to diversify income sources, withstand food shortages, and build resilience to food insecurity. This study estimated the index for AA using eight (8) observable variables. As shown in Table 3, the principal component analysis (PCA) test results show good suitability, with three factors retained defining 66.18% of the variation in the AA index, based on the KMO criterion of eigenvalues greater than 1 (Field, 2005).

Landholding, Tropical Livestock Units (TLU), and productive labor sizes correlated with Factor 1. Factor 2 was determined by cash income from crop harvest, matured Eucalyptus trees, and fruit harvest. Factor 3 was influenced by mature Enset crops ready to harvest and their expected years of feeding (James, 2002). Mature Enset, expected fruit harvest, and productive family labor are the most crucial agricultural assets for household resilience to food insecurity. The AA index is defined as:

AGRI = 0.2446factor1 + 0.2158factor2 + 0.1547*factor3 ... Equ(6)

Table 3. Principal Component factor loadings for Access to Agricultural Asset

Variables	Comp1	Comp2	Comp3
Land holding size in hectare	0.5224		
Livestock holding in TLU	0.5283		
Number of matured Enset			0.7519
Number of Years to feed the family			0.5520
Expected crop harvest in ETB		0.5149	
Monetary value of mature Eucalyptus tree		0.4627	
Mature fruit ready for harvest in ETB		0.6473	
Productive family labour (>15 and <65)	0.5974		
Eigenvalues	2.62675	1.2579	1.03642
Variances	0.3283	0.1572	0.1296
Cumulative variance	0.3283	0.4855	0.6151
Variance (%) =61.51%			
KMO test of sampling adequacy=0.728			
Bartlett's test of Sphericity is significant at p=0.0001; chi-square=423.813			
Det =0.242			
Degree of freedom=28			
Extraction method: Principal Component Analysis			

Source: Own survey, 2022

3.2.4. Agricultural Input and Technology Adoption (AITA)

Applying improved agricultural methods and technologies to rural household farms is critical to increasing agricultural productivity, thereby fulfilling the food shortfall and improving household resilience to food insecurity in a growing population and dwindling land yield (Adane, 2018). For this purpose, the AITA index is estimated using five (5) agricultural technology-related variables (Table 4). The PCA model's compatibility test yielded positive results, with three factors retained explaining 89.53% of the variance in the AITA index determination.

The PCA analysis revealed that all variables have a positive correlation with the AITA index. Access to farmer trainings, development agent (DA) contacts, and veterinary services positively correlated with Factor 1. The use of improved seeds and pesticides influenced Factor 2, while access to chemical fertilizer and herbicides determined Factor 3. The study highlights improved seed access and chemical fertilizer use as crucial agricultural technologies, with higher factor loading values determining the AITA latent variable index. The survey results are consistent with the information gathered from Key Informant Interviews (KII), Focus Group Discussions (FGD), and researcher field observations. The latent variable index for AITA is determined using the following method:

AGRTECHAI = 0.2964factor1 + 0.1786factor2 + 0.1721*factor3 ... Equ(7)

Table 4. Principal Component factor lodging for Agricultural Technology Adoption (ATA)

Variables	Comp1	Comp2	Comp3
FTC service	0.5889		
DA contact	0.5316		
Veterinary services	0.5944		
Improved seed use		0.8215	
Pesticide use		0.4314	
Chemical fertilizer use			0.7112
Herbicides			0.6907
Eigenvalues	2.26868	1.20849	1.05298
Variances	0.3241	0.1726	0.1504
Cumulative variance	0.3241	0.4967	0.6472

Variance (%) =64.72%

KMO test of sampling adequacy=0.692

Bartlett's test of Sphericity is significant at p=0.0001; chi-square=461.133

Degree of freedom=21

Factor Extraction method: Principal Component Analysis

Source: Own survey, 2022

3.2.5. Non-agricultural or Physical Assets (NAA)

In rural areas, ownership of non-agricultural assets is a sign of wealth status (Dhraief *et al.*, 2019) and an important source of livelihood risk management. Based on the literature and the researcher's experience, 11 variables were used, all measured in the current economic value in Ethiopian Birr (ETB), which are suitable for principal component analysis (Table 5).

The PCA analysis retained four components, explaining 57.52% of the variance in the NAA latent variable index (Field, 2005; Kaiser, 1964).

The NAA index is calculated as follows;

NNAi = 0.2516*Factor 1 + 0.1166*Factor 2 + 0.1041*Factor 3 + 0.1029*Factor 4 ....Equ (8)

Table 5. Component loadings of variables to estimate (NNA) component of resilience

Variables	Component			
	Comp1	Comp 2	Comp3	Comp4
Bed	0.4866			
Stove owned	0.4193			-0.4591
Jewelry		0.6934		
Watch		0.6790		
Mobile phone			0.5498	
Bicycle			0.7119	
Radio				0.8121
Eigenvalues	2.86857	1.28787	1.11104	1.06
Variances	0.2608	0.1171	0.1010	0.0964
Cumulative variance	0.2608	0.3779	0.4789	0.5752

Variance (%) =57.52%

KMO test of sampling adequacy=0.696

Bartlett's test of Sphericity is significant at p=0.0001; chi-square=513.121

Determinant of the correlation matrix Det = 0.178

Degree of freedom=55

Extraction method: Principal Component Analysis

Source: Own computation from survey, 2022

3.2.6. Adaptive Capacity (AC)

Adaptive capacity is a crucial aspect of household resilience, allowing households to absorb, adapt, or react to shocks (Alinovi *et al*., 2009; Alinovi *et al*., 2010). The literature treats adaptive capacity differently from resilience analysis, with some treating it as a separate component (Walker *et al*., 2004) and others as part of resilience analysis (Pisano, 2012; Frankenberger *et al*., 2014; Abebe, 2018; Debessa, 2018). This study treats adaptive capacity as a determinant component for household resilience to food insecurity, following previous works (Alinovi *et al*., 2009; Alinovi *et al*., 2010; Guyu & Muluneh, 2015; Debessa, 2018).

For ease of PCA analysis, optimal scaling (mean = 0 and variance = 1) was carried out for dummy and categorical variables. Statistical requirements were checked and found suitable, and seven components were retained that explain 58.81% of the variance in adaptive capacity (AC) determination using PCA analysis (Table 6).

Except for the number of ill members in the household, the study found that household adaptive ability, particularly reading and writing capacity, spiritual education, and monetary deposits, have positive and higher correlations with the AC index, implying greater resilience to food insecurity.

AC = 0.0931factor1 + 0.0888factor2 + 0.0884factor3 + 0.0877factor4 + 0.0847factor5 + 0.0777factor6 + 0.0676*factor7 ... Equ(9)

Table 6. Component loadings of variables to estimate Adaptive Capacity

Variables	Component						
	Comp 1	Comp 2	Comp 3	Comp 4	Comp 5	Comp 6	Comp 7
HH ability to read/write	0.7090						
HH Years of schooling	0.6010						
Ill members		-0.5079					
Number of disable		0.5780					
Income sources			0.4907				
Agri income source			0.5110				
Number of crops grown			0.5162				
Single and Earning				0.5426			
Salary/wage				0.6075			
Spiritual education attn.					0.6776		
Transfers					0.4479		
Family business						0.6332	
Cash deposit							0.6460
Eigenvalues	2.82781	1.82181	1.57836	1.43022	1.34778	1.11136	1.05599
Variances	0.0931	0.0888	0.0884	0.0877	0.0847	0.0777	0.0676
Cumulative variance	0.1488	0.2447	0.3278	0.4031	0.4740	0.5325	0.5881

Variance (%) =58.81%

KMO test of sampling adequacy=0.604

Bartlett's test of Sphericity is significant at p=0.0001; chi-square=866.269

Degree of freedom=171

Extraction method: Principal Component Analysis

Source: Own survey, 2022

3.2.7. Access to Basic Services (ABS)

Access to basic services (ABS) or public services delivered by national governments and supporting organizations enhances households' resilience to external shocks by providing in-kind and in-service supports, improving their overall quality of life (Alinovi *et al.*, 2010). Dummy and categorical variables were changed to continuous form using optimal scaling for the convenience of PCA analysis. Four components were retained, explaining 68.18% of the variance in the ABS index estimation (Table 7).

ABSI = 0.1609factor1 + 0.1168factor2 + 0.1163factor3 + 0.1097factor4 + 0.0960*factor5 ... Equ(10)

The study reveals that access to primary and secondary schools is highly correlated with Factor 1. Attaining preparatory school and mobile access have negative and positive correlations with Factor 2, respectively. The correlation of access to the main road and microfinance services with Component 3 is highly positive, indicating a strong connection between these variables. Access to domestic water and markets has a positive correlation with Component 4. Component 5 is determined by the positive correlation between 'Access to Electricity' and 'Access to Potable Water'. The most crucial public services in the area are access to electricity, domestic water, and secondary school, as determined by the factor loadings (Table 7).

Table 7. Component loadings of variables to estimate (ABS) component of resilience

Variables	Comp1	Comp2	Comp3	Comp4	Comp5
Primary school	0.6530				
Secondary school	0.6602				
preparatory school		-0.5761			
Access to mobile phone		0.5869			
Access to main road			0.5149		
Access to microfinance			0.5858		
Access to water for domestic use				0.7479	
Access to market				0.4560	
Access to Electricity					0.8349
Access to potable water					0.4377
Eigenvalues	1.93116	1.40125	1.39586	1.31583	1.1524
Variances	0.1609	0.1168	0.1163	0.1097	0.0960
Cumulative variance	0.1609	0.2777	0.3940	0.5037	0.5997

Variance (%) =59.97%

KMO test of sampling adequacy=0.6240

Bartlett's test of Sphericity is significant at p=0.0001; chi-square=523.174

Det =0.171

Degree of freedom=66

Extraction method: Principal Component Analysis: Principal Component Analysis

Source: Own survey, 2022

3.2.8. Stability

Stability, a cross-sectional dimension of resilience to food insecurity, refers to the stability of the food supply and socio-economic factors in the face of different adverse external shocks and stresses (Alinovi *et al*., 2010). Following similar previous studies and taking into account the particular study area context, this study has used human health issues like the frequency of visits to clinics due to illness, death of a family member, climatic shocks like drought, high rainfall, death of livestock, crop failure due to disease and pest, and socio-economic changes such as food item price inflation and the perceived capacity of the household head to maintain the current level of consumption if a drought occurs in the coming production season. Some variables in dummy and categorical forms were transformed into continuous forms using optimal scaling (mean = 0 and variance = 1). PCA analysis showed the compatibility of the data set (Table 8), with three components retained, explaining 69.15% of the variance in stability (S) estimation.

All variables except family member illness were significant, i.e., the absolute value of loadings was greater than 0.4 (Stevens, 2002), affecting household resilience capacity negatively. However, as expected, the capacity to maintain the current food consumption if a drought occurs is negatively correlated with the S latent variable, indicating a potential drought-related impact.

Stability Index= 0.3922*Factor1 + 0.1683*Factor2 + 0.1309*Factor3 .... Equ(11)

The results showed that Factor 1 was positively correlated with drought, heavy rainfall, and crop loss caused by drought; Factor 2 was positively correlated with family members and livestock deaths; and Factor 3 was positively correlated with the effect of rising commodity prices and negatively correlated with households' ability to continue their current level of consumption into the future. Depending on the degree of factor loading of variables, rising food prices and animal deaths are important stability factors or shocks to families.

Table 8. Component loadings of variables to estimate stability (S) component

Variables	Comp1	Comp2	Comp3
Drought	0.5401		
High rainfall	0.5388		
Crop failure due to drought	0.5424		
Family member death		0.5793	
Livestock death		0.7483	
Food item price rise			0.7599
Able to keep current food consumption?			-4602
Eigenvalues	3.1377	1.34678	1.04759
Variances	0.3922	0.1683	0.1309
Cumulative variance	0.3922	0.5606	0.6915

Variance (%) =69.15%

KMO test of sampling adequacy=0.762

Det = 0.093

Bartlett's test of Sphericity is significant at p=0.0001; chi-square=791.088

Degree of freedom=28

Extraction method: Principal Component Analysis

Source: Own survey, 2022

3.3 Household Resilience to Food Insecurity

Two steps were involved in determining household resilience: first, indices for each of the eight constituent pillars (IFA, SSN, AA, AITA, NAA, AC, ABS, and S) were computed; second, the household resilience index was determined by using the pillars that were defined in the first stage as covariates in PCA analysis.

RI = 0.2712Factor1 + 0.1565Factor2 + 0.1423*Factor3 ... Equ(12)

Field's PCA data compatibility recommendation yielded promising results (Field, 2005) (Table 9), with six out of eight variables significantly contributing to three retained components with loading values greater than 0.4 (Stevens, 2002). However, households' access to Agricultural Technology Innovation and Adaptive Capacity showed weak access and need for strengthening.

The factor loadings can be utilized as a correlation coefficient or a regression coefficient, which analyzes PCA assumptions using orthogonal rotation (Field, 2005). The PCA result showed that access to AA, IFA, and NAA are positively correlated with Factor 1; access to SSN positively determined Factor 2; ABS and S positively and negatively correlated with or determined Factor 3, respectively. As in other studies by Adane (2018), Alinovi *et al.* (2009), Alinovi *et al.* (2010), Beyene (2016), and Debebe (2021), the size of the beta coefficient is used to establish the relative importance of pillars to household resilience to food insecurity. In this regard, access to SSN (0.8283), ABS (0.7808), and NAA (0.5523) is the factor that contributes most strongly to household resilience to food insecurity in the study area, according to the size of the beta coefficient of loadings. The KII and FGD results also support the quantitative result with informal social support systems in the case of social, economic, or environmental shock responses.

