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RESPONSE OF TOMATO FRUIT PHYSICOCHEMICAL QUALITY AND SHELF LIFE TO MATURITY STAGE AND STORAGE DURATION

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Abstract

As a climacteric nature and fresh produce, tomato is highly perishable that needs smooth postharvest handling, technologies and treatment methods to maintain its quality and extend shelf life. The aim of the study was to explore the influence of different maturation stages and storage duration. The experiment was conducted in Dilla University from April to May 2021 which consisted of five maturation stages and five storage duration with three replications arranged in CRD factorial combination. Fifty fruits for each maturity stage were taken and packed inside boxes and stored in refrigeration at 12°C temperature and 95% relative humidity. Fruits were evaluated for firmness, pH value, total soluble solids, titratable acidity and shelf life. The interaction effects of maturation stage and storage period were highly significant in fruit firmness, titratable acidity, pH value and shelf life. The highest firmness was observed in fruits harvested at full green stage (0% coloration) during the initial storage period and declined when fruits get ripened and stored for prolonged period of time. Total soluble solids and pH value increased simultaneously with advancing maturation stage and storage duration. However, the content of titratable acidity increased up to half ripening stage and the second week, followed by a diminishing trend when fruits fully ripened and stored for prolonged time. Therefore, harvesting at the right maturation stage and proper postharvest handling of tomato fruits is vital to maintain physicochemical quality and extend storability potential with obvious commercial interest.

Keywords: Maturity stage, Postharvest handling, Quality, Tomato, Shelf life

1 Introduction

Tomato (*Solanum lycopersicum* L.) is one of the popular horticultural crops in Ethiopia (Yusufe *et al*., 2017) and ranked first among all vegetables in terms of its nutritional contribution with high biological activity in the human diet (Suarez *et al*., 2018). The issue of post-harvest losses is of high importance in the efforts to combat hunger, raise revenue and improve food security in the world's poorest countries like Ethiopia. One-third of food produced for human consumption is lost or wasted globally, which amounts to about 1.3 billion tons per year (Gustavsson *et al*., 2011) due to post-harvest losses. In Ethiopia the highest postharvest loss (45.3%) is recorded in tomato fruit (Kasso and Bekele, 2018).

Tomato as a climacteric fruit, its ripening process is a genetically programmed of events that terminates with senescence (Al-Dairi *et al*., 2021; Tiwari *et al*., 2020). Postharvest factors such as transpiration, fungal infection, acceleration of the ripening process and senescence could affect the quality parameters of tomato fruit. Preservation treatments (Alyousuf *et al*., 2021; Chavan and Sakhale, 2020), postharvest handling technologies (Dyshlyuk *et al*., 2020;

Aghadi *et al*., 2020; Changwal *et al*., 2021) and low temperature are the effective mechanisms to reduce ethylene production (Riudavets *et al*., 2016).

The main features of tomato such as rapid ripening rate and high perishability shortened the shelf life and rapid loss of qualities (Paul and Pandey, 2013; Opara *et al*., 2011). Ethylene hormone is considered as trigger of a wide range of physical, physiological and biochemical changes in tomato. The ripening process is accelerated by ethylene and this endogenous production of that hormone results in short postharvest life (Tiwari *et al*., 2020). The effect of the ripening stage on the postharvest quality of tomatoes can further be compounded by sub-optimal handling such as rough handling, poor sanitation and warm storage temperatures, which provide opportunities for huge losses (Al-Dairi *et al*., 2021; Abera *et al*., 2020; Chavan and Sakhale, 2020; Gatahi, 2020).

Tomato fruits are harvested at different ripening stages from mature green to red coloured depending on the market requirements (Njume *et al*., 2020) and consumer preferences (Tolasa *et al*., 2021). When fruits are harvested at early maturity stages, they may not have developed the ability to produce much flavour. On the other hand, if fully ripened fruits were harvested, they would have a very short postharvest life (Changwal *et al*., 2021).

Even though there are several research findings in tomato pre and postharvest handling and processing technologies, there is limited information on the influence of maturity stages and storage duration on retaining the postharvest physicochemical quality properties and extending shelf life. Therefore, the purpose of this study was to mitigate the huge postharvest loss between producer and consumer mainly aimed to evaluate the response of tomato fruit quality and shelf life, harvested at different maturity stages and cold stored for prolonged periods.

2 Materials and Methods

2.1 Experimental Site Description

The experiment was carried out from April to May 2021 at Dilla University, which is located at $6°25'25''$ N latitude and $38°16'45''$ E longitudes. Dilla has an altitude of 1434 meters above sea level and found in 361*km* south of Addis Ababa, the capital city of Ethiopia. The temperature and relative humidity of the storage refrigerator were $12°C$ and 95%, respectively.

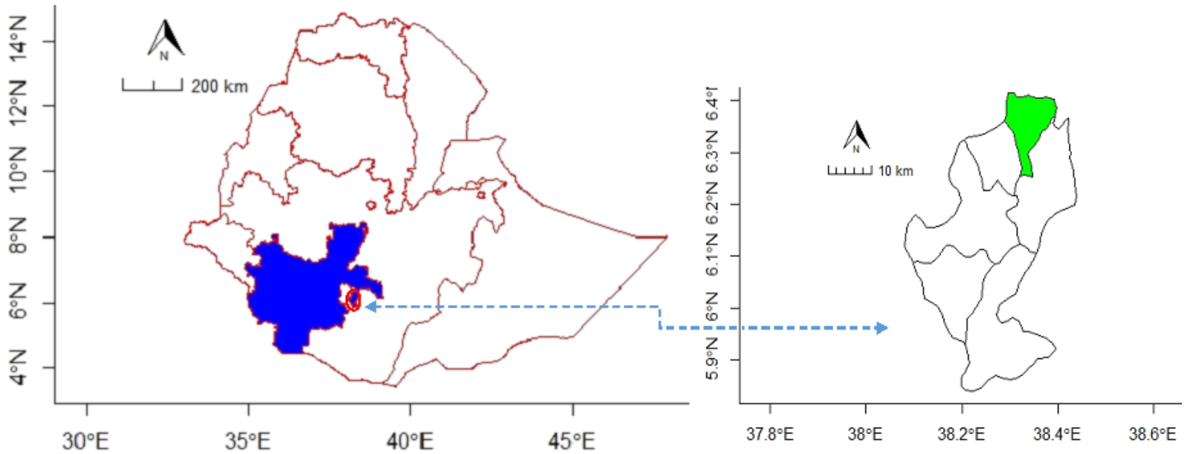

Figure 1. Research site (*Blue color: SNNPRS; Green color: Dilla Zuria wereda*)

2.2 Experimental Design and Treatments

The treatments were comprised of tomato fruit (plum variety) harvested at five maturity stages (0, 25, 50, 75, 100% colourations) and stored for four weeks (0, 1, 2, 3 and 4 weeks) under cold storage at 12°C temperature and 95% relative humidity. The treatments were combined in complete randomized design (CRD) factorial experiment, resulting in a total of 25 treatment combinations with three replications and 75 total observations (5*5*3). Each treatment consisted of fifteen fruits per replication packed in card board boxes for storage.