Table 9. Component Loadings of Variables to Estimate Household Resilience (RCI)

Variables	Comp1	Comp2	Comp3
Agricultural Assets	0.4542		
Access to Non-agricultural Assets	0.5523		
Income and Food Access	0.4631		
Social Safety Nets		0.8283	
Access to Basic Services			0.7808
Stability			-0.5301
Eigenvalues	2.16977	1.25211	1.1386
Variances	0.2712	0.1565	0.1423
Cumulative variance	0.2712	0.4277	0.5701

Variance (%) =57.01%

KMO test of sampling adequacy=0.691

Bartlett's test of Sphericity is significant at p=0.0001; chi-square=295.986, Det. R-Matrix=0.371

Degree of freedom=28

Extraction method: Principal Component Analysis

Source: Own survey, 2022

The findings of the PCA analysis finally categorized households into different resilience levels. The study found that 179 (59.06%) of the respondents were non-resilient, and 124 (40.94%) were resilient at different levels, with an average resilience score of -3.30033E-10, indicating a non-resilient mean resilience score (Table 10).

Table 10. Level of Household Resilience to Food Insecurity

Resilience index	Resilience status				
	Non-resilient (RI≤0.00)	Moderately resilient (0.00<RI≤0.50)	Resilient (0.50<RI≤1.00)	Highly resilient (RI≥1.00)	Total
No. respondents	179	76	33	15	303
Percent	59.74%	24.42%	10.89%	4.95%	100
Minimum	-1.1014280	0.0147597	0.5030434	1.0250580	-59.9659144
Maximum	-0.0000952	0.4913051	0.9766411	1.8484960	18.1485606
Mean	-0.335005108	0.238796850	0.675617052	1.301466067	22.2953627
Std. Dev.	0.2374532536	0.1506310020	0.1295782057	0.2240763545	19.5219910

Source: Own survey, 2022

4 Conclusion and Recommendation

The study highlights food insecurity in a district as a significant development challenge due to livelihood shock and stress factors such as small landholding size, food item price rise, drought, family illness, crop pests, and disease. It examined household resilience and threatening shocks using one-time cross-sectional data; however, it lacks consideration of temporal and geographical dynamics. It provides insights for policymakers to plan and implement lasting development policies in changing socio-economic conditions.

The study reveals that social safety net, basic services, and non-agricultural assets are key factors in enhancing household resilience to food insecurity, while agricultural technology and adaptive capacity are less influential. Finally, the PCA shows that most households (59.76%) were non-resilient to food insecurity shocks.

The study highlights areas for enhancing households' resilience to food insecurity in the district and proposes the following policy suggestions for long-term strategies to address these challenges:

- Resilience studies reveal access to social safety nets, basic services, and non-agricultural assets as key resilience sources. Strengthening non-agricultural asset ownership and refining policies to expand social safety net and basic services can enhance household resilience against food insecurity.
- Household resilience is largely influenced by their adaptability and access to agricultural technology, however found to be the least contributed factor in the study. A well-designed agricultural extension program can enhance resilience by focusing on education, income generation, health services, and social and technical skills for responding to environmental and socio-economic changes.
- The FGD, KII, and PCA results highlight the issue of fragmented landholding and restricted agricultural ownership due to population pressure, leading to food production shortfalls. It suggests that policymakers should increase off-farm activities for young people and households with working age, and explore small-farmland-based agricultural techniques as a solution for food insecurity.

Conflict of interest: The authors declare that they have no conflict of interest.

References

Abebe, G. (2018). Household food insecurity in the Sidama Zone of Southern Ethiopia. Factors, coping and adaptation strategies.

Abera, U. (2014). Interface between Indigenous Agricultural Knowledge and Modern Agricultural Technologies and Their Impacts on Food Security in Gamo Highlands, South West Ethiopia. Unpublished PhD Dissertation, University of South Africa.

Abi, M., & Tolossa, D. (2015). Household food security status and its determinants in girar jarso woreda, north Shewa zone of oromia region, Ethiopia. *Journal of Sustainable Development in Africa*, 17(7), 118-137.

Adane Atara, D. T. B. D. (2018). Rural Households' Resilience to Food Insecurity in Southern Ethiopia: The Case of Boricha Woreda in Sidama Zone.

Alinovi, L., D'errico, M., Mane, E., & Romano, D. (2010). Livelihoods strategies and household resilience to food insecurity: An empirical analysis to Kenya. *European report on development*, 1(1), 1-52.

Alinovi, L., Mane, E., & Romano, D. (2009). Measuring household resilience to food insecurity: Application to Palestinian households. *Agricultural survey methods*, 341-368.

Anantharam, P., Emerson, L. E., Bilcha, K. D., Fairley, J. K., & Tesfaye, A. B. (2021). Undernutrition, food insecurity, and leprosy in North Gondar Zone, Ethiopia: A case-control study to identify infection risk factors associated with poverty. *PLoS Neglected Tropical Diseases*, 15(6), e0009456.

Assefa, E. (2012). Landscape dynamics and sustainable land management in southern Ethiopia. Christian-Albrechts Universität Kiel.

Ayele, T. (2020). A Review of the Trends and Causes of Food Insecurity in Ethiopia. *Food Science and Quality Management*, 99, 7–12. https://doi.org/10.7176/fsqm/99-02

Bahadur, A. V., Peters, K., Wilkinson, E., Pichon, F., Gray, K., & Tanner, T. (2015). The 3As: tracking resilience across BRACED. Working and discussion papers.

Baptista, D. M. S., Farid, M. M., Fayad, D., Kemoe, L., Lanci, L. S., Mitra, M. P., Muehlschlegel, T. S., Okou, C., Spray, J. A., & Tuitoek, K. (2022). Climate change and chronic food insecurity in sub-Saharan Africa. International Monetary Fund.

Bartlett, M. S. (1937). Properties of sufficiency and statistical tests. Proceedings of the Royal Society of London. Series A-Mathematical and Physical Sciences, 160(901), 268-282.

Bekele, S. (2017). Potato value chain analysis: The case of chencha woreda, gamo gofa zone, southern Ethiopia. Dev. Ctry. Stud., 7(4), 38-50.

Béné, C., Frankenberger, T., Griffin, T., Langworthy, M., Mueller, M., & Martin, S. (2019). 'Perception matters': New insights into the subjective dimension of resilience in the context of humanitarian and food security crises. *Progress in Development Studies*, 19(3), 186-210.

Beyene, F. (2016). Analysis of rural household resilience to food insecurity: the case of Damot Pulasa district, Wolaita zone, Southern Ethiopia, Wolaita Sodo University.

Beyene, F., Senapathy, M., Bojago, E., & Tadiwos, T. (2023). Rural household resilience to food insecurity and its determinants: Damot Pulasa district, Southern Ethiopia. *Journal of Agriculture and Food Research*, 11, 100500.

Beyene, G. B. (2001). Problems and Challenges of Agricultural Extension in Chencha Woreda (District), Gamo Gofa Zone, South Ethiopiaa.

Bisi-Amosun, O. O. (2019). The Sociocultural Dynamics of Food (In) security Among Farming Households in Oyo State, Nigeria Purdue University.

Boliko, M. C. (2019). FAO and the situation of food security and nutrition in the world. *Journal of nutritional science and vitaminology*, 65(Supplement), S4-S8.

Camire, M. E. (2021). Food Insecurity. *Handbook of Rural Aging, February*, 170–175. https://doi.org/10.4324/9781003128267-31

Caroline, D., & Kristina, T. (2022). Food security in conflict and Peacebuilding settings: Beyond a humanitarian concern. *Cyberleninka*(2(63)), 38-61.

Carter, M. R., Little, P. D., Mogues, T., & Negatu, W. (2006). Shocks, sensitivity and resilience: Tracking the economic impacts of environmental disaster on assets in Ethiopia and Honduras.

Cheber, D. (2021a). Farm households' vulnerability and resilience to food insecurity in the face of climate variability: evidence from north shewa zone, amhara region, ethiopia.

Cheber, D. (2021b). Farm households'vulnerability and resilience to food insecurity in the face of climate variability: evidence from north shewa zone, Amhara Region, Ethiopia Haramaya university.

Cheber, D., Beyene, F., Haji, J., & Lemma, T. (2021). Analysis of Households Food Insecurity in the Face of Climate Variability: Evidence from North Shewa Zone, Amhara Region, Ethiopia. *Sustainable Agriculture Research*, 9(4), 1-43.

Ciani, F., & Romano, D. (2014). Testing for household resilience to food insecurity: Evidence from Nicaragua.

Constas, M., & Barrett, C. B. (2013). Principles of resilience measurement for food insecurity: metrics, mechanisms, and implementation plans. Expert Consultation on Resilience Measurement Related to Food Security, Food and Agricultural Organization and World Food Program, Rome, Italy.

Constas, M., Frankenberger, T., & Hoddinott, J. (2014). Resilience measurement principles: Toward an agenda for measurement design. Food Security Information Network, Resilience Measurement Technical Working Group, Technical Series, 1.

CSA. (2011). Population size of Regions, zones and woredas in 2011.

CWARDO. (2014). Chencha woreda Food Security and Early Warning food security profiles. In.

Debessa, A. A. (2018). Rural Households' Resilience to Food Insecurity in Southern Ethiopia: The Case of Boricha Woreda in Sidama Zone.

Degaga, D. T. (2005). Rural livelihoods, poverty and food insecurity in Ethiopia: a case study at Erenssa and Garbi communities in Oromiya Zone, Amhara National Regional State. (No Title).

Demekea, M., & Teferab, N. (2011). Rural Household Resilience to Food Insecurity in Ethiopia:

Panel Data Evidence. Essays on Welfare, Demand and Resilience to Food Insecurity in Rural Ethiopia, 98.

Desalegn, R. (1996). Resilience and vulnerability: Enset agriculture in Southern Ethiopia. Enset based sustainable agriculture in Ethiopia, 83-106.

Devereux, S. (2000). Famine in the twentieth century.

Dhraief, M. Z., Dhehibi, B., Daly Hassen, H., Zlaoui, M., Khatoui, C., Jemni, S., Jebali, O., & Rekik, M. (2019). Livelihoods strategies and household resilience to food insecurity: A case study from rural Tunisia. *Sustainability*, 11(3), 907.

Diamond, L., & Morlino, L. (2004). The quality of democracy: An overview. Journal of democracy, 15(4), 20-31.

El Bilali, H., Callenius, C., Strassner, C., & Probst, L. (2019). Food and nutrition security and sustainability transitions in food systems. *Food and energy security*, 8(2), e00154.

Eshetu, F., & Mekonnen, E. (2016). Determinants of off farm income diversification and its effect on rural household poverty in Gamo Gofa Zone, Southern Ethiopia. *Journal of Development and Agricultural Economics*, 8(10), 215-227.

Fan, S., Pandya-Lorch, R., & Yosef, S. (2014). Resilience for food and nutrition security. IFPRI, Washington DC, USA.

FAO. (1996). <Food Security Introduction.pdf>.

FAO (2010). The state of food insecurity in the world 2010: addressing food insecurity in protracted crises. Food and Agriculture Organization of the United Nations, Rome, Italy, ISBN-13: 9789251066102, Pages: 57.

FAO (2014). Resilience index measurement and analysis (RIMA) model

Field, A. (2005). Discovering statistics using SPSS: and sex and drugs and rock 'n' roll (2^{nd} Edition).

Folke, C. (2006). Resilience: The emergence of a perspective for social–ecological systems analyses. *Global environmental change*, 16(3), 253-267.

Frankenberger, T. R., Constas, M. A., Nelson, S., & Starr, L. (2014). How NGOs approach resilience programming. *Resilience for food and nutrition security*, 177.

Girmay, g. (2019). Resilience of rural households to food insecurity in Ahferom wereda, central zone of Tigray national regional state, Ethiopia.

Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. Handbook of qualitative research, 2(163-194), 105.

Guyu, D. F., & Muluneh, W.-T. (2015). Wild foods (plants and animals) in the green famine belt of Ethiopia: Do they contribute to household resilience to seasonal food insecurity? *Forest ecosystems*, 2, 1-12.

Guyu, F., & Muluneh, W.-T. (2015). Wild foods (plants and animals) in the green famine belt of Ethiopia: Do they contribute to household resilience to seasonal food insecurity? *Forest ecosystems*, 2, 1-12.

Haan N., Majid N., and Darcy J. (2006). A review of emergency food security assessment practice in Ethiopia: A study commissioned by and prepared for World Food Program, Rome May. 2006

Hassen, A. (2019). Soil conservation PRACTICES and its contribution to food security in Chencha woreda, Southern Ethiopia. Thesis.

Holling, C. S. (1973). Resilience and stability of ecological systems. *Annual review of ecology and systematics*, 4(1), 1-23.

James, S. (2002). Applied multivariate statistics for the social sciences. Mahwah, NJ: Lawrence Erlbaum Associates., Vol. 4.

Kaiser, H. F. (1964). A method for determining eigenvalues. *Journal of the Society for Industrial and Applied Mathematics*, 12(1), 238-248.

Keil, A., Zeller, M., Wida, A., Sanim, B., & Birner, R. (2008). What determines farmers' resilience towards ENSO-related drought? An empirical assessment in Central Sulawesi, Indonesia. *Climatic Change*, 86, 291-307.

L. Alinovi, E. M. D. R. (2009). Measuring household resilience to food insecurity: application to Palestinian households.

Lovendal, C. R., Knowles, M., & Horii, N. (2004). Understanding vulnerability to food insecurity: Lessons from vulnerable livelihood profiling.

Maxwell, D., Vaitla, B., Tesfay, G., & Abadi, N. (2013). Resilience, Food Security Dynamics and Poverty Traps in Northern Ethiopia. Analysis of a Biannual Panel Data Set, 2011–2013. *Feinstein International Center, Friedman School of Nutrition Science and Policy at Tufts University, Boston*.

MoARD. (2009). Food Security Programme 2010-2014.

Mulat Demeke and Nigussie Tefera (2013). Sustainable resilience for food and nutrition security: The case of farming rural households in Ethiopia.

Mulugeta, M. (2009). Causes of rural household food insecurity: a case from Kuyu District, Central Ethiopia. *Journal of Sustainable Development in Africa*, 11(4), 286–304.

Mulugeta Tefera (2014). Resilience to drought induced food insecurity shocks: The case of Borena pastoral communities in Dire and Yabello Districts, oromia, Ethiopia. A thesis submitted to the Center for Food Security Studies College of Development Studies.

Mwanki A. (2005). Achieving Food Security in Africa - Challenges and Issues. Cornell University. USA.

Negussie, M. a. (2010). Household Resilience to Food Insecurity in Ethiopia: Panel Data Evidence.

Niemistö, N. (2011). The resilience of rural Ethiopian livelihoods: a case study from Hararghe zone, Eastern Ethiopia

OCHA (2023). Ethiopian Food Security Status. 2023–2024.

Pisano, U. (2012). Resilience and Sustainable Development: Theory of resilience, systems thinking. *European sustainable development network* (ESDN), 26, 50.

Robson, C. (2002). Real World Research (2^{nd} edn). Oxford: Blackwell.

Saunders, M., Lewis, P., & Thornhill, A. (2003). Research methods forbusiness students. *Essex: Prentice Hall: Financial Times.*

Tadesse, Y., Almekinders, C. J. M., Schulte, R. P. O., & Struik, P. C. (2021). Potatoes and livelihoods in Chencha, southern Ethiopia. NJAS: Wageningen Journal of Life Sciences, 88(1), 105-111. https://doi.org/10.1016/j.njas.2018.05.005

Tashakkori, A., & Teddlie, C. (1998). *Mixed methodology: Combining qualitative and quantitative approaches* (Vol. 46). sage.

Tefera, N., & Kayitakire, F. (2015). Alternative approaches to Measuring Resilience for Food and Nutrition Security.

Tolossa, M. A. D. (2015). Household food security status and its determinants in Girar Jarso woreda, North Shewa Zone Of Oromia Region, Ethiopia. *Journal of Sustainable Development in Africa*, 17(7), 20.

Schipper, E. L. F., & Langston, L. (2015). A comparative overview of resilience measurement frameworks approaches. July.

United Nations Framework Convention on CC (2006). Background paper on impacts, vulnerability and adaptation to CC in Africa. *African Workshop on Adaptation Implementation of Decision 1/CP.10 of the UNFCCC Convention*, Accra, 21-23 September 2006.

Utallo, A. U., Shano, T. S., & Degaga, D. T. (2019). The effect of production decline of Qoltso on food security in Gamo Highlands, South-west Ethiopia. *GeoJournal,* 86(2), 635-647. https://doi.org/10.1007/s10708-019-10087-1

Vaitla, B., Tesfay, G., Rounseville, M., & Maxwell, D. (2012). Resilience and livelihoods change in Tigray, Ethiopia. Somerville, MA: Tufts University, Feinstein International Center.

Walker, B., Holling, C. S., Carpenter, S. R., & Kinzig, A. (2004). Resilience, adaptability and transformability in social–ecological systems. *Ecology and society*, 9(2).

WFP, F. (2022). Resilience Measurement and Analysis: Round 1. 1-57.

WFP. (2016). World Food Program and Urban Safety Nets Maximizing Food Security and Nutrition. .

Winderl, T. (2014). Disaster resilience measurements: stocktaking of ongoing efforts in developing systems for measuring resilience.

Woldetsadik, s. (2015). Analysis of the impact of climate change on smallholder farmers agricultural production: the case of Maokomo special woreda of Benishangul Gumuz region, North Western Ethiopia St. Mary's university].

Workneh Negate (2008). Food Security Strategy and Productive Safety Net Program in Ethiopia. In Digest of Ethiopia's National Policies, Strategies, and Programs, ed. Taye Assefa. Forum for Social Studies.

Yamane Taro. 1967. Statistics an introductory Analysis, second edition, New York: Harper and Row.

Zereyesus, Y. A., Cardell, L., Valdes, C., Ajewole, K., Zeng, W., Beckman, J., Ivanic, M., Hashad, R. N., Jelliffe, J., & Kee, J. (2022). *International Food Security Assessment*, 2022–32.

Zerihun, S., Mulugeta, M., & Abi, M. (2024). Rural household resilience to food insecurity in Majang Zone, Southwestern Ethiopia. *F1000Research*, 13, 162. https://doi.org/10.12688/f1000research.142289.1

EJED 2024 6(2):49–58
Ethiopian Journal of Environment and Development
http://www.du.edu.et/duj

Contribution of Homegarden Agroforestry to Household Income Generation and Woody Plant Species Diversity in Lay Armachiho District, Northern Ethiopia

Habtamu Getahun [1*] **and Eshetu Yirsaw** [1]

Department of Natural Resources Management,
College of Agriculture and Natural Resources, Dilla 419, Ethiopia.
**Corresponding author; Email: eshetu.yirsaw@yahoo.com*

Received: 07th August 2024 *Accepted: 10th December 2024*

Article DOI: **10.20372/ejed.v06i2.04**

Abstract

Homegarden agroforestry (HGAF) is a complex, multifunctional, and sustainable land use system that integrates various farming components to provide economic, social, and environmental services. This study aims to assess the role of HGAF in household income generation and woody plant species diversity in the Lay Armacho district of Northern Ethiopia. Multistage sampling techniques were employed for household sampling, using both quantitative and qualitative approaches for data collection. Quantitative data were gathered from a sample of 315 farmers through structured and semi-structured questionnaires. Qualitative data were collected via focus group discussions (FGDs) and key informant interviews (KIIs). The quantitative data were analyzed using descriptive statistics and one-way analysis of variance (ANOVA). For assessing plant species diversity, each homegarden was divided into one or more 10 x 10 m plots based on size, and a plot was randomly selected for analysis. The results indicate a highly significant difference in annual income generation between HGAF adopters and non-adopters, with adopters generating an average of 24,276.85 ± 20,059.60 Ethiopian Birr, compared to 11,379.96 ± 5,873.46 Birr for non-adopters. In terms of woody plant species diversity, HGAF in the study area exhibited a diversified and evenly distributed array of species, comprising a total of 52 woody plant species belonging to 30 families. Thus, practicing homegarden agroforestry holds significant value for both income generation and woody plant species diversity in the study area. To fully realize these benefits, it is recommended that all farmers in the region adopt homegarden agroforestry practices.

Keywords/Phrases: Homegarden agroforestry, Household income, Woody Plant species diversity, Ethiopia

1 Introduction

Homegarden agroforestry (HGAF) is a complex, multifunctional, and sustainable land use system practiced around residences that integrates multiple farming components (Nzilano, 2013; Weerahewa *et al*., 2012). It serves as a small-scale food production and storage system operated by and for household members, mimicking a natural multilayered ecosystem (Mitchell & Hanstad, 2004; Mohri *et al*., 2013). Unlike monocropping agricultural systems, HGAF is characterized by a highly diversified range of cultivated plant species, a multi-storied vegetation structure, a high rate of nutrient cycling, and the maintenance of in situ soil fertility (Kang & Akinnifesi, 2000).

Despite its importance, HGAF is often overlooked as a source of food security and income generation worldwide (Nzilano, 2013). While primarily utilized to provide supplemental food and cash, HGAF can also serve as a habitat for diverse plant species and help conserve natural forests by alleviating pressure on local ecosystems. It provides food, timber, fuel wood, fodder, and medicinal plants (Kumar, 2015). Consequently, it holds significant value for household income generation (Atiso & Fanjana, 2020; Guuroh *et al*., 2012), food security (Sharma *et al*., 2022), medicinal uses (Kumar & Tiwari, 2017), ornamental purposes, and other non-food livelihood needs of the poor (Maroyi, 2009; Regassa, 2016).

Despite these benefits, research on the contribution of HGAF to household income and woody species diversity remains limited in certain regions of Ethiopia (Beyene *et al*., 2018; Mekonnen *et al*., 2014), including the current study area (LAWAO, 2022). Therefore, this study aims to investigate the role of homegarden agroforestry in household income generation and woody plant species diversity in the study area.

2 Materials and Methods

2.1 Description of the Study Area

The study was conducted in the Lay Armachiho district, located approximately 771 km from Addis Ababa and 23 km from Gondar town. Lay Armachiho is one of the woredas in the Amhara regional state, within the Central Gondar zone. It is situated between latitudes 12*o*33'0"N and 12*o*54'0"N and longitudes 37*o*15'0"E and 37*o*31'30"E (Figure 1).

Agroecologically, the district is classified as Kola, Woyna Dega, and Dega, receiving an average rainfall of 1,300 to 1,500 mm. The minimum and maximum annual average temperatures are 18°C and 27*o*C, respectively. The topography of the study area features hills, plains, mountains, and valleys, with an average elevation ranging from 1,600 to 2,700 meters above sea level. The predominant land use types in the area include cultivated (arable) land, agroforestry, grazing, and forest cover (LAWAO, 2022). The study focused on three kebeles: Addisgie, Jiha, and Shumara Lomye.

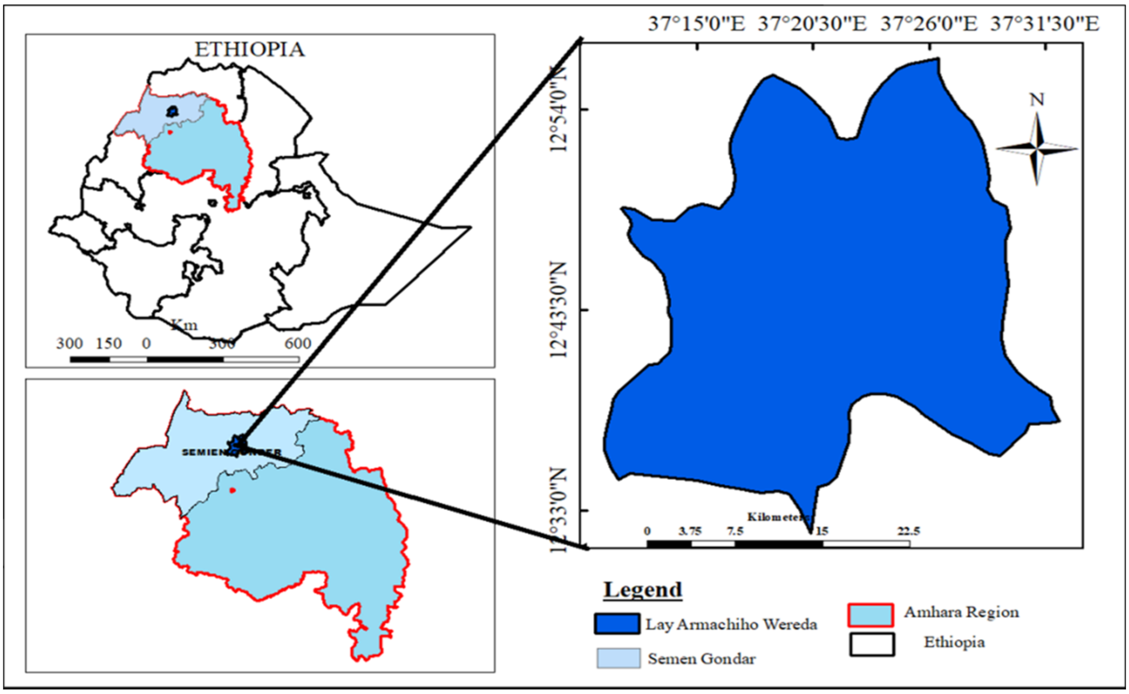

Figure 1. Map of the study area

2.2 Research Methods

2.2.1 Household Sampling Technique and Sample Size Determination

Multistage sampling techniques were employed in this study. First, the woreda was purposefully selected due to the widespread presence of homegarden agroforestry practices in the area. Next, three kebeles were randomly chosen. Finally, the sample size of households from each kebele was determined using a combination of stratified and random sampling methods, applying a proportional formula to account for the heterogeneous nature of homegarden agroforestry practices.

Stratification was based on whether farmers were practicing homegarden agroforestry or not. Using this approach, the sample size was calculated using Yamane's (1997) formula:

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

Where:
N = the total population
n = the required sample size
e = the precision level which is $\pm$ 5%

Based on this sampling method, 315 households were selected from a total of 1,502 households across the three kebeles. Proportional representation was established for each kebele, resulting in the selection of 118 respondents from Shumara Lomye, 104 from Jiha, and 93 from Addisgie. The proportionality for each kebele was determined using Yamane's (1997) formula:

$$n_i = \frac{N_i x n}{N}$$

Where:
N_i = Total population of each kebele
n_i= required sample size for each kebele

Key informants (KIs) were selected using the snowball method (Bernard, 2017). Initially, five farmers were randomly asked to provide the names of six KIs each. From the thirty candidate KIs mentioned, the top five were selected from each kebele, resulting in a total of 15 KIs for the entire study. Additionally, in each kebele, a focus group was formed consisting of 8 to 10 participants, taking into account socioeconomic factors such as age, education, and gender (Kumar, 2018).