2.3 Experimental Procedures

Fruits of tomato were harvested from greenhouse in different maturity stages determined in the field by fruit colouration guide plus days from anthesis. The fruits were harvested manually with care to minimize mechanical injuries or damage at 0% colouration (full green), 25% colouration, 50% colouration (half ripened), 75% colouration, and 100% colouration (completely ripened). After harvest, tomato fruits were immediately transported using plastic crates and held at 12°C temperature and 95% relative humidity. Fruits with bruises, sign of infection or those different from the group were discarded from the samples. The fruits were also washed with tape water, surface dried with soft cloth and subdivided, sorted, weighed and stored in three refrigerators as technical replication. All fruits were packed using a card board box for all treatments separately.

2.4 Data Collection Procedures

Samples of tomato fruits were randomly taken from each treatment for physicochemical quality assessments. First, data were measured at the initial stage of storage period and subsequent records were taken each week. Fruit quality data were collected for firmness, total soluble solids, titratable acidity, pH value and determined the storability potential of tomato fruits.

2.4.1. Fruit Firmness

Fruit firmness was measured using texture analyzer according to Xie *et al.* (2009). The firmness measurement was carried out using a cylindrical stainless-steel probe of 2mm in diameter. The speed of the probe was set at $1mm.s^{-1}$. Puncture tests were carried out on rectangular fruit pieces taken from the two opposite equatorial sides of the same fruit. Three tomato fruits were analyzed per replication and results were expressed in Newton per pod.

2.4.2. Total Soluble Solids (TSS)

Juice of tomato fruits was extracted from three fruits in a blender as described by Cherono *et al.* (2018). The homogenized sample was filtered using funnel with filter paper in a beaker. The filtrate was taken for TSS determination using digital refractometer in ^{o}Brix by placing a few drops of clear tomato juice on the prism surface. Between samples, the prism of the refractometer was cleaned thoroughly, rinsed with distilled water and dried using soft tissue paper.

2.4.3. Titratable Acidity (TA)

10ml juice of tomato fruit was extracted from three fruit samples, 90ml of distilled water was added and then homogenized in a blender. The homogenized sample was filtered by funnel with filter paper in a beaker. The titratable acidity of tomato was measured by titration instrument using $NaOH$ (0.1N) as a standardized titration solution (Teka, 2013). The $NaOH$ was slowly titrated into the juice-water solution. When the point of neutrality or the end point of titration was reached at pH of 8.2, the amount of $NaOH$ used on the burette read off and recorded to calculate the TA using the following formula.

$$TA(g) = \frac{(Titre * 0.1N\,NaOH * 0.67)}{1000} * 100$$

2.4.4. pH Value

10ml juice of tomato was extracted from three fruits and 90ml distilled water was added and homogenized in a blender as described by Cherono *et al.* (2018). The homogenized sample was filtered using funnel with filter paper in a beaker and the *pH* value of the filtrate was measured using *pH* meter with the application of the electrode directly in to the blended pulp. The electrode was removed and rinsed in distilled water to make it ready for the next sample test.

2.4.5. Shelf Life

The shelf life of tomato fruits was evaluated by counting the number of days required to attain the last stage, but up to the stage when fruits remained still acceptable for marketing as described by Pila *et al.* (2010). It was decided based on the appearance and spoilage of fruits. When 50 percent of fruits showed symptoms of shrinkage or spoilage due to pathogens and chilling injury, that lot of fruits was considered to have reached end of shelf life.

2.5 Statistical Analysis

The experiment was subjected to two-way analysis of variance in complete randomized design and data were analysed using R program (version 4.1.4, 2021). Analysis of variance was performed to determine the effect of independent variables (maturity stage and storage duration) on the dependent variables (TSS, TA, *pH* value, firmness and shelf life) at a 5% significance level ($P < 0.05$). To determine the significant differences between treatment means, fisher's range test was applied. Correlation analysis was also computed to see the relationship between the principal components.

3 Results and Discussion

3.1 Fruit Firmness

The interaction effect of maturity stage and storage duration on tomato fruit firmness shown high significance ($P < 0.001$). The highest firmness (82.89 *N*) was observed in fruits harvested at 0% maturation stage (full green) during the initial storage period, followed by fruits harvested at 0% maturation stage stored for one week (74.14 *N*) and 25% maturation stage at the initial storage period (73.74 *N*). On the other hand, the minimum values of tomato fruit firmness were recorded at 100% maturation stage (fully ripened) during the fourth (16.49 *N*) and third (22.46 *N*) weeks, respectively (Figure 2).

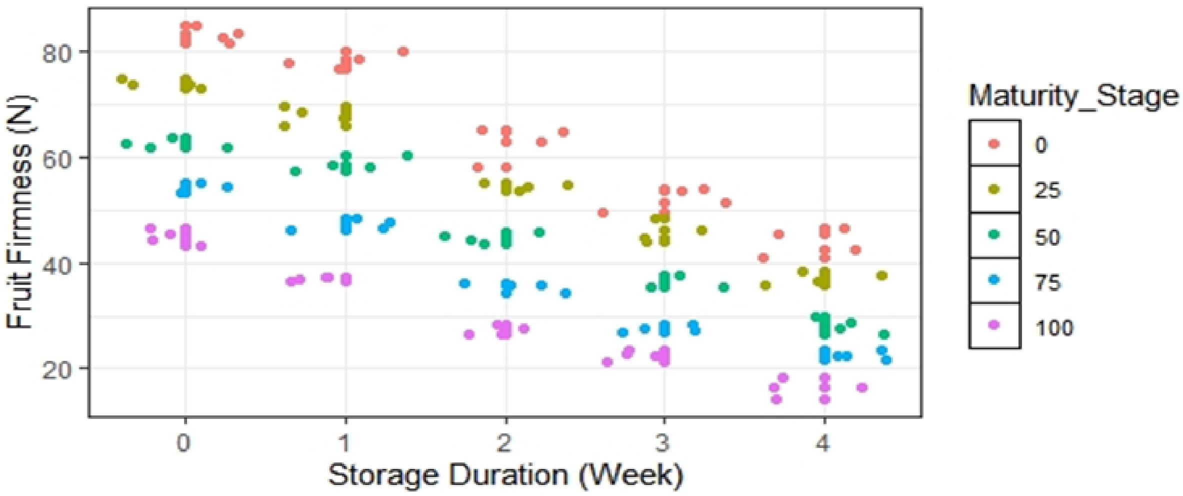

Figure 2. Response of tomato fruit firmness to maturity stage and storage duration

Fruit firmness was in an increment trend with declining maturity stages and storage duration (Figure 2). Fruits harvested at the full green stage were firmer by 46.31% than fruits harvested at complete ripened stage. The finding of this study is incoherence with several research results (Tolasa *et al.*, 2021) who stated that fruit firmness is deteriorated with increasing ripening stages. The apparent decline in fruit firmness with increased maturity stage might be due to cell wall softening directly influencing the levels of fruit firmness. It is also in agreement with the result of Pila *et al.* (2010) who reported that decrease in texture is due to the activity of softening enzymes such as pectin methyl esterase (Chuni *et al.*, 2010). This could also be due to the presence of hemicelluloses and pectin substances that lead to disruption and loosening of the cell walls (Paul and Pandey, 2013).