2.2.2 Estimation of Woody Plant Species Diversity

Homegardens were randomly selected from each kebele, focusing on households that extensively practice homegarden agroforestry. All woody plant species were recorded from the three kebeles where agroforestry is practiced. In total, 34 homegardens were selected-12 from Shumara Lomye, 13 from Jiha, and 9 from Addisgie-based on the proportionate number of households practicing homegarden agroforestry.

To assess woody species diversity, each homegarden was divided into several 10 x 10 m plots, from which a plot was randomly selected for analysis (Negash, 2013). Within each selected plot, the diameters at breast height (DBH, 1.3 m) for trees and diameters at stump height (d40 cm) for shrubs were measured. Species identification and data collection were conducted with the help of knowledgeable local elders, agricultural experts, and researchers. For any unidentified species, photographs were taken and specimens preserved for further identification at the national herbarium. Woody species nomenclature was based on "Useful Trees and Shrubs of Ethiopia" (Bekele, 2007) and "Flora of Ethiopia and Eritrea" (Edwards *et al.*, 2000) as references.

2.3 2.2.3 Data Type and Sources

Both primary and secondary data were utilized in this study. Primary data were collected through structured and semi-structured questionnaires, along with field inventories. Secondary data were obtained from woreda and kebele administrations, as well as from published and unpublished documents.

2.2.4 Method of Data Analysis

The data collected through the household survey was analyzed using both qualitative and quantitative methods. Prior to analysis, the quantitative data were coded and entered a computer for processing using MS Excel and SPSS (Statistical Package for Social Sciences, version 25). Descriptive statistics were employed to analyze the data from the sampled households. The qualitative data were narrated and summarized accordingly.

A one-way analysis of variance (ANOVA) and independent t-test were used to compare the income generation contributions of homegardens between adopters and non-adopters of homegarden agroforestry (HGAF) at a significance level of $P<0.05$. To assess woody plant species diversity in homegarden agroforestry, the Shannon diversity index (H'), Simpson diversity index (D), and species evenness (E) indices were utilized.

3 Results and Discussions

3.1 Contribution of Homegarden Agroforestry to Household Income Generation

Homegarden agroforestry has a significant effect on annual household income generation, as indicated in Table 1. The mean annual income (± standard deviation) for homegarden adopters was 24,276.85 ± 20,059.60 Ethiopian Birr, compared to 11,379.96 ± 5,873.46 Ethiopian Birr for non-adopters.

Table 1. Average annual income of adopters and non-adopters in Ethiopian Birr

Practice	N	Mean ± Std. Deviation	P
Adopters	196	24276.85 ± 20059.60	0.00
Non-adopters	119	11379.96 ± 5873.46	

Significant level P<0.05

There is a highly significant difference in annual income generation between homegarden adopters and non-adopters. As indicated in Table 1, the mean annual income for adopters was 24,276.85 ± 20,059.60 Ethiopian Birr, compared to 11,379.96 ± 5,873.46 Ethiopian Birr for non-adopters. This result demonstrates that homegarden agroforestry adopters have a greater average annual income than their non-adopter counterparts. This disparity arises because homegarden agroforestry contributes to household income in various ways due to its diverse range of products.

Evidence from the household survey, key informants, and group discussions indicates that households practicing homegarden agroforestry can generate income both directly and indirectly.

In terms of direct income generation, households can increase their income by selling verities of fruits like Mangifera indica, Musa spp., Citrus aurantifolia, Citrus sinensis, Persea americana, Psidium guajava, Carica papaya, and Citrus reticulata; and Vegetables such as Brassica oleracea, Lactuca sativa, Brassica carinata, Allium cepa L., Solanum lycopersicum, and Allium sativum. In addition to fruits and vegetables, they obtain a variety of incomes from cash crops like Coffea arabica L., Rhamnus prinoides, and Catha edulis; and also from animals and their products, poultry and its products, honey, food crops, and other tree products.

For indirect income generation, homegardens provide shelter for chickens, protecting them from predators such as eagles. These chickens can either be sold at local markets or consumed at the household level, contributing to increased household income. Additionally, homegarden agroforestry reduces expenditures on food, fuelwood, fodder, construction materials, and medicine, further enhancing household income.

These findings align with previous studies conducted by Nzilano (2013) in Mbeya rural district, Tanzania, and Atiso & Fanjana (2020) in Boloso Bombe District, Southern Ethiopia. Both studies indicated that homegarden agroforestry significantly contributes to household income generation in rural communities, deriving income from diverse products. The income generated from homegarden sales significantly improves families' financial status (Mitchell & Hanstad, 2004).

Another study by Guuroh *et al.* (2012) in Bieha district, southern Burkina Faso, found that 70% of households relied solely on homegardens and farms for food and cash income. These households increased their income levels by selling animals, fruits, vegetables, fuelwood, medicine, timber, and fodder.

Income from homegarden agroforestry, derived from various components, is illustrated in Figure 2 below. Specifically, 6.44% of income came from food crops, 31.12% from fruits, 3.28% from vegetables, 0.05% from spices, 0.81% from fuelwood, 40.35% from cash crops, 1.09% from tree products, 7.27% from poultry and its products, 6.48% from animals and their products, 2.08% from honey, and 1.03% from other sources.

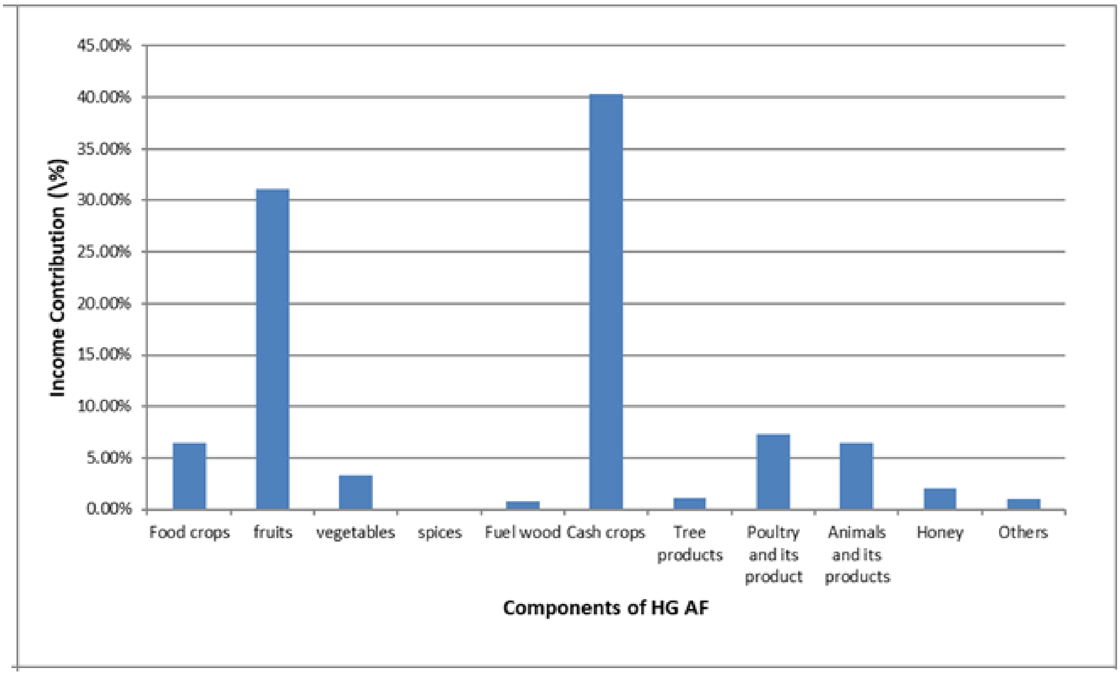

Figure 2. Contribution of Each Component in Homegarden Agroforestry to Income Generation

The main sources of income from homegarden agroforestry in the study area were cash crops (40.35%) and fruits (31.12%), followed by poultry (7.27%) (Fig. 2). This indicates that homegarden agroforestry in the study area is primarily composed of cash crops and fruits.

These findings are consistent with those of Jemal *et al*. (2018) and Hamore & Lemage (2019), which emphasize the vital role of cash crops and fruit trees in generating household income. Mathewos *et al*. (2018) also reported similar results. Additionally, a study by Tang (2011) in Burkina Faso noted that households derive income from various components within homegarden agroforestry, including fruits, vegetables, fuelwood, fodder, medicine, and timber. According to Tang's findings, fruits were the most common source of income for households within homegardens.

3.2 Woody Plant Species Diversity of Homegarden Agroforestry

In the present study, a total of 52 woody plant species belonging to 30 families were identified in the study area (Figure 3). Among these species, 65.4% were trees, 23.1% were shrubs, and 11.5% were classified as other types of trees. This result aligns with previous findings by Tefera *et al*. (2016), who recorded 52 woody plant species in homegarden agroforestry in the Dilla Zuria District of southern Ethiopia. It is also comparable to the findings of Birhane *et al*. (2020) and Molla & Kewessa (2015), who identified 49 and 55 woody species, respectively, belonging to 31 families in Hawassa Zuria District in the Sidama Zone and in Dellomenna District in southeastern Ethiopia.

The highest number of species in the study area was represented by the Fabaceae family, which accounted for 11.5% of the species, followed by the Moraceae and Rutaceae families, each comprising 9.6%. The Myrtaceae family ranked third, contributing 5.8% of the species. The families Anacardiaceae, Bignoniaceae, Celastraceae, Combretaceae, Euphorbiaceae, Meliaceae, and Rosaceae represented 3.8% of the species each, while the remaining families accounted for 1.9% of the species, as shown in Figure 3. Detailed information is provided in Appendix 1.

Similar results were reported by Barbhuiya *et al*. (2016) in the Eastern Himalayan Region of Mizoram, Northeast India, where the Fabaceae family was dominant, followed by the Rutaceae family. Shukla *et al*. (2017) also reported comparable findings.

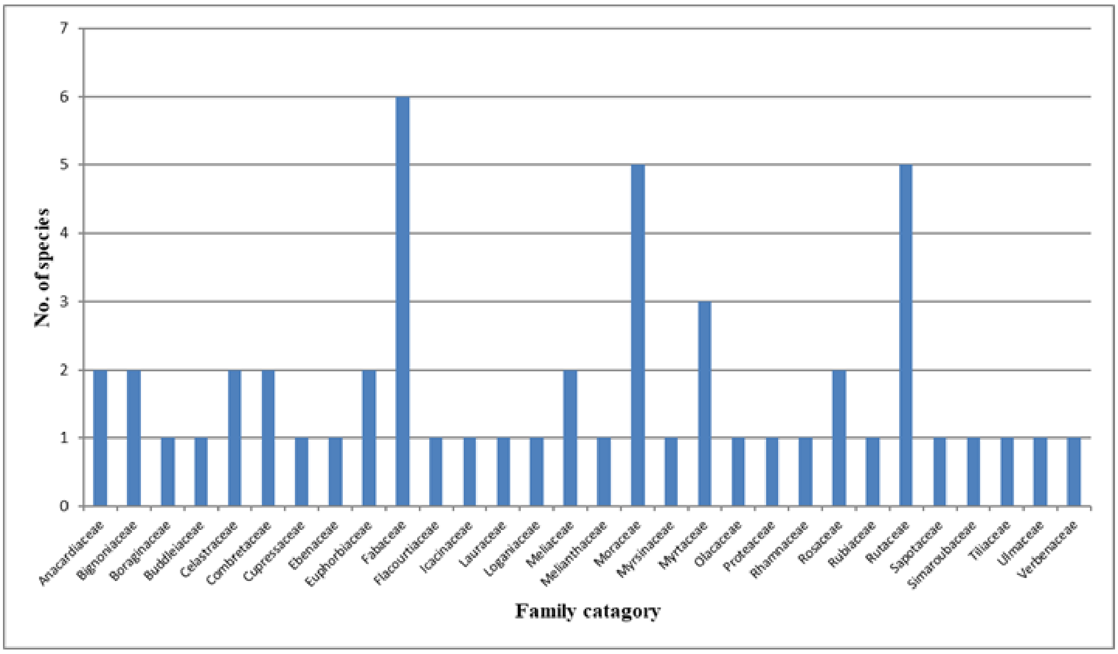

Figure 3. Families with No. of species contained in the study area

In order to get better picture on extent of woody plant species diversity in the study area several diversity indices were employed including Shannon diversity (H'), Simpson's diversity (D), Evenness (H'/H_{max}) and Richness as indicated in Table 2.

Table 2. Woody species diversity indices (Mean ±SD) of homegarden

Richness	Shannon diversity (H')	Simpson's diversity (D)	Evenness (E=H'/H_{max})	Individual
10 ± 1.71	1.92 ± 0.22	0.81 ± 0.06	0.74 ± 0.10	27 ± 11.96

The Shannon diversity index (H'= 1.92 ± 0.22) and evenness (0.74 ± 0.10) indicate a diverse and evenly distributed richness of woody plant species (S = 10 ± 1.71) in the study area. According to Kent (2012) and Magurran (2004), the Shannon diversity index typically lies between 1.5 and 3.5, although exceptional cases can exceed 4.5. The species evenness ranges from 0 to 1.

This result is comparable to the findings of Yismaw and Tadesse (2018), who studied three agroecological zones in this area. They reported an average Shannon diversity index (H' = 1.79 ± 0.09), Simpson's diversity index (D = 0.73 ± 0.04), and evenness (E = 0.74 ± 0.05). However, the present study demonstrates higher species richness (S = 10 ± 1.71) compared to their previous finding (S = 5 ± 0.55). The increased species richness in this study may be attributed to gradual species restoration due to improved management practices over the six years since the prior research.