Tomato fruit firmness reduced throughout the storage periods. The highest value of fruit firmness was reported at the initial storage time and the lowest value during the fourth week. This result is in agreement with several research findings (Tolasa *et al.*, 2021; Chavan and Sakhale, 2020; Moneruzzaman *et al.*, 2008). The decline in firmness of tomato fruits during increase storage periods could be due to high respiration rate, weight loss and enzymatic changes (Cantwell *et al.*, 2009). It was indicated that the high-water content of fruits might have provided high turgidity and resulted in high fruit firmness at the initial storage period (Tolasa *et al.*, 2021). Tomato fruit firmness had very strong negative correlation ($r = -0.97^{***}$) with total soluble solids and pH value ($r = -0.95^{***}$) while positive correlation ($r = 0.56^{**}$) with titratable acidity (Figure 3).

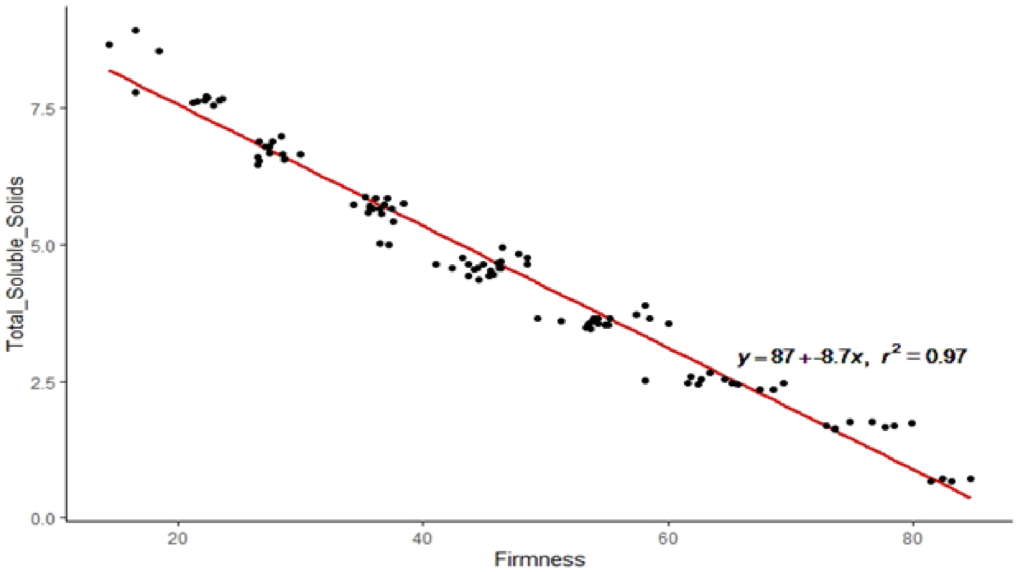

Figure 3. Correlation between firmness and total soluble solids of tomato fruit

3.2 Total Soluble Solids (^{o}Brix)

The main effect of maturity stage and storage period in tomato total soluble solid shown highly significant difference ($P < 0.001$); while the interaction effect was non-significant ($P > 0.05$). The data presented in figure 4 vividly depicts that TSS of tomato was influenced by maturity stage and storage duration. TSS content increased with advancing in maturity stages. The mean TSS of tomato fruit harvested at 0, 25, 50, 75 and 100% maturation stages were 2.60, 3.60, 4.65, 5.62 and 6.59 ^{o}Brix, respectively. The maximum TSS value recorded at fully ripened stage was higher by 39.45% compared to fruits harvested at full green stages.

The TSS content in this study is in alignment with several research findings (Tolasa *et al.*, 2021) who reported an increasing trend in TSS content as the maturity stages increased. The increment in TSS might be due to disassociation of some molecules and structural enzymes to soluble compounds, which directly influence the levels of total soluble solids (Dyshlyuk *et al.*, 2020; Chuni *et al.*, 2010). The increase in TSS during successive stages of maturation could also be due to the degradation of polysaccharides to simple sugars thereby causing a rise in the level of TSS (Tolasa *et al.*, 2021; Moneruzzaman *et al.*, 2008; Zapata *et al.*, 2008).

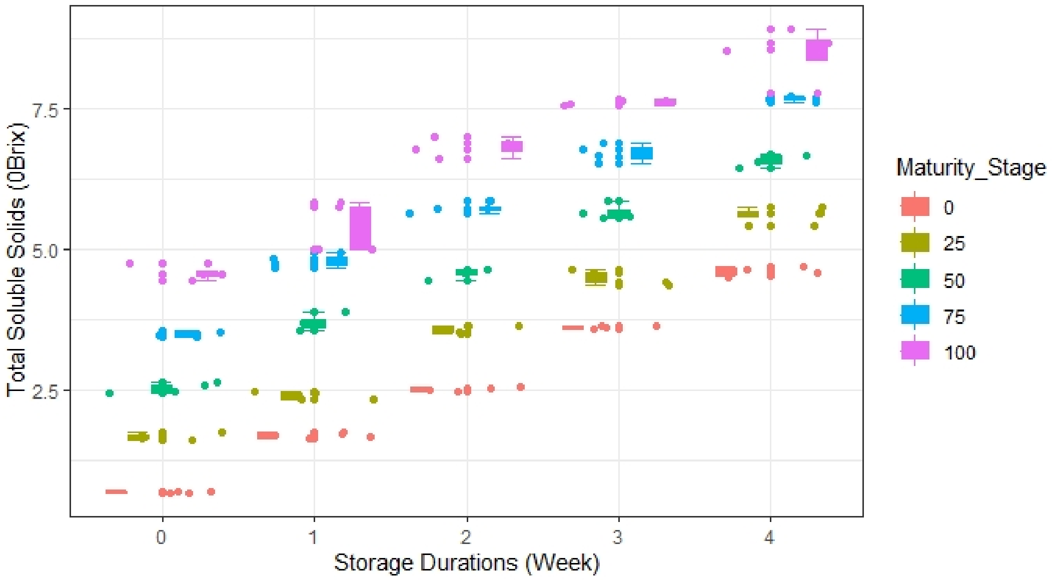

Figure 4. Response of tomato fruit total soluble solid to maturity stage and storage duration

Like maturity stages, TSS of tomato fruits was also influenced by storage duration. TSS content increased alongside storage duration. This result is in line with reports of Al-Dairi *et al.*, 2021, Tolasa *et al.*, 2021, Pila *et al.*, 2010; Cantwell *et al.*, 2009) who found that an increase in total soluble solids during prolonged storage periods. The increment in the TSS content for stored fruits was probably due to increasing of respiration and metabolic activity. In this regard Pila *et al.* (2010) found that higher respiration also increases the synthesis and use of metabolites resulting in higher TSS due to the higher change from carbohydrates to sugars. It could also be due to fruit senescence, degradation and high weight loss (Cantwell *et al.*, 2009) and the hydrolytic changes in starch concentration (Gyanendra, 2012) during storage which may lead to higher concentration of sugars in fruits.

3.3 Titratable Acidity (%)

There was a highly significant ($P < 0.001$) difference in the interaction effects of maturity stage and storage duration on titratable acidity (TA) of tomato fruits (Figure 5). The maximum (1.51%) and minimum (0.27%) TA values of tomato fruit were observed at 50% maturation stage stored for one week and 100% maturation stage at the fourth week of storage time, respectively. TA values increased from full green to 50% maturation stages followed by a gradual declining when fruits ripening to the completely coloured stage throughout all storage duration. This result is in line with Al-Dairi *et al.* (2021), Zapata *et al.* (2008), Moneruzzaman *et al.* (2008) and Cantwell *et al.* (2009) who reported that TA increased with increasing in storage time; and the highest TA values were found in fruits harvested at maturation stage than green fruits. In addition, Tolasa *et al*. (2021) stated that tomato fruit titratable acidity decreased with advancing in maturity stages, and the maximum acidity was found in half-matured tomato and declined in fully ripened fruits. The reduction in titratable acidity during storage might be due to the fruits undergoing the ripening process which diminished its malic acid and favoured the formation of sugars (Moneruzzaman *et al*., 2008).