Another comparable study was conducted by Birhane *et al.* (2020) in Hawassa Zuria District in the Sidama Zone, Southern Ethiopia, which reported woody species diversity indices of Shannon diversity index (H' = 1.87), Simpson's index (D = 0.77), and evenness (E = 0.81). However, the Shannon diversity index (H') in the present study is lower than that reported by Mengitu & Fitamo (2015) in Dilla Zuriya Woreda, Gedeo Zone, SNNPRS, Ethiopia, where they found H' = 3.42. This discrepancy may be due to the fact that SNNPRS, particularly the Gedeo Zone, is well known for its homegarden agroforestry practices, whereas such practices are less extensive in the northern parts of Ethiopia.

4 Conclusion

In general, practicing homegarden agroforestry significantly contributes to income generation for households, both directly and indirectly. There is a highly significant difference in annual income between homegarden agroforestry adopters and non-adopters. Homegarden adopters generate income from a variety of sources, including food crops, fruits, vegetables, fuelwood, cash crops, tree products, poultry and its products, animal products, and honey. Among these, fruits and cash crops were the primary contributors to income generation in the study area. Homegarden agroforestry also plays a major role in enhancing woody plant species diversity. The study area exhibited a diverse and evenly distributed range of woody plant species, with the Fabaceae, Moraceae, and Rutaceae families being the most dominant.

Acknowledgements

The authors express their gratitude to Dilla University for its financial support, as well as to the Lay Armachiho Wereda Agricultural Development Office, extension workers, and farmers for their collaboration during data collection.

References

Atiso, H., & Fanjana, F. (2020). Contribution of agroforestry home gardens to household income generation in Boloso Bombe District, southern Ethiopia. *Agricultural Research & Technology*. Open A Ccess Journal, 25(2), 1–12. https://doi.org/10.19080/ARTOAJ.2020.25.556295

Azene Bekele. (2007). Useful trees and shrubs for Ethiopia: identification, propagation and management in 17 agro-ecological zones. In Nairobi, Kenya: RELMA in ICRAF Project, World Agroforestry Centre, Eastern Africa Region.

Barbhuiya, A. R., Sahoo, U. K., & Upadhyaya, K. (2016). Plant diversity in the indigenous home gardens in the Eastern Himalayan Region of Mizoram, Northeast India. Economic Botany, 70(2), 115-131. https://doi.org/10.1007/s

Bernard, H. R. (2017). Research methods in anthropology: Qualitative and quantitative approaches. Rowman & Littlefield. (5^{th} edition).

Beyene, M., Mohammed, M., & Nigatu, L. (2018). Plant Species Diversity and Structure in Homegarden Agroforestry Systems of Bulen District, North-Western Ethiopia. International Journal of Environmental Sciences & Natural Resources, 15(4), 121–132. https://doi.org/10.19080/ijesnr.2018.15.555917

Birhane, E., Ahmed, S., Hailemariam, M., Negash, M., Rannestad, M. M., & Norgrove, L. (2020). Carbon stock and woody species diversity in homegarden agroforestry along an elevation gradient in southern Ethiopia. *Agroforestry Systems*, 94(3), 1099–1110. https://doi.org/10.1007/s10457-019-00475-4

Desta Hamore and, & Lemage, B. (2019). Management of Traditional Agroforestry Homegarden and its Contribution to Household Livelihood Diversification in Tembaro District, Southern Ethiopia. *Journal of Agriculture and Environmental Sciences*; Vol 4 No 2 (2019), 4(2), 57–68. http://ejol.aau.edu.et/index.php/JAES/article/view/1432

Edwards, S., M. Tadesse, S. Demissew, and I. H. (2000). Flora of Ethiopia & Eritrea. In Magnoliaceae to Flacourtiaceae. Addis Ababa, Ethiopia and Uppsala, Sweden: The National Herbarium, Addis Ababa University. (Vol. 2 part 1).

Guuroh, R. T., Uibrig, H., & Acheampong, E. (2012). Homegardens as a Source of Income for Rural Households-A Case Study of Bieha District, Southern Burkina Faso. *Journal of Agricultural Science and Technology* B, 2, 798–813. https://www.cia.gov/library/publications/the-world-factbook/g

Jemal, O., Callo-Concha, D., & Van Noordwijk, M. (2018). Local Agroforestry Practices for Food and Nutrition Security of Smallholder Farm Households in Southwestern Ethiopia. Sustainability, 10(8). https://doi.org/10.3390/su10082722

Kent, M. (2012). Vegetation Description and Data Analysis. a practical approach. John Wiley & Sons.

Kumar, R. (2018). Research methodology: A step-by-step guide for beginners. In Sage (3^{rd} edition).

Magurran, A. E. (2004). Measuring Biological Diversity. In Blackwell Science Ltd.

Mathewos, M., Hundera, K., & Biber-Freudenberger, L. (2018). Planting fruits and vegetables in homegarden as a way to improve livelihoods and conserve plant biodiversity. *Agriculture* (Switzerland), 8(12), 1–17.

Mekonnen, E. L., Asfaw, Z., & Zewudie, S. (2014). Plant species diversity of homegarden agroforestry in Jabithenan District , North- western Ethiopia. May. https://doi.org/10.5897/IJBC2014.0677

Mengitu, M., & Fitamo, D. (2015). Plant Species Diversity and Composition of the Homegardens in Dilla Zuriya Woreda, Gedeo Zone, SNNPRS, Ethiopia. Plant, 3(6), 80. https://doi.org/10.11648/j.plant.20150306.14

Mitchell, R., & Hanstad, T. (2004). Small homegarden plots and sustainable livelihoods for the poor. FAO Livelihood Support Programme, LSP Working Paper 11, 2–51.

Molla, A., & Kewessa, G. (2015). Woody Species Diversity in Traditional Agroforestry Practices of Dellomenna District, Southeastern Ethiopia: Implication for Maintaining Native Woody Species. *International Journal of Biodiversity*, 2015(iii), 1–13. https://doi.org/10.1155/2015/643031

Negash, M. (2013). The indigenous agroforestry systems of the south-eastern Rift Valley escarpment, Ethiopia: Their biodiversity, carbon stocks, and litterfall. In Tropical Forestry Reports (Vol. 44). http://urn.fi/URN:ISBN:978-952-10-9415-6

Nzilano, B. L. (2013). Contribution of agroforestry homegardens to household food security and income generation among communities in Mbeya rural district, Tanzania (Doctoral dissertation, Sokoine University of Agriculture). 47(2), 330-373. ttp://onlinelibrary.wiley.com/doi/10.1111/imre.12028/abstract

Shukla, G., Vineeta, A. K., & Chakravarty, S. (2017). Plant diversity, structure and uses of the plants in home garden of Jharkhand,. *India. Indian J Trop Biodiv*, 25(1), 40–50.

Tang, G. R. (2011). Contribution of Home Gardens to Household Income Generation in Burkina Faso: A Case Study of Bieha District (Doctoral dissertation, Verlag nicht ermittelbar).

Tefera, Y., Abebe, W., & Teferi, B. (2016). Woody Plants Species Diversity of Home Garden Agroforestry in three Agroecological Zones of Dilla. 3(3), 98–106.

Yismaw, M. T., & Tadesse, D. B. (2018). The Contribution of Agro forestry System to Tree Biodiversity Conservation and Rural Livelihood: The Case of Lay Armachiho District, Gondar, Ethiopia. *Int. J. Sci. Res. & Mgt.*, 6(5), 129–139. https://doi.org/10.18535/ijsrm/v6i5.ah02

Appendices

Plant's local name, scientific name, and their family, habit and total abundance in the study area

St. No.	Scientific Name	Local Name	Family	Habit	Abundance
1.	*Acacia seyal*	Girar (nech girar)	Fabaceae	Tree	2
2.	*Albizia gummifera*	Kachona	Fabaceae	Tree	5
3.	*Anogeissus leiocarpus*	kikira	Combretaceae	Tree	11
4.	*Apodytes dimidiata*	donga	Icacinaceae	Tree	12
5.	*Azadirachta indica*	Neem	Meliaceae	Tree	1
6.	*Bersama abyssinica*	Azamir	Melianthaceae	Tree	6
7.	*Brucea antidysenterica*	waginos	Simaroubaceae	Shrub/tree	3
8.	*Buddleia polystachya*	anfar	Loganiaceae	shrub/tree	1
9.	*Calpurnia aurea*	Zigta	Fabaceae	Shrub/tree	2
10.	*Casimiroa edulis*	Yetlian kok	Rutaceae	Tree	18
11.	*Catha edulis*	Chat	Celastraceae	Shrub	33
12.	*Celtis africana*	Quaniquana	Ulmaceae	Tree	2
13.	*Citrus aurantifolia*	lomi	Rutaceae	Shrub	34
14.	*Citrus medica*	Tiringo	Rutaceae	Shrub	1
15.	*Citrus reticulata*	Menderin	Rutaceae	Shrub	3
16.	*Citrus sinensis*	Birtukan	Rutaceae	Shrub	46
17.	*Coffea arabica*	Buna	Rubiaceae	Shrub	210
18.	*Cordia africana*	Wanza	Boraginaceae	Tree	58
19.	*Croton macrostachyus*	Bisana	Euphorbiaceae	Tree	15
20.	*Diospyros mespiliformis*	serkin	Ebenaceae	Tree	7
21.	*Dovyalis abyssinica*	koshem	Flacourtiaceae	Shrub	2
22.	*Ekebergia capensis (E. rueppeliana)*	Lol	Meliaceae	Tree	3
23.	*Erythrina abyssinica*	kuara	Fabaceae	Tree	5
24.	*Eucalyptus camaldulensis*	bahrzaf	Myrtaceae	Tree	1
25.	*Ficus congesta*	godn shola	Moraceae	Tree	3
26.	*Ficus sur (F. capensis)*	banbuleda	Moraceae	Tree	3
27.	*Ficus sycomorus*	Shola	Moraceae	Tree	10
28.	*Ficus thonningii Blume*	Enst chibaha	Moraceae	Tree	7
29.	*Ficus vasta*	warka	Moraceae	Tree	7
30.	*Grevillea robusta*	Grevila	Proteaceae	Tree	12
31.	*Grewia ferruginea*	Lenkoata	Tiliaceae	Tree	1
32.	*Jacaranda mimosifolia*	Yetawla zaf	Bignoniaceae	Tree	1
33.	*Juniperus procera*	Yehabesha- tid	Cupressaceae	Tree	3
34.	*Maesa lanceolata*	Kilabo	Myrsinaceae	Shrub/tree	3
35.	*Malus domestica*	aple	Rosaceae	Shrub	7
36.	*Mangifera indica*	mango	Anacardiaceae	Tree	107
37.	*Maytenus arbutifolia*	atat	Celastraceae	Shrub	9
38.	*Millettia ferruginea*	birbira	Fabaceae	Tree	16

St. No.	Scientific Name	Local Name	Family	Habit	total Abundance
39.	*Mimusops kummel*	Ishe	Sapotaceae	Tree	4
40.	*Nuxia congesta*	atquaro	Buddleiaceae	Tree	4
41.	*Olea africana*	Weira	Olacaceae	Tree	5
42.	*Persea americana*	Avocado	Lauraceae	Tree	20
43.	*Premna schimperi*	chocho	Verbenaceae	Shrub	1
44.	*Prunus persica*	Yehabesh Kock	Rosaceae	tree/shrub	4
45.	*Psidium guajava*	Zeituna	Myrtaceae	Shrub	6
46.	*Rhamnus prinoides*	gesho	Rhamnaceae	Shrub	135
47.	*Rhus vulgaris*	kimo	Anacardiaceae	Tree	5
48.	*Sapium ellipticum*	ahoma	Euphorbiaceae	Tree	3
49.	*Sesbania sesban*	meno zaf	Fabaceae	Shrub/tree	1
50.	*Stereospermum kunthianum*	zana	Bignoniaceae	Tree	2
51.	*Syzygium guineense*	Dokma	Myrtaceae	Tree	58
52.	*Terminalia avicennioides*	wonbela	Combretaceae	Tree	1
Total					919

EJED 2024 6(2):59–71

Ethiopian Journal of Environment and Development

http://www.du.edu.et/duj

EJED

Determinants and Challenges of Enrollment in Community-Based Health Insurance in Southern Ethiopia

Getasew Berhanu Melese[1], **Mary Abera Debisa**[2*], **Tekuamwork Demisse**[2], and **Yodit Abebe Mamo**[2]

[1]*College of Natural and Computational Sciences, Dilla University, Dilla, Ethiopia,*
[2]*Department of Public Administration and Development Management, College of Business and Economics, Dilla University, Dilla, Ethiopia*
[*]*Corresponding author; Email: signoritamarya@gmail.com*

Received: 10th October 2024 *Accepted: 15th December 2024*

Article DOI: **10.20372/ejed.v06i2.05**

Abstract

Since 2011, Ethiopia has been implementing the Community-Based Health Insurance (CBHI) scheme in various regions to enhance universal health coverage by reducing out-of-pocket expenses for low-income families and to promote healthcare access for poorer households. The purpose of this study is to examine household enrollment and non-enrollment decisions, as well as the main challenges in implementing the program. A multi-stage sampling process was employed to select the participating households. Study subjects were chosen through simple random selection based on population proportions (PPS). Primary data was gathered using a pretested questionnaire. To support the quantitative findings, interviews with CBHI specialists and focus group discussions (FGDs) with both members and non-members of CBHI were conducted. Data analysis was performed using STATA version 15 and SPSS version 20, employing both descriptive and inferential statistics. Of the total respondents, 42.7% were enrolled in the CBHI program, while 57.3% were not. To understand the primary determinants of CBHI enrollment, 15 variables were identified. Factors such as residence, illness, family size, occupation, attitude, awareness, information, payment fairness, service quality, and drug availability were found to be significant in relation to CBHI enrollment in the multivariable analysis ($P < 0.05$). The main challenges identified in the program include poor service delivery and long waiting times, among others. The study revealed the factors influencing enrollment and non-enrollment in the CBHI scheme, as well as its key implementation challenges. It is essential for the government to collaborate with relevant organizations to address the barriers faced by low-income households in enrolling in the program and to find solutions to the challenges of its implementation.