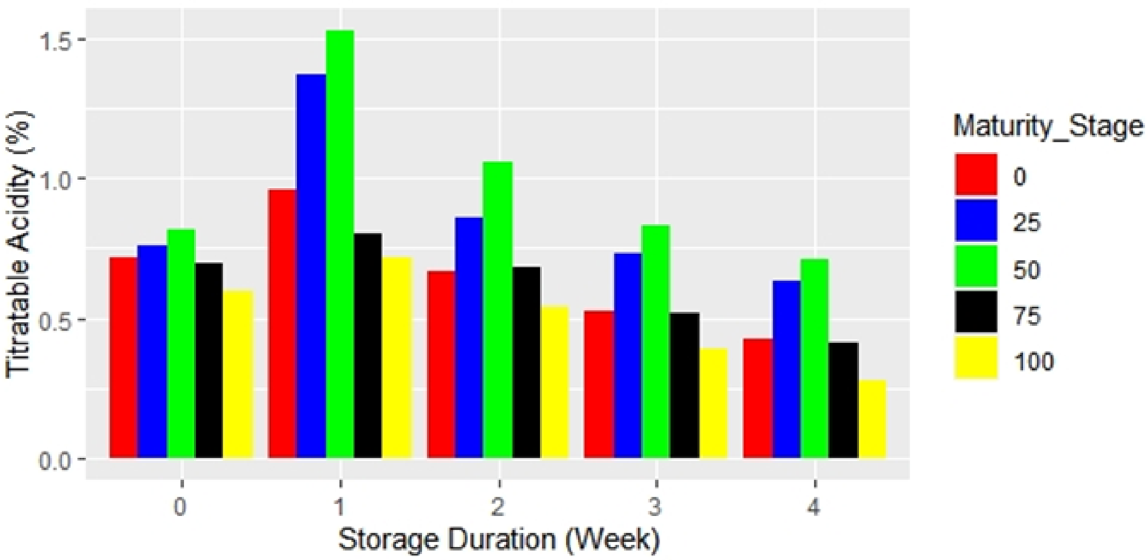

Figure 5. Response of tomato titratable acidity to maturity stage and storage duration

Regarding to the storage duration, there was an increment in titratable acidity until the first week followed by a decreasing trend with increasing storage period. This finding agrees with reports of Tolasa *et al*. (2021) and Anthon *et al*. (2011) who observed that titratable acidity of fruits increased to some extent and then decreased with prolonged storage periods. As confirmed by Anthon and Barrett (2012), this could be due to higher rate of respiration and fruit senescence during increasing storage period that might have utilized titratable acids as a substrate for catabolic process. This is in line with the work of Chavan and Sakhale (2020) who stated that the decrease in TA value during prolonged storage period is due to the rise in respiration rate that might necessitate using more organic acids in the respiration process. In accordance with the reports of Dyshlyuk *et al*. (2020), fruits might utilize the acids during the storage so that the acid in the fruits during prolonged storage periods decreases. This fact has been further substantiated by Tolasa *et al*. (2021) who observed that the change in titratable acidity during prolonged storage was mainly due to the metabolic activities of living tissues which takes place depletion of organic acids.

3.4 *pH* Value

The interaction effect of maturity stage and storage duration on *pH* value of tomato fruits shown highly significant ($P < 0.001$) difference (Table 1). The *pH* of tomato fruits progressively increased with increasing in storage duration. The highest (7.34) and lowest (2.87) *pH* values of tomato fruit were observed at 100% maturation stage stored for four weeks and 0% maturation stage at the initial storage period, respectively. *pH* values increased from full green to full maturation stages throughout all storage duration.

Table 1. Interaction effect of maturity stage and storage duration on tomato *pH*-value (mean ± sd)

Maturity Stage (%)	Storage Duration (Weeks) 0	1	2	3	4	Mean
0	2.87 ± 0.05^r	3.36 ± 0.02^p	3.89 ± 0.08^n	4.17 ± 0.11^{kl}	4.49 ± 0.05^j	3.74±0.06
25	3.16 ± 0.05^q	3.76 ± 0.08^o	4.24 ± 0.05^k	4.48 ± 0.12^j	5.02 ± 0.10^h	4.13±0.08
50	3.70 ± 0.02^o	4.08 ± 0.06^{lm}	4.81 ± 0.05^i	5.07 ± 0.06^h	5.55 ± 0.08^f	4.64±0.05
75	4.03 ± 0.06^m	4.48 ± 0.12^j	5.18 ± 0.05^g	5.57 ± 0.05^f	6.31 ± 0.14^c	5.11±0.08
100	4.59 ± 0.12^j	5.86 ± 0.09^e	6.20 ± 0.11^d	6.86 ± 0.08^b	7.34 ± 0.06^a	6.17±0.09
Mean	3.67±0.06	4.30±0.07	4.86±0.07	5.23±0.08	05.74±0.09	
P-Value		***				
LSD		0.11				
CV (%)		1.69				

This finding is in agreement with Tolasa *et al*. (2021) who reported that *pH* content increased with advancing in ripening stages of tomato fruit. The rise in *pH* value during increasing fruit ripening stage was probably due to the decline of titratable acidity. This is in line with Anthon *et al*. (2011) who reported that the increase in *pH* value was paralleled by a decrease in titratable acidity, due to loss of respiratory citric acid. In contrast, Fawole and Opara (2013) reported that there was no significant difference in *pH* values during maturity stages of tomato fruits.

The highest *pH* value of tomato fruit was observed on the fourth week while the lowest *pH* value was recorded in the initial storage time. This result is in line Tolasa *et al*. (2021) who reported that days of storage induced to increase *pH* of fruit juice. It was also confirmed by Al-Dairi *et al*. (2021) who found that there is an increment in *pH* value of tomato fruit during advancing in storage duration. The increase in the *pH* of stored fruits might be due to decreasing in acidity of the fruit and metabolic activity. Tomato *pH* value had a very strong positive correlation ($r = 0.90^{***}$) with total soluble solids (Figure 6).