Keywords/Phrases: Challenges, Community-based Health Insurance, Enrollment, Implementation, Low Income Family, Non-enrollment, Southern Ethiopia, Universal Health Coverage

1 Introduction

Community-Based Health Insurance (CBHI) provides healthcare services for individuals living and working in rural areas or the urban informal sector who cannot access public, private, or employer-sponsored health insurance. It is an alternative financing method that is controlled, established, and managed by members through their contributions (Abdilwohab *et al*., 2021; Dagnaw *et al*., 2022; Tabor, 2005).

Designing adequate health financing systems in developing countries, particularly low-income ones, remains a challenge and is the subject of ongoing discussion (Adeniyi-Jones, 1976). This is largely due to limited economic resources, slow economic growth, restrictions within the public sector, and low organizational capacity.

The Ethiopian healthcare system is characterized by high out-of-pocket costs, increasing healthcare demands, difficulties in mobilizing health resources among rural populations, and an inability to fully recover the costs of care incurred by beneficiaries (Mariam, 2001). These payments cover expenses for goods and services from pharmacies, traditional providers, private providers, public facilities, and services abroad.

Like many countries, Ethiopia's heavy reliance on out-of-pocket spending forces individuals and households to either forgo necessary medical care-potentially worsening health conditions-or incur expenses that heighten the risk of poverty (Bank, 1993; Organization, 2000). In response, the country launched a pilot program for CBHI in 2011, which saw impressive adoption rates, reaching 41% in its first year. However, 18% of households who enrolled in the initial year ceased their payments the following year (Mebratie *et al.*, 2015).

Ethiopia is committed to achieving Universal Health Coverage (UHC), which involves providing high-quality healthcare services that are equitable and accessible to everyone. The country is working to develop a comprehensive and sustainable risk protection system with health financing mechanisms tailored to its needs, particularly in the informal sector, which comprises over 85% of the population (Agency, 2015a).

Primary healthcare funding is a structural component of health systems essential for establishing UHC (Abdilwohab *et al.*, 2021). This funding involves three interconnected functions: resource allocation (including purchasing and paying for services), mobilization and collection of funds, and pooling of prepaid resources (Evans & Etienne, 2010). UHC aims to eliminate financial barriers that prevent individuals from accessing necessary medical care, which is vital for maintaining a healthy and productive society. Mechanisms like CBHI are potential instruments for achieving UHC by providing health security through risk-sharing (Abdilwohab *et al.*, 2021).

CBHI is part of the Ethiopian government's broader healthcare financing reform strategy, aimed at promoting financial protection, cost-sharing between government and citizens, equitable access to healthcare, and social inclusion in health and domestic resource mobilization (Solomon, Hailu, & Tesfaye, 2011). Based on the principles of mutual aid and social solidarity, CBHI targets individuals in rural and urban informal sectors who lack access to traditional insurance options. It is a member-controlled funding method designed to reduce unpredictable or high healthcare costs to regular premium payments (Chankova, Sulzbach, & Diop, 2008; Tabor, 2005; Uzochukwu *et al.*, 2010).

In line with the Ethiopian Health Policy ratified in 1993, the Ministry of Health developed a healthcare funding plan that emphasizes health insurance. The government aimed to reduce out-of-pocket spending from 37% to less than 15% and catastrophic health expenditures from 3.5% to 2.5% by implementing the CBHI program in 80% of districts. However, according to the 2016 Ethiopian Demographic and Health Survey (EDHS), only 5% of villages were registered in the program, reflecting regional disparities. Performance statistics also indicated that only two million, or 0.2%, of the 900 million eligible individuals participated in community insurance (De Allegri *et al.*, 2008; Ekman, 2004; Wang & Pielemeier, 2012).

2 Problem statement

Community-Based Health Insurance (CBHI) can help fulfill the World Health Assembly's call for universal health coverage, particularly in low-income countries (LICs) where significant inequities exist in healthcare delivery (De Allegri *et al.*, 2006; Tien *et al.*, 2005). As financial risk protection is a critical component of UHC, Ethiopia began implementing a comprehensive and sustainable CBHI scheme in 2011. While the CBHI system protects members from catastrophic health expenditures, improving the quality of health services is essential for increasing member satisfaction and meaningfully advancing UHC (Ridde *et al.*, 2018).

Approximately 84% of the world's population resides in developing countries, where at least 50% live in poverty. The 1.3 billion rural poor workers in the informal sector contribute to 20% of the world's GDP (Taddesse *et al.*, 2020). Thus, the significance of health insurance for impoverished and marginalized communities is undeniable.

Low levels of health insurance coverage are prevalent in Sub-Saharan Africa (Zhao *et al*., 2014). The formal sector, which constitutes about 10% of the population, is largely the only group with access to existing health insurance systems (Wiesmann & Jütting, 2000). Most low-wage workers in Africa's informal sector and self-employed rural residents have never accessed social protection linked to health insurance programs (Basaza *et al*., 2009). Community-based health insurance (CBHI) is emerging as a viable option to enhance access to primary healthcare.

Out-of-pocket medical expenses severely impact the financial stability of lower socioeconomic groups, leading to poor living conditions. Globally, over 150 million households face financial hardship due to healthcare costs, with approximately 25 million falling into extreme poverty each year. In Sub-Saharan Africa, where resources are limited, over 90% of healthcare-related financial issues arise (Maeda *et al*., 2014; Xu *et al*., 2007). In six Middle Eastern and North African countries, 7–13% of households experience catastrophic medical expenses (Elgazzar *et al*., 2010). These regions account for 90% of the world's disease burden (Noubiap *et al*., 2014; Pablo & Schieber, 2006; Wang & Pielemeier, 2012).

Despite countries agreeing at the World Health Organization (WHO) General Assembly in 2005 to achieve UHC through risk-pooling mechanisms and reduced out-of-pocket payments, actual healthcare spending remains low, at less than 12% (Gottret & Schieber, 2006; Pablo & Schieber, 2006; Wang & Pielemeier, 2012). Direct healthcare spending varies, with 42% in Kenya, 27% in Ghana, and 37% in Ethiopia. Implementing health insurance programs could help nations reduce direct healthcare costs (Nimpagaritse & Bertone, 2011). Ethiopia has one of the lowest rates of health service consumption in Sub-Saharan Africa, with inpatient healthcare utilization at just 6% (Leive & Xu, 2008).

In recent years, the Ethiopian population has expressed significant concerns about inadequate healthcare facilities and the financial pressures associated with healthcare (Agency, 2015a; Atnafu *et al*., 2018). Only 1.2% of the population had health insurance through a combination of government and commercial organizations (Atnafu *et al*., 2018).

There is growing interest in how CBHI programs can assist the poor, especially those in the informal sector, in accessing basic healthcare (Agency, 2015a; Mwaura & Pongpanich, 2012). Since 2011, Ethiopia has implemented the CBHI program to improve health outcomes for underprivileged rural residents. However, not all rural households are covered by CBHI, primarily due to low government initiative, lack of awareness, and accessibility issues (Agency, 2015a; Atnafu *et al*., 2018).

Therefore, this study aims to investigate the factors influencing enrollment and non-enrollment in CBHI programs, as well as the challenges faced in their implementation. It seeks to provide potential solutions for the government, policymakers, and other stakeholders by identifying determinant factors, implementation challenges, and proposing actionable recommendations.

3 Materials and Methods

3.1 Study population

The source population comprised all households that had lived in the area for more than six months, while the study population included all household heads in the randomly selected kebeles. Household heads and/or spouses who were employed by the government were excluded from the study.

3.2 Sample size determination and sampling techniques

Using a single population percentage formula and the following assumptions, the sample size was determined to be 847. This was based on an assumed maximum household enrollment rate in the CBHI of 50%, a maximum tolerable error of 5%, a Z-statistic of 1.96, an anticipated non-response rate of 10%, and a design effect of 2.

A multi-stage sampling process was employed to select the participating households. In the first stage, four zones were randomly chosen as the primary sampling units. In the second stage, eight woredas (two from each zone) were randomly selected as secondary sampling units. Finally, in the third stage, 16 kebeles were randomly chosen from the eight selected woredas. Within each chosen kebele, study subjects (households) were selected through simple random sampling based on population proportions relative to the sample size (PPS).

3.3 Data collection tools and procedures

Data was collected using a pretested, interviewer-administered questionnaire. The survey was developed based on data from the National Health Insurance Agency's CBHI evaluation study in Ethiopia (Agency, 2015b). The English version of the questionnaire was translated into the regional language for data collection. The instrument underwent pretesting on 5% of the actual sample size in two kebeles outside the target area, ensuring that the socio-demographic and other relevant parameters were like those of the study population. Based on the pretest findings, certain items were modified or added, while others that were unclear were clarified. Data collectors and supervisors reviewed the pretest information to enhance their understanding of the data collection process.

Five graduate nurses fluent in the local language and two professional nurses with bachelor's degrees in healthcare participated in the data collection. Face-to-face interviews were conducted after participants were informed about the study's objectives and the importance of their participation. Supervisors, along with the lead investigator, conducted daily checks to ensure that the questionnaires completed by the data collectors were accurate, consistent, and relevant. Any pertinent feedback was communicated to the data collectors the following morning before the regular data collection commenced.

3.4 Method of data analysis

Data review, cleaning, and entry were performed using STATA version 15 and SPSS version 20 prior to analysis. Both descriptive and inferential statistics were employed to evaluate the data. The enrollment status of households in CBHI was presented using frequency distributions, percentages, and graphs in the descriptive statistics.

The correlation between each explanatory factor and the outcome variable (CBHI enrollment status) was assessed using the chi-square test. Factors with a p-value of less than 0.15 in the bivariate analysis were included in the final multivariable logistic regression analysis. The model fit was evaluated using the Hosmer-Lemeshow statistic and the coefficient of deviation, indicating a good fit (P = 0.863).

Potential variables were examined for multicollinearity using the variance inflation factor (VIF) test, with a threshold of 10. No multicollinearity was found, as all candidate variables had a VIF value of 3. To determine the enrollment status of households in CBHI, binary logistic regression was applied. A variable was considered to have a statistically significant association with CBHI enrollment status if its p-value was less than 0.05 in the final model. The strength of the association was evaluated using a 95% confidence interval odds ratio.

3.5 Ethical Considerations

This study received ethical approval from the Institutional Review Board (IRB) of Dilla University, College of Medicine and Health Sciences, in accordance with the Helsinki Declaration. Permission letters were also obtained from the SNNP Regional Health Office, the Zone Health Department, and the Woredas Health Departments. All identifiers of respondents were kept confidential, and the data were anonymized. Following IRB approval, verbally informed consent was obtained from each respondent. Given that most of the study population was from a rural area, literacy levels were assumed based on oral informed consent. Participants retained the right to choose whether to participate in the study, either in whole or in part.

4 Results and Discussion

4.1 Socio-Demographic Characteristics of the respondents

The distribution of CBHI participants according to their demographic and socioeconomic factors is presented in Table 1 above. This study included a total of 847 households, achieving a response rate of 100%. Among the respondents, 306 (36.1%) were households headed by women, while 485 (63.9%) were headed by men. In fact, men typically lead or manage the majority of households in both urban and rural Ethiopia.

Table 1. Socio-demographic characteristics of the respondents

Variables	Category	Frequency	Percent
Gender	Male	541	63.9%
	Female	306	36.1%
Age	less than 34	174	20.5%
	35-39	277	32.7%
	40-50	254	30.0%
	greater than 50	142	16.8%
Residence	Urban	197	23.3%
	semi-urban	232	27.4%
	Rural	418	49.4%
Occupation	farmer	335	39.6%
	Informal sector	157	18.5%
	day laborer	189	22.3%
	unemployed	166	19.6%
Education	no formal education	248	29.3%
	Primary	279	32.9%
	secondary & above	320	37.8%
Family size	1-4	382	61.6%
	5 or more	465	38.4%
Marital status	Single	102	12.0%
	Married	657	77.6%
	Other	88	10.4%
Enrollment Status	Enrolled	362	42.7
	Non-enrolled	485	57.26

Among the respondents, 277 (32.7%) were aged between 35 and 39, making this the most common age group. Additionally, 254 (30%) were under 34, 174 (20.5%) were between 40 and 50, and 142 (16.8%) were over 50. A total of 418 participants (48.4%) primarily resided in rural areas, followed by 232 participants (27.3%) from semi-urban areas and 197 (23.3%) from urban areas.

In terms of occupation, 189 respondents (22.3%) were day laborers, while 335 (39.6%) were farmers. The remaining group included 166 individuals (19.6%) who were unemployed and 157 (18.5%) working in the informal economy. Educationally, 320 households (37.8%) had at least a secondary education, while 248 households (29.5%) had no formal education, and 279 households (32.9%) had only primary education.

Furthermore, 382 participants (61.6%) came from households with fewer than five members, and 657 households surveyed (77.3%) were married. A total of 355 participants (41.9%) reported having been unwell in the past year. Notably, 485 study participants (57.3%) did not have community-based health insurance (CBHI) at the time of the study, while 362 (42.7%) did (see Table 1). These demographic characteristics provide valuable insights into the overall profile of the respondents.