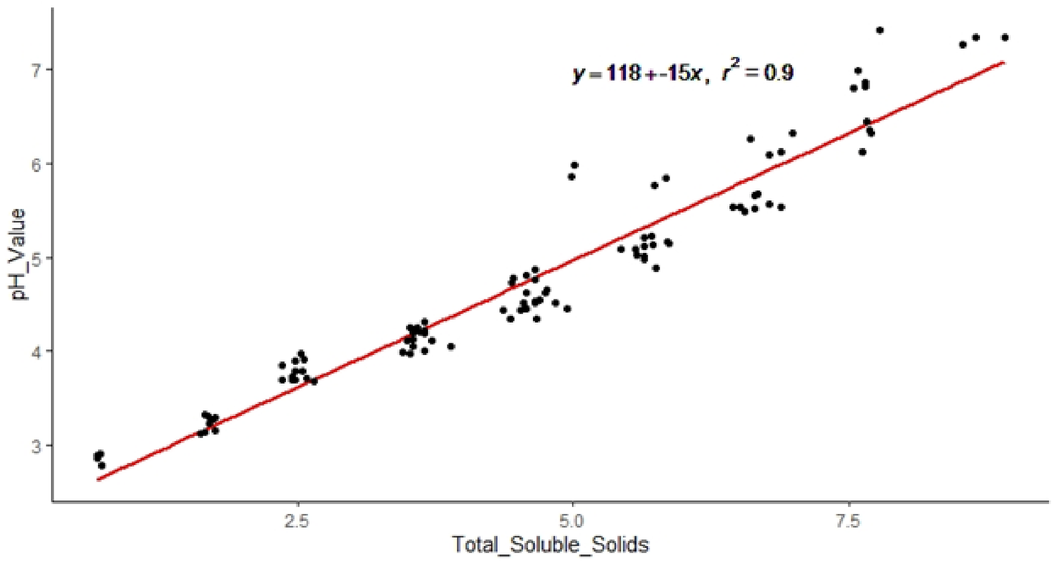

Figure 6. Correlation between pH value and total soluble solids of tomato fruits

3.5 Shelf Life

The interaction effects of maturity stage and storage duration on shelf life of tomato fruits shown highly significant difference ($P < 0.001$) (Table 2). The maximum shelf life was recorded at 50% maturation stage (30.65 days) followed by 25% maturation stage (27.62 days) stored for four weeks while the minimum shelf life was observed at full green stages during the initial storage period (12.27 days) and week one (14.46 days). At the initial storage periods, fruits harvested at 0% and 100% coloration stages end their shelf life due to rotting, wilting, chilling injury and development of spots on the fruit skin.

Table 2. Interaction effect of harvesting stage and storage duration on mean shelf life (days)

Maturity Stage	Storage Duration (Weeks)					Mean
(%)	0	1	2	3	4	
0	12.27^k	14.46^j	15.26^i	16.76^h	18.51^g	15.45
25	18.41^g	22.98^e	24.34^d	25.63^c	27.62^b	23.80
50	21.15^f	24.35^d	25.85^c	27.41^b	30.65^a	25.88
75	16.52^h	18.87^g	22.65^e	24.43^d	25.65^c	21.62
100	15.26^i	16.73^h	17.17^h	21.24^f	23.56^e	18.79
Mean	16.72	19.48	21.05	23.09	25.20	
P-Value			***			
LSD			0.69			
CV (%)			11.27			

The results are in line with the findings of several researchers (Changwal *et al*., 2021; Tolasa *et al*., 2021; Pila *et al*., 2010), who reported that tomato fruits harvested at half ripened stage had a better shelf life than the unripe and full red tomato fruits. This could be due to the high weight loss percentage and respiration rate of completely ripened fruits and lack of a well-developed fruit cuticular wax layer at full green stage which in turn might have resulted in lower shelf life. Moreover, the increasing trend in overall shelf life of fruits during prolonged storage period might be due to the presence of refrigeration storage equipment. This reality is supported by Chavan and Sakhale (2020) who found that refrigeration is used to reduce spoilage and extend the shelf life of fresh fruit and vegetables by slowing down the metabolism and reducing fruit deterioration.

4 Conclusion

In the investigation of the effect of maturity stages (0, 25, 50, 75 and 100% fruit colouration) and storage duration (0, 1, 2, 3 and 4 weeks) on fruit firmness, total soluble solids, titratable acidity, *pH* value and shelf life of tomato fruits, there was a significant difference in the main or interaction effects. The interaction effect of maturity stage and storage duration was highly significant ($P < 0.001$) in titratable acidity, *pH* value, fruit firmness and shelf life. The main effects of maturity stage and storage duration on total soluble solids shown highly significant difference ($P < 0.001$). TSS and *pH* value increased while fruit firmness and the storability potential of tomato fruits declined with advancing maturity stages. Fruits harvested at 50% and 25% colouration stages had the highest titratable acidity and shelf life across all storage duration which could be used for long distance marketing.

Conflict of Interest

The author declares that there is no conflict of interest.

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CROPPING SYSTEM, SOIL CONSERVATION AND TECHNOLOGY ADOPTION IN THE ENSET (*Ensete ventricosum* (Welw.) Cheesman) BASED FARMING SYSTEM IN GEDEO ZONE, SOUTHERN ETHIOPIA

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Abstract
Enset (Ensete ventricosum) is a multipurpose crop used for food, fodder, fiber production, fuel, traditional medicine, and other cultural practices. The Gedeo enset based farming system is diversified and unique in its design and function. The objective of this study was to assess cropping system, soil conservation, and technology adoption in the Gedeo enset based farming. The enset based farming system of Gedeo was stratified based on the agro-ecological zones. Accordingly, two kebeles from Dega (highlands), four kebeles from Weyna Dega (midland), and one kebele from Kola (lowland) woredas were selected. Data were collected through key informant interviews, structured questionnaires, and focus group discussions. A total of 230 randomly selected households were interviewed, which was about 10% of the total number of enset producers. The study provides an overview of enset based farming systems, traditional and modern tools, soil erosion conservation activities, and technology adoption of the Gedeo. The result revealed that compared to other existed mixed crops, as altitude increases, enset cropland coverage increases. In lowland areas, the land cover of enset was insignificant. Comparative enset-coffee land covers mainly maters in the midland. The type and the number of animals holding differ across and within the households. In the Gedeo agroforestry system, the problem of soil erosion and conservation practices was insignificant. The result suggests the need for the involvement of the concerned body in the introduction and dissemination of improved technologies by considering the agroforestry system and the mixed crops.

Keywords: Cropping system, Enset, Soil conservation, Technology adoption

1 Introduction

Enset (*Ensete ventricosum*) plant belongs to the order Zingiberales, family Musaceae and the genus Ensete. It is a perennial, monocarpic, herbaceous, drought-tolerant, banana-like plant (Birmeta *et al.*, 2004; Kress *et al.*, 2001). Commonly in Ethiopia known by its vernacular name enset. It is a multipurpose crop used for food, fodder, fiber production, fuel, traditional medicine, and other different cultural practices (Kippe, 2002; Negash and Niehof, 2004; Tsegaye, 2002; Tsehaye and Kebebew, 2006). It is a staple or co-staple food crop for more than one-fifth of Ethiopia's population (Brandt *et al.*, 1997). Its multi-annual production time and flexibility in harvesting make the crop a reliable food source (Rahmato, 1995).

Enset has only been domesticated in Ethiopia and produced in Southern Nation and Nationality Peoples, Oromia, and Gambella Regional States of Ethiopia (Tsegaye, 2002). The Gedeo enset farming system is unique in its design and function. In Gedeo, enset-based agricultural systems date back from the Neolithic (Kippe, 2002).

The diversity of the systems and the ability of enset to produce a relatively large amount of food per unit area and time could be the main factors that contributed to this stability (Tsegayei and Struik, 2001). Enset improves directly or indirectly the local climate and soil conditions (Tsegaye and Struik, 2001).

The decline in productivity was primarily associated with population pressure, recurrent drought, increased incidence of enset pest and disease, degradation of the soil and the environment (Shumbulo *et al*., 2012; Tsegaye and Struik, 2001). Before modifying existing approaches or technologies to improved new scientific methods, information on the status and conditions of the cropping system is needed. Hence, the objective of this research was to assess cropping system, soil conservation, and technology adoption in the Gedeo enset based farming.

2 Materials and Methods

2.1 Location of the Study Area

Out of the total area of the Gedeo Zone, midlands cover 67.53%, highlands 32.41%, and lowlands 0.06%. The mean annual temperature of the zone ranges between 12.6-22.5°*C*, and the mean annual rainfall ranges between 1001-1800*mm* (Kippe, 2002). It is sub-divided into six woredas. It is 90*Km* far from Hawassa and 360*Km* from Addis Ababa. The zonal capital is Dilla, situated on the road from Hawassa to Moyale (Figure 1).

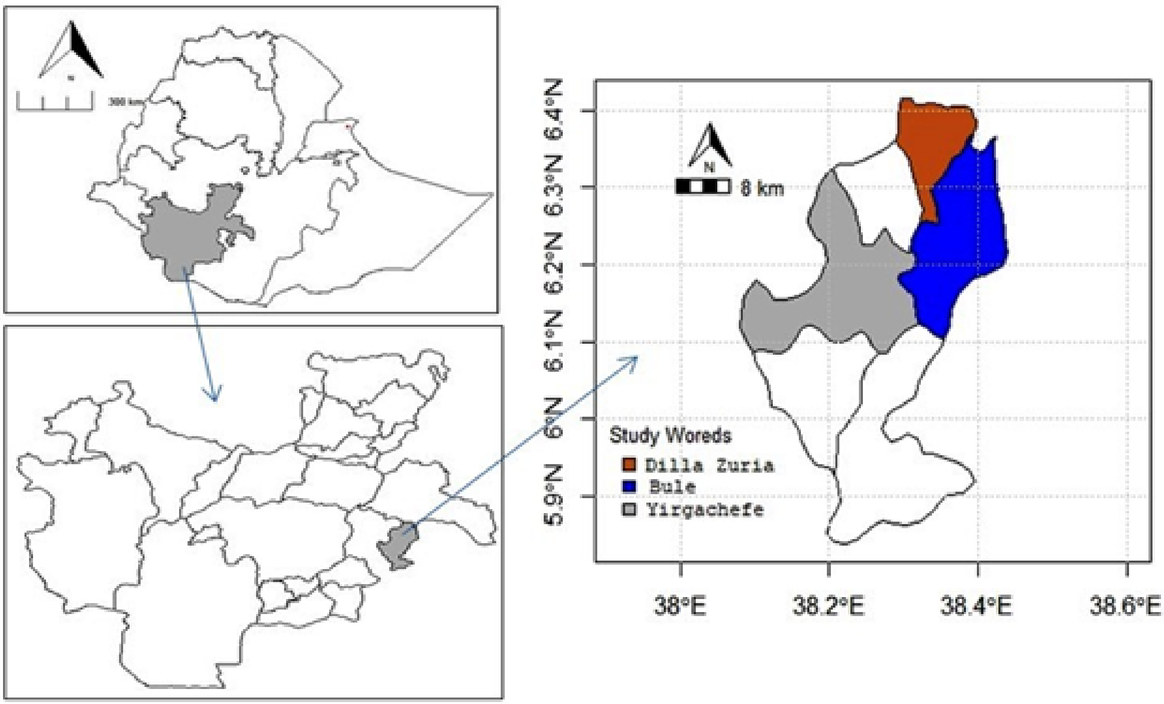

Figure 1. Map of the study area

2.2 Survey Design and Data Collection

The enset farming system of Gedeo was stratified based on the agro-ecologic zones. These were lowlands ($<1,500$ m.a.s.l), midlands (1,500-2,500 m.a.s.l) and highlands ($>2,500$ m.a.s.l) (Kippe, 2002). Accordingly, two kebeles ('*Haro Welabu*' and '*Sika*') from Dega (highland) of Bule woreda, four kebeles ('*Wete*', '*Bowcha*', '*Amba*', '*Haru*') from Weyna Dega (midland) of Yirgachefe and Dilla Zuria woredas, and one kebele from Kola (lowland) Dilla town were selected. Data were collected through interviews, structured questionnaires, and focus group discussions. Key informants were selected and interviewed by consulting agriculture experts and development agents. Cultural attachment and indigenous knowledge of enset were the main criteria for selecting key informants. From each woreda, three key informants participated in the interview. A semi-structured questionnaire was developed based on key informants and secondary data and pretested before the data collection. A total of 230 households were randomly selected, which was about 10% of the total number of enset producers (Table 1).

Table 1. Socio-economic data of respondents from each Kebeles

Household Characteristics	Category	Respondents' Frequency (%)						
		Haro Welabu	Sika	Wete	Bowcha	Amba	Harsu	Haroresa
Gender	F	9.1	20.0	12.8	12.3	46.2	30.0	50.0
	M	90.9	80.0	87.2	87.7	53.8	70.0	50.0
Land size	< 1	0.0	3.5	3.0	66.7	80.0	8.0	12.8
	(1-2]	15.4	50.9	42.4	33.3	10	64	66.3
	(2-2.5)	46.2	17.5	12.1	0.0	0.0	24.0	12.8
	≥ 2.5	38.5	28.1	39.4	0	10	4	8.2
Education level	< 8	46.2	86.0	87.9	83.4	60.0	95.8	86.0
	9-12	30.8	14.0	12.1	0.0	30.0	4.2	14.0
	> 12	23.1	0.0	0.0	16.7	10.0	0.0	0.0
Family size	< 5	0.0	22.8	6.1	50.0	10.0	12.0	8.1
	5-10	38.5	70.2	51.5	33.3	50.0	76.0	82.6
	> 10	61.5	7.0	42.4	16.7	40.0	12.0	9.3
Age	< 30	0.0	29.8	18.2	0.0	10.0	12.0	0.0
	30-60	100.0	64.9	81.8	66.7	90.0	80.0	95.3
	61-80	0.0	5.3		16.7	0.0	8.0	4.7
	> 80	0.0	0.0	0.0	16.7	0.0	0.0	0.0

2.3 Data Analysis

The collected data were checked for completeness and reliability. Data clarification was performed using focus group discussions and field observation. In addition, informal and formal group discussions, and expert elicitations were conducted to verify inconsistencies and enrich and validate information gathered from individual interviews. Descriptive statistical summaries such as frequencies, percentages, and averages performed using R version 4.0.3 (R Development Core Team, 2020).

3 Results and Discussion

3.1 The Farming System

3.1.1. Cropping System

According to most respondents, the land coverage of enset compared to other mixed-crops was almost equal at the lowland (Haroresa) and the lower-midland (Harsu, Amba, and Bowcha; Table 2). The land coverage was high in the higher-midland (Wete) and the lower-highland (Sika), but it was lower in the higher-highland (Haro Welabu; Table 2). Other authors also reported the intercropping of enset with perennial tree crops, especially fruit and coffee, in enset based farming systems (Temesgen *et al.*, 2014; Belachew *et al.*, 2017).

According to most respondents, the land coverage of coffee was low in the lower-midlands (Amba and Harsu) and the lowland compared to other existed mixed-crops (Haroresa); (Table 2). In the higher-midland, it was almost in equal coverage with other crops. However, it was nil in the highlands (Haro Welabu and Sika; Table 2). Some farmers (about 40%) from midlands (Wete and Bowcha) covered a large portion of their land by coffee than other mixed crops (Table 2).