4.2 Determinants of enrollment status of household in community-based health insurance program

Table 2. Determinants of respondents' enrolment in CBHI among bivariate and multivariate logistic regression analysis, Southern Ethiopia

Variables		Enrollment status		COR (95% CI)	AOR(95% CI)
		No	Yes		
Gender	Male	298	243	0.78(0.587, 1.038)	1.213(0.812, 1.81)
	Female	187	119	1	1
Age	Less than	34 114	60	1.697(1.078, 2.673)	0.977(0.505, 1.892)
	35-39	167	110	1.356(0.902, 2.04)	0.956(0.550, 1.663)
	40-50	129	125	0.922(0.611, 1.391)	1.103(0.647, 1.881)
	Greater than	50 75	67	1	1
Residence	Urban	138	59	2.753(1.92, 3.948)	2.185(1.25, 3.817)*
	Semi-urban	155	77	2.369(1.696, 3.31)	1.452(0.887, 2.379)
	Rural	192	226	1	1
Sickness	No	162	193	0.439(0.332, 0.581)	0.401(0.279, 0.575)*
	Yes	323	169	1	1
Education	No formal education	131	117	0.547(0.389, 0.769)	0.961(0.572, 1.615)
	Primary	139	140	0.485(0.348, 0.675)	0.833(0.538, 1.289)
	Secondary and above	215	105	1	1
Family size	1-4	255	127	2.052(1.551, 2.714)	2.024(1.412, 2.903)*
	Five or more	230	235	1	1
Marital status	Single	82	20	2.708(1.415, 5.181)	1.615(0.680, 3.837)
	Married	350	307	0.753(0.478, 1.185)	0.652(0.350, 1.215)
	Other	53	35	1	1
Occupation	Farmer	145	190	0.211(0.138, 0.324)	0.310(0.168, 0.572)*
	Informal sector operator	104	53	0.543(0.331, 0.892)	0.634(0.349, 1.152)
	Day laborer	106	83	0.354(0.222, 0.565)	0.280(0.156, 0.503)*
	Unemployed	130	36	1	1
CBHI attitude	Negative	234	286	0.248(0.182, 0.338)	0.226(0.155, 0.329)*
	Positive	251	76	1	1
CBHI awareness	No	404	350	0.171(0.092, 0.319)	0.170(0.080, 0.360)*
	Yes	81	12	1	1
Information	No information	166	94	0.804(0.523, 1.237)	0.739(0.434, 1.259)
	Health professionals	112	138	0.37(0.241, 0.567)	0.312(0.180, 0.540)*
	Community/religious leaders	106	84	0.575(0.366, 0.902)	0.442(0.249, 0.785)*
	radio/television/magazines	101	46	1	1
Payment fairness	Not fair	331	319	0.292(0.201, 0.423)	0.343(0.219, 0.536)*
	Fair	153	43	1	1
Service availability	Not enough	304	198	1.391(1.055, 1.835)	0.993(0.686, 1.436)
	Enough	181	164	1	1
Service quality	Not good	296	178	1.619(1.229, 2.132)	0.874(1.315, 2.671)*
	Good	189	184	1	1
Drug availability	Insufficient	289	272	0.488(0.362, 0.658)	0.396(0.270, 0.581)*
	Sufficient	196	90	1	

We can identify who is enrolling in CBHI and how insured households differ from uninsured ones by comparing background characteristics between the two groups. Table 2 summarizes the comparison of several household-level factors between CBHI participants and non-participants.

To understand the primary determinant factors of CBHI enrollment, a total of 15 variables were identified. The following variables were significantly associated with CBHI enrollment in the multivariable analysis ($P < 0.05$): place of residence, illness, family size, occupation, attitude, awareness, and information (see Table 2).

The results of the multivariable logistic regression indicate that households in urban areas were 2.185 times more likely to participate in the CBHI program compared to those in rural areas (AOR = 2.185; 95% CI: 1.25, 3.817). Additionally, the likelihood of study participants enrolling in CBHI was significantly lower in families without a member suffering from a chronic illness, compared to those with such a member (AOR = 0.401; 95% CI: 0.279, 0.575).

Families with five or more members were approximately twice as likely to enroll in the CBHI program compared to families with fewer members (AOR = 2.2; 95% CI: 1.503, 3.223).

Farmers and day laborers had a 0.31 (AOR = 0.31; 95% CI: 0.168, 0.572) and 0.28 (AOR = 0.28; 95% CI: 0.156, 0.503) times lower likelihood of enrolling in CBHI, respectively, compared to unemployed individuals.

Participants who received information from health care professionals were 0.312 times less likely (AOR = 0.312; 95% CI: 0.180, 0.540) to enroll in the CBHI scheme compared to those who received information from radio, television, or magazines. Similarly, participants who received information from community, religious, or other leaders were 0.442 times less likely (AOR = 0.442; 95% CI: 0.249, 0.785) to enroll.

The odds ratio for participants with a negative attitude toward CBHI was estimated to be 0.226 (95% CI: 0.155, 0.329). For those unaware of CBHI, the odds ratio was 0.17 (95% CI: 0.080, 0.360), while those who believed that payment was unfair had an odds ratio of 0.343 (95% CI: 0.219, 0.536). Participants who perceived the quality of services as poor had an odds ratio of 0.87 (95% CI: 0.874).

4.2 Discussion

The purpose of this study was to evaluate the factors influencing the implementation of community-based health insurance (CBHI) in southern Ethiopia. According to our data, 42.7% of the 847 households surveyed are covered by a CBHI program. Other studies report different percentages, which may be attributed to variations in study populations, regions, time frames, and methodologies. Some studies focused on healthcare facilities or urban residents, who may be more familiar with the CBHI scheme, while others were conducted in rural areas. Various factors, such as cultural influences, distance from healthcare facilities, geographic obstacles, and lower levels of awareness, may contribute to households lacking knowledge about the CBHI plan.

While comparing the two groups helps to understand the sample, it is essential to control for variations in other characteristics to determine whether a variable is related to enrollment.

Residence: Table 2 lists the factors strongly associated with enrollment based on respondents' neighborhoods. Households in urban areas have a significantly higher likelihood of enrolling in CBHI compared to those in rural regions. Interviews with CBHI specialists indicate that those living in or near cities are more aware of the program and its benefits. Urban residents generally have better access to healthcare services and prefer public hospitals or private care. In contrast, rural households often exhibit poorer attitudes and lower awareness levels, as awareness-raising efforts are less prevalent in rural areas.

Health Status or Illness: As more households experience health issues, the cost of healthcare services increases, prompting them to seek risk-pooling options like insurance. Our findings suggest that households with higher illness rates are more inclined to enroll. Specifically, respondents without a family member with a chronic illness were significantly less likely to join CBHI compared to those with such a member. This aligns with previous research indicating that households with at least one member having a health issue in the past year are more likely to participate in insurance systems, illustrating the effect of adverse selection on enrollment decisions. This is encouraging from a health perspective, as it indicates that those who need healthcare the most are obtaining insurance.

Family Size: Data indicates that households with five or more members have a much higher likelihood of signing up for CBHI. This is reasonable, as the probability of illness increases with the number of family members, along with the desire to reduce healthcare costs. Larger families also face a greater risk of health issues, increasing the likelihood that at least one member will seek to join risk-pooling institutions. This finding is consistent with earlier studies showing that larger households are more likely to purchase insurance due to the financial burden during health crises.

Occupation: Our findings reveal that farmers and day laborers have a lower likelihood of enrolling in the CBHI program compared to unemployed individuals. Although these groups require health insurance due to their inability to afford healthcare costs, they are less likely to enroll than those without jobs.

Attitude: Participants with a favorable attitude toward the CBHI program were more likely to enroll than those who did not share that perspective. Positive word-of-mouth from enrolled members who receive quality care can influence the perceptions of their neighbors, encouraging them to join CBHI.

Awareness: Low literacy rates and a lack of knowledge about CBHI within the community contribute to low enrollment. Awareness of the program is identified as a key factor influencing CBHI enrollment. Participants with greater knowledge and understanding of the program are more likely to enroll. This finding aligns with other studies indicating that familiarity with insurance concepts simplifies enrollment decisions.

Information: The source of information is a crucial determinant for CBHI enrollment. Individuals who received information from radio or television were more likely to be CBHI members compared to those who received information from healthcare providers or community leaders. This suggests that participants find the information provided by healthcare professionals and community leaders insufficient.

Payment: Participants who believe that payment for the CBHI program is fair are more likely to enroll compared to those who perceive it as unfair.

Service Quality: The quality of services provided by health institutions significantly influences enrollment decisions. Participants who believe that the quality of care offered by healthcare providers is good are more likely to engage with CBHI than those who perceive service quality as poor. This aligns with findings from other studies, as individuals seek high-quality healthcare at reasonable prices when joining the program. Factors such as availability of healthcare professionals, waiting times, and respect from caregivers play important roles in determining membership in the program.

Drug Availability: Individuals who believe there is insufficient access to medications are less likely to enroll in CBHI compared to those who feel that access is adequate. As noted in focus group discussions with members of the enrolled CBHI community, even if the service provider is excellent, the inability to obtain medications from healthcare facilities poses a significant barrier. Participants expressed that they often have to spend additional money to purchase medications that are not readily available.

4.3 Implementation Challenges

CBHI Enrollment Plan

Respondents were asked about their interest in enrolling in the CBHI scheme. Of the 485 households that comprised the non-enrolled participants, 371 (76.5%) expressed a willingness to participate, while the remaining 114 (23.5%) indicated no interest in joining the CBHI program.

Some factors that prevented households from signing up for CBHI included the program's limited coverage (which is primarily concentrated in urban areas), insufficient funds for the annual contribution or the ability to pay out-of-pocket, a lack of desire for frequent healthcare visits, inadequate understanding of the CBHI program, a lack of confidence in its effectiveness, shortages of medications, and general unawareness of the scheme, among others.

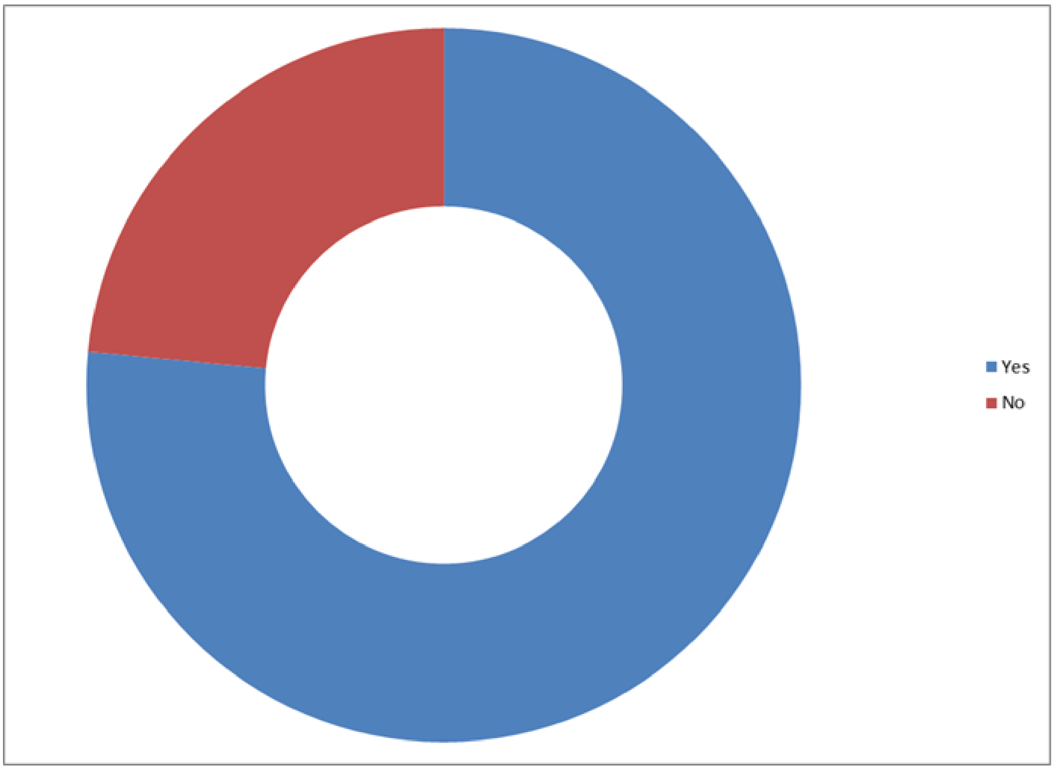

Figure 1. CBHI enrollment plan of the households

Stay in CBHI

According to the statistics below, a significant portion of respondents among the enrolled households expressed a desire to continue using the service. This suggests that the program positively impacts the health status of these households in relation to their needs.