Table 2. Relative land coverage of enset and coffee

Description	Relative land coverage	Respondents' Frequency (%)						
		Haro Welabu	Sika	Wete	Bowcha	Amba	Harsu	Haroresa
Enset compared to other crops	Higher	36.4	56.0	62.8	47.4	0.0	0.0	0.0
	Lower	51.5	32.0	0.0	0.0	7.6	40.0	20.0
	Almost equal	12.1	12.0	37.2	52.6	92.3	60.0	80.0
Coffee compared to other crops	Higher	0.0	0.0	37.2	38.6	0.0	0.0	0.0
	Lower	3.0	4.0	1.2	5.3	69.2	100.0	100.0
	Almost equal	0.0	0.0	61.6	56.1	30.8	0	0.0
	No coverage	97.0	96.0	0.0	0.0	0.0	0.0	0.0
Enset compared to coffee	Higher	100.0	100.0	46.5	17.5	69.2	0.0	80.0
	Lower	0.0	0.0	34.9	73.7	23.1	70.0	20.0
	Almost equal	0.0	0.0	18.6	8.8	7.7	30.0	0.0

Enset coverage compared to coffee was higher in the lowland (Haroresa) than in the highlands (Haro welabu and Sika; Table 2). In the midlands, the enset land coverage fluctuated across the farm. It was higher in Wete and Amba but lower in Bowcha and Harsu (Table 2). In Gedeo, at middle altitude in the range of 1600–2000 m.a.s.l, coffee and enset co-dominate the agroforestry system (Abebe and Bongers, 2012; Sileshi, 2016). The coffee component decreases with increased altitude but enset is found at all altitude ranges (Gebrehiwot and Maryo, 2015). Unlike the present study, other studies showed that at lower altitudes below 1600 m.a.s.l, enset is rare in coffee–fruit crops–tree-based agroforestry (Abebe and Bongers, 2012; Sileshi, 2016).

The enset based cropping system involves intercropping with diverse crop species and landrace (Adem and Kibatu, 2020; Abebe, 2005; Yemataw *et al.*, 2018; Tsegaye and Struik, 2002). In southern and southwestern parts of the country, in particular, in Gedeo agroforestry, coffee and enset are the dominant perennials (Taye *et al.*, 2001; Anteneh *et al.*, 2015; Bishaw *et al.* 2013). In southern Ethiopia, they cover more than 60% of the cropland (Abebe, 2013). The indigenous agroforestry of the Gedeo is interrelated to hundreds of plant species of herbaceous, trees, shrubs, and climbers (Mulugeta and Mabrate, 2017). Gedeo agroforestry is economically viable than other land-use systems because of the constituent high-value cash crops and staple crops. This practice improves the production system and increases productivity per unit area (Tsegaye and Struik, 2002). In coffee-producing areas, the diversification of coffee with compatible crop types like enset increases land resource use efficiency and productivity (Taye *et al.*, 2001; Anteneh *et al.*, 2015; Famaye, 2005; Begum *et al.*, 2015). The mixture helps the farmers to use the enset crop as food and income source. Coffee and enset optimum-intercropping ratio can enhance land-use efficiency and the yield and productivity of mixed crops (Mekonnen *et al*., 2020).

In Gedeo, planting density of enset showed variability within and across the agroecological zones (Figure 2). The highest planting density was from lowland areas, and the lowest was from midlands and highlands agroecology (Figure 2). Other studies also showed that the average landholding size of agroforestry is small, and they support a very high dense population (Abebe *et al*., 2006).

Planting density significantly affects yield. Optimizing planting density can result in increased crop production (Blomme *et al*., 2018). However, optimizing the Gedeo enset plant density is challenging due to the complex agroforestry system (Legesse *et al*., 2013; Abiyot, 2013; Mulugeta and Mabrate, 2017; Kippe, 2002) and smaller land size (Abebe & Bongers, 2012; Sileshi, 2016). It is also one of the challenges and sources of variation in estimating the area under production and yield for enset in the Gedeo zone (Borrell *et al*., 2020).

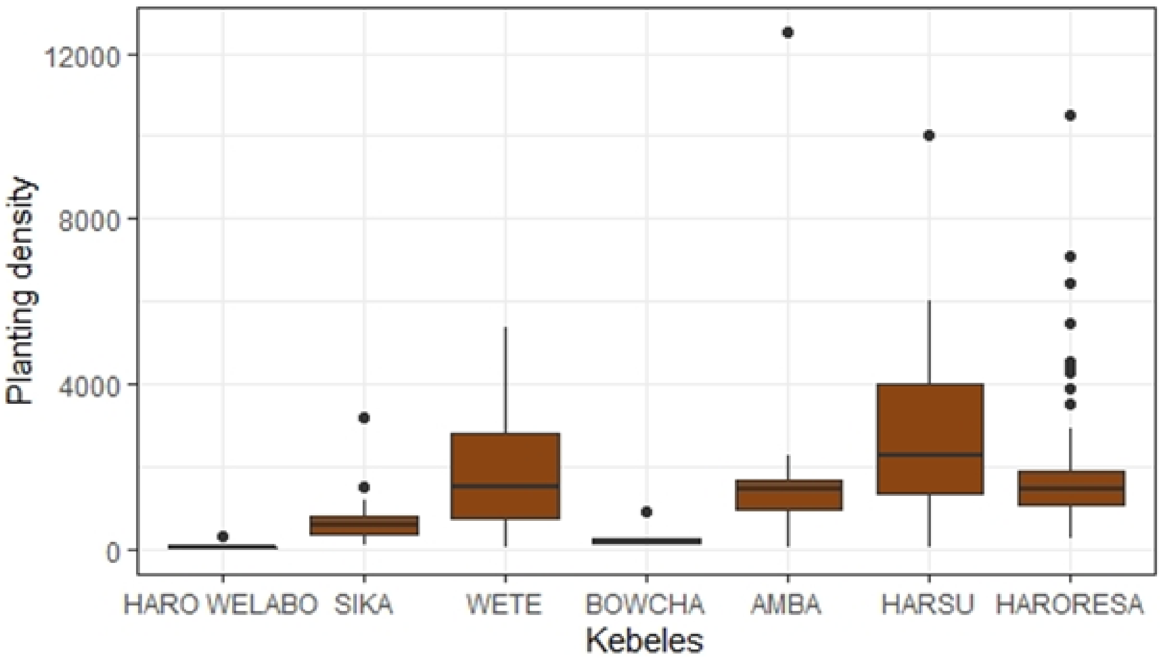

Figure 2. Planting density of enset crop

3.1.2. Animal Husbandry

According to most respondents, the average holding of chicken was much larger than other animal types (Figure 3). From the livestock, the contribution of sheep and goats was higher (Figure 3). Mesele (2007) showed that the livestock component was less compared to the other animals. Other studies also showed that the poultry contribution was higher, followed by sheep and goat (Kippe, 2002; Selamawit and Matious, 2015; Mesele, 2007).

Apart from plants like enset and coffee, livestock animals are a component of Gedeo indigenous agroforestry practices (Kippe, 2002; Debele and Habta, 2015; Mesele, 2007). In this study, the type and the number of animals holding differed across and within the households. Livestock holding is crucial for manure production in enset cultivation. Another study also showed that livestock was kept within farm compounds grazing in front yards and fed with enset leaves and other crop residues. Thus, the production of enset and livestock are interdependent.

The share of livestock was mainly affected by land size and shortage of grazing land (Debele and Habta, 2015). Farmers practiced the cut-and-carry system of chopped enset leaves and corms, particularly during the dry season (Mesele, 2007). So, the potential use of enset as feed in the agroforestry system is very high (Debele and Habta, 2015).