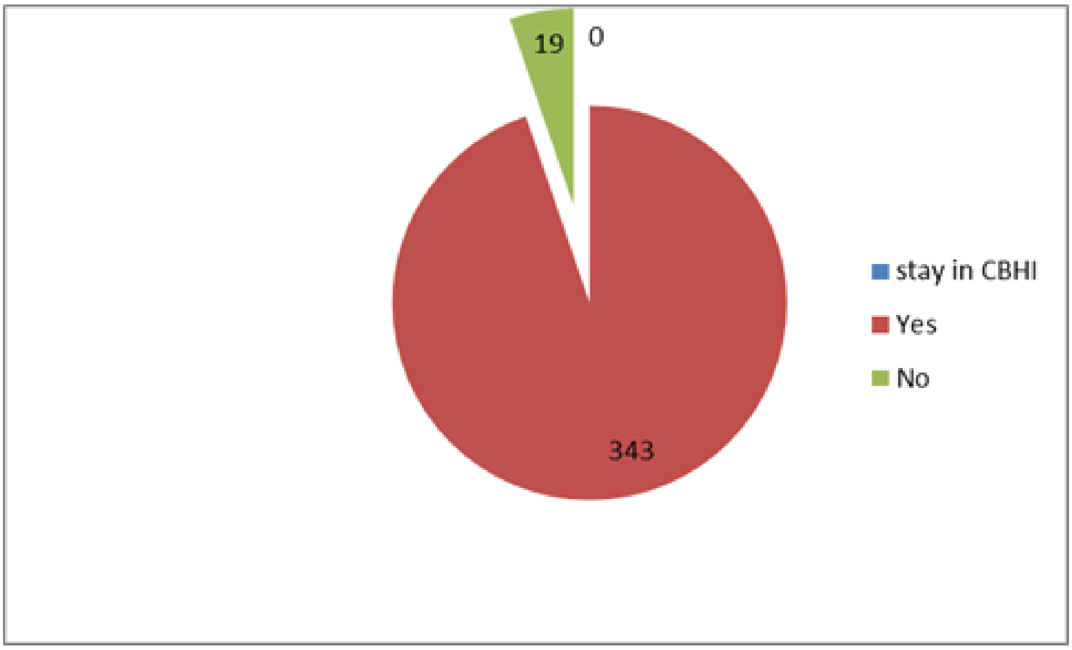

Figure 2. Willingness of CBHI enrolled households to stay in the program

Those who expressed a lack of interest in remaining CBHI members provided several justifications for their withdrawal. These include poor service experiences, rumors, reduced income, a belief that they won't fall ill, a perception that they can afford medical costs, and relocation.

Discussions with CBHI experts revealed that most program participants receive higher-quality healthcare at lower costs, leading to improved health conditions for their family members. Many users, particularly those with chronic illnesses, are the biggest beneficiaries of this program, even among those who are generally in good health. Focus group discussions with beneficiaries indicated that they wish to remain in the program due to its provision of low-cost annual health insurance, coverage for common family illnesses, and overall high-quality services despite some health centers offering subpar care and pharmacies with limited drug supplies.

Major Challenges of the Scheme

The recipients of CBHI were asked to identify any issues they encountered while using the program. As shown in the chart above, some key concerns expressed by beneficiaries included the low quality of healthcare services, lengthy wait times for care, a shortage of healthcare professionals, and bureaucratic hurdles in accessing services.

Table 3. Implementation challenges of the scheme

Implementation challenge	Frequency	Percent
Poor quality service	120	33.1
Partiality	14	3.9
Bureaucracy	52	14.4
Shortage of professional	53	14.6
Longer waiting time	89	24.6
Longer registration	34	9.4
Total	362	100

Additionally, several issues were noted, including a shortage of medications, remote locations of medical facilities, limited access to comprehensive medical services, unethical behavior by some medical professionals, and discrimination favoring out-of-pocket patients. Other concerns include inadequate awareness of the program, drug-related corruption, insufficient follow-up and support, and conflicts between healthcare beneficiaries and providers. The process of identifying those in need within kebeles also faces challenges, such as nepotism.

The organization is currently in debt due to a mismatch between income and expenses, primarily because most beneficiaries have chronic illnesses and extensively use the services. As a result, the organization has fallen behind on its loan payments. Another significant challenge facing the CBHI system is the financial strain of providing services and medications to plan participants.

5 Conclusion

- Decisions regarding CBHI membership and non-enrollment are influenced by respondents' socio-demographic, economic, and knowledge levels.
- Factors such as location, illness, family size, occupation, attitude, awareness, and availability of medications were identified as key determinants of CBHI enrollment. Additional reasons for non-enrollment include negative perceptions of CBHI, low awareness of the program, unfair payment practices, poor service quality, and inadequate medication supply.
- The main implementation challenges of the CBHI scheme include poor service quality and medication availability from the beneficiary perspective, as well as financial issues, insufficient funding, and delayed payments from beneficiaries.

- To enhance satisfaction with service delivery, it is essential to provide comprehensive healthcare and improve overall service quality. Furthermore, health facility management, policymakers, and other responsible officials should focus on increasing members' understanding of CBHI benefits through education and information campaigns. Additionally, a nationwide longitudinal study should be conducted to identify the challenges affecting household satisfaction with the CBHI program.

Acknowledgments

We extend our gratitude to the communities of both CBHI members and non-members, as well as the CBHI specialists in each subject area, for their openness and cooperation in answering all of the research questions. We also thank Dilla University's Research and Dissemination Directorate for providing the funding necessary to conduct the study that forms the basis of this publication. Any remaining inaccuracies in this article are our sole responsibility.

Funding

The Dilla University Research and Dissemination Directorate provided funding for this project.

Ethical Approval Number

This study received ethical approval from the Institutional Review Board (IRB) of Dilla University, reference number DUIRB/00322,02, College of Medicine and Health Sciences, in accordance with the Helsinki Declarations. All identifiers of respondents were kept confidential, and data were anonymized. Following IRB approval, verbally informed consent was obtained from each participant. Given that most of the study population was from rural areas, literacy levels were assessed through oral consent. Participants were fully informed of their right to participate or to withdraw from the study, either wholly or in part.

References

Abdilwohab, M. G., Abebo, Z. H., Godana, W., Ajema, D., Yihune, M., & Hassen, H. (2021). Factors affecting enrollment status of households for community based health insurance in a resource-limited peripheral area in Southern Ethiopia. Mixed method. *PloS one*, 16(1), e0245952.

Adeniyi-Jones, O. (1976). Community involvement: new approaches. *WHO chronicle*, 30(1), 8-10.

Agency, E. H. I. (2015a). Evaluation of community-based health insurance pilot schemes in Ethiopia. In: Ethiopian health insurance agency Addis Ababa.

Agency, E. H. I. (2015b). Evaluation of community-based health insurance pilot schemes in Ethiopia. Final Report. 2015 May.

Atnafu, D. D., Tilahun, H., & Alemu, Y. M. (2018). Community-based health insurance and healthcare service utilisation, North-West, Ethiopia: a comparative, cross-sectional study. *BMJ open*, 8(8), e019613.

Bank, W. (1993). World Development Report 1993: *Investing in Health*, Volume1: The World Bank.

Basaza, R., Criel, B., & Van der Stuyft, P. (2008). Community health insurance in Uganda: why does enrolment remain low? A view from beneath. *Health policy*, 87(2), 172-184.

Basaza, R., Pariyo, G., & Criel, B. (2009). What are the emerging features of community health insurance schemes in East Africa? *Risk Management and Healthcare Policy*, 2, 47.

Chankova, S., Sulzbach, S., & Diop, F. (2008). Impact of mutual health organizations: evidence from West Africa. *Health policy and planning*, 23(4), 264-276.

Csa, I. (2016). Central Statistical Agency (CSA) Ethiopia and ICF. Ethiopia Demographic and Health Survey, Addis Ababa. Central Statistical Agency.

Dagnaw, F. t., azanaw, M. M., adamu, a., ashagrie, t.,Mohammed, a. a., Dawid, H. Y., tiruneh, M., Demissie, B.,Yemata, G. a., Yitbarek, G. Y., abebaw, Y., & Hailemeskel,H. S. (2022). community-based health insurance, health-care service utilization and associated factors in South Gondar Zone Northwest, ethiopia, 2021: a comparative cross-sectional study. *PLoS One*, 17(7), e0270758. https://doi.org/10.1371/journal.pone.0270758

De allegri, M., Sanon, M., Bridges, J., & Sauerborn, r. (2006). Understanding consumers' preferences and decision to enrol in community-based health insurance in rural west africa. Health Policy (Amsterdam, Netherlands), 76(1), 58– 71. https://doi.org/10.1016/j.healthpol.2005.04.010

De Allegri, M., Pokhrel, S., Becher, H., Dong, H., Mansmann, U., Kouyaté, B., . . . Bridges, J. (2008). Step-wedge cluster-randomised community-based trials: an application to the study of the impact of community health insurance. *Health Research Policy and Systems*, 6(1), 1-8.

Dror, D. M., Hossain, S. S., Majumdar, A., Pérez Koehlmoos, T. L., John, D., & Panda, P. K. (2016). What factors affect voluntary uptake of community-based health insurance schemes in low-and middle-income countries? A systematic review and meta-analysis. *PloS one*, 11(8), e0160479.

Ekman, B. (2004). Community-based health insurance in low-income countries: a systematic review of the evidence. *Health policy and planning*, 19(5), 249-270.

Elgazzar, H., Raad, F., Arfa, C., Mataria, A., Salti, N., Chaaban, J., . . . Majbouri, M. (2010). Who pays? Out-of-pocket health spending and equity implications in the Middle East and North Africa.

Ethiopia, F. (2015). Health sector transformation plan I. Adis Ababa.

Evans, D. B., & Etienne, C. (2010). Health systems financing and the path to universal coverage. In (Vol. 88, pp. 402-403): SciELO Public Health.

Fonta, W. M., Ichoku, H. E., & Ataguba, J. E. (2010). Paying for community-based health insurance schemes in rural Nigeria: the use of in-kind payments. *African review of money finance and banking*, 109-128.

Gottret, P. E., & Schieber, G. (2006). *Health financing revisited: a practitioner's guide*: World Bank Publications.

Leive, A., & Xu, K. (2008). Coping with out-of-pocket health payments: empirical evidence from 15 African countries. *Bulletin of the World Health Organization*, 86(11), 849-856C.

Maeda, A., Araujo, E., Cashin, C., Harris, J., Ikegami, N., & Reich, M. R. (2014). *Universal health coverage for inclusive and sustainable development: a synthesis of 11 country case studies*: World Bank Publications.

Mariam, D. H. (2001). Exploring alternatives for financing health care in Ethiopia: an introductory review article. *Ethiopian Journal of Health Development*, 15(3), 153-163.

Mebratie, A. D., Sparrow, R., Yilma, Z., Alemu, G., & Bedi, A. S. (2015). Dropping out of Ethiopia's community-based health insurance scheme. *Health policy and planning*, 30(10), 1296-1306.

Mirach, T. H., Demissie, G. D., & Biks, G. A. (2019). Determinants of community-based health insurance implementation in west Gojjam zone, Northwest Ethiopia: a community based cross sectional study design. *BMC health services research*, 19, 1-8.

Mwaura, J. W., & Pongpanich, S. (2012). Access to health care: the role of a community based health insurance in Kenya. *Pan African Medical Journal*, 12(1).

Nair, D. (2016). Determinants of enrollment in comprehensive health insurance scheme and implementation challenges: a study in Kerala, South India. *Health Science Journal*, 10(1), 1.

Nimpagaritse, M., & Bertone, M. P. (2011). The sudden removal of user fees: the perspective of a frontline manager in Burundi. *Health policy and planning*, 26 (suppl 2), ii63-ii71.

Noubiap, J. J. N., Joko, W. Y. A., Obama, J. M. N., & Bigna, J. J. R. (2014). Community-based health insurance knowledge, concern, preferences, and financial planning for health care among informal sector workers in a health district of Douala, Cameroon. *Pan African Medical Journal*, 16(1).

Organization, W. H. (2000). *The world health report 2000: health systems: improving performance:* World Health Organization.

Pablo, P., & Schieber, G. (2006). Health financing revisited: A practitioner's guide. *The International Bank for Reconstruction and Development/The World Bank.*

Ridde, v., asomaning antwi, a., Boidin, B., chemouni, B.,Hane, F., & touré, l. (2018). time to abandon amateurism and volunteerism: addressing tensions between the Alma-Ata principle of community participation and the effectiveness of community-based health insurance in Africa. *BMJ Global Health*, 3(Suppl 3), e001056. https://doi.org/10.1136/bmjgh-2018-001056

Solomon, F., Hailu, Z., & Tesfaye, D. (2011). Ethiopia's community-based health insurance: a step on the road to universal health coverage. Health Financ Gov.

Tabor, S. R. (2005). Community-based health insurance and social protection policy. World Bank, Washington: Social Protection Discussion Paper Series.

Taddesse, G., Atnafu, D. D., Ketemaw, A., & Alemu, Y. (2020). Determinants of enrollment decision in the community-based health insurance, North West Ethiopia: a case-control study. *Globalization and health*, 16(1), 1-9.

Tien, t. v., Holst, J., & Brandrup-lukanow, a. (2005). the inclusion of the poor in a social health insurance frame work: the strategies applied in vietnam. Extending Soc Prot Health GTZ Version Frankf Am Main, 63–70.

Uzochukwu, B., Onwujekwe, O., Eze, S., Ezuma, N., Obikeze, E., & Onoka, C. (2010). Implementing community based health insurance in Anambra State, Nigeria. CREHS policy brief February.

Wang, H., & Pielemeier, N. (2012). Community-based health insurance: An evolutionary approach to achieving universal coverage in low-income countries. *Journal of life sciences*, 6(3), 321-330.

Wiesmann, D., & Jütting, J. (2000). The emerging movement of community based health insurance in Sub-Saharan Africa: experiences and lessons learned. *Africa spectrum*, 193-210.

Xu, K., Evans, D. B., Carrin, G., Aguilar-Rivera, A. M., Musgrove, P., & Evans, T. (2007). Protecting households from catastrophic health spending. *Health affairs*, 26(4), 972-983.

Zhao, Y., Kang, B., Liu, Y., Li, Y., Shi, G., Shen, T., . . . Wang, L. (2014). Health insurance coverage and its impact on medical cost: observations from the floating population in China. *PloS one*, 9(11), e111555.