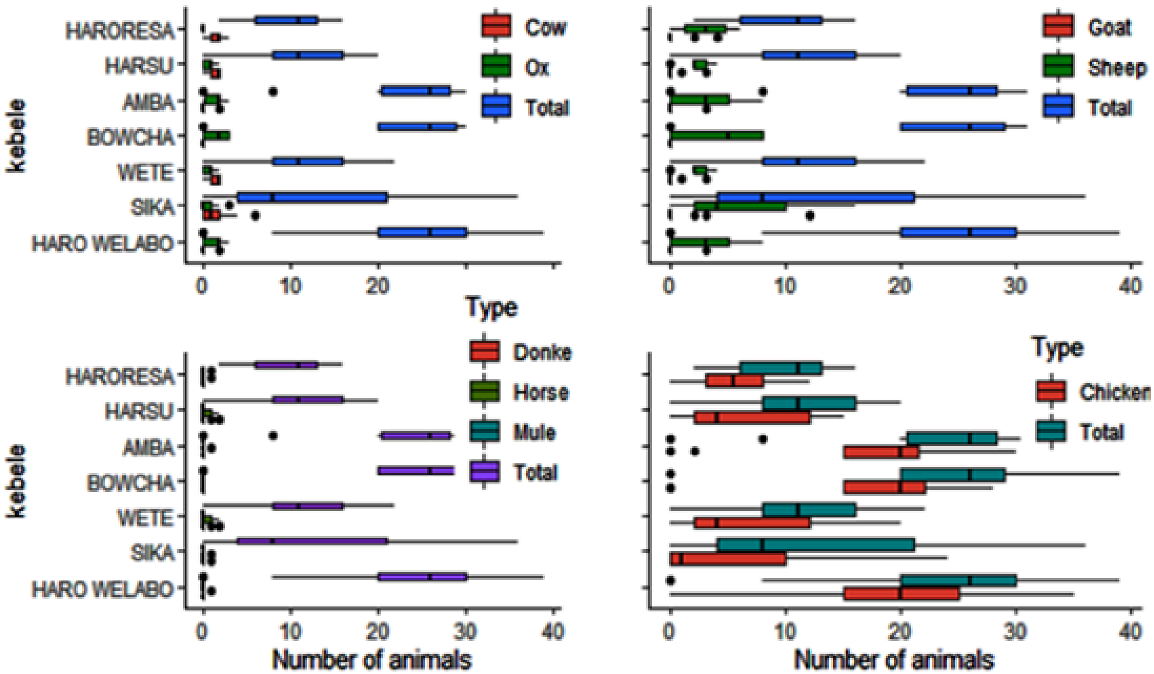

Figure 3. Types and distribution of farm animals

3.2 Soil Erosion and Conservation

3.2.1. Causes and Effects of Soil Erosion

According to most respondents, soil erosion was common and did not change from time to time in highland but decreased in midland and lowland areas. However, some farmers in highland and midland agreed on increased soil erosion (Table 3). In all agroecology of the study area, most farmers agreed on the decrease in crop yield as the main effect of soil erosion. However, a significant number of farmers also indicated land size and crop shifting as an additional effect of soil erosion (Table 3). Although much of the landscape of Gedeo is very steeply sloped, incidences of runoff and erosion are minimal because of the vegetation cover in the agroforestry system (Bishaw *et al*., 2013). One of the typical characteristics of the Gedeo agroforestry system is its productivity on slopes as steep as 80% (EPA, 2004), which is steeper than the optimal slope for agriculture (Gebrehiwot and Maryo, 2015).

Table 3. Soil erosion in the Gedeo enset based agriculture

Description	Category	Respondents' Frequency (%)		
		Highlands	Midlands	Lowlands
Soil erosion status	Cannot predict	10.3	6.0	40.0
	Decreased	5.2	60.2	60.0
	Increased	37.9	33.7	0.0
	No change	46.6	0.0	0.0
Effect of soil erosion	Decreased yield	74.1	83.1	100.0
	Decreased land size	0.0	43.4	0.0
	Crop shifting	0.0	30.1	0.0
Cause of soil erosion	Deforestation	34.5	40.4	100.0
	Sloppy area plow	32.8	68.1	100.0
	Over plow	3.4	40.4	100.0
	Heavy rain	0.0	51.2	100.0
	Over grazing	0.0	38.6	100.0
	No government control	0.0	51.2	100.0

3.2.2. Soil Conservation Practices

According to our study, almost half of the respondents from the highland (Haro Welabu and Sika) did not implement soil conservation practices (Table 4). However, in the higher-midland (Wete and Bowcha), most households perform soil conservation practices. In lower-midlands (Amba and Harsu) and lowland (Haroresa), almost all farmers did not perform conservation practices (Table 4). In the higher midland, at Bowcha, labor exchange was a common practice, but at Wete, most households used their family while some used payment and labor exchange schemes (Table 4). In the highland, it was mainly performed by payment while sometimes using labor exchange. Other studies also showed that in the construction of soil and water conservations, food for work and cash for labor schemes were applied including in their lands (Shiferaw and Holden, 1998; Bekele, 2003; Amsalu and De Graaff, 2007; Bewket, 2007; Birhanu and Meseret, 2013).

Conservation practices and soil erosion are highly affected by agroecology and farming systems. In the Ethiopian highlands, suitable soil conservation measures are necessary to control soil erosion due to runoff and slope gradients (Adimassu *et al.*, 2012a; Adimassu *et al.*, 2012b). However, in Gedeo highlands and sloppy areas, soil and water conservation practices are low due to the agroforestry system (Mesele, 2013). Gedeo indigenous agroforestry is the oldest agricultural self-sufficient system fully packaged with production and ecological services (Mulugeta and Mabrate, 2017; Kippe, 2002; Legesse *et al.*, 2013). The Gedeo community practices least a home-garden type of agroforestry system (Legesse *et al.*, 2013). The agroforestry system maintained the soil from erosion by decreasing runoffs, mulching, and maintaining moisture (Kippe, 2002; Brandt *et al.*, 1997; Mesele, 2013).

Table 4. Soil conservation practices in the Gedeo enset farming system

Description	Category	Respondents' Frequency (%)						
		Haro Welabu	Sika	Wete	Bowcha	Amba	Harsu	Haroresa
Practiced soil-conservation	Yes	48.5	44.0	52.3	89.5	0.0	0.0	0.0
	No	51.5	56.0	47.7	10.5	100.0	100.0	100.0
Conservation-practices scheme	Family	0.0	0.0	41.3	3.9	0.0	0.0	0.0
	Payment	56.3	71.4	29.4	0.0	0.0	0.0	0.0
	Labor exchange	43.8	28.6	29.4	96.1	0.0	0.0	0.0

3.3 Technology Adoption and Extension Services

3.3.1. Traditional Implements

The present study identified different farming tools such as sickle, spade and machete are common in other crop production systems. However, Sisa, Chuko, Meta, Woreme, and Cheko are commonly used for enset based farming systems. Figure 4 shows tools typical to cultivation and harvesting of enset with a cultural attachment to the society. In other enset growing areas, similar traditional tools and implements are used (Pijls *et al*., 1995).

Almost all farming communities have traditional agricultural tools and implements (Das and Nag, 2006). Traditional tools and implements refer to those invented in ancient times, and used for a long time, until recently or still being used now (Sarkar *et al*., 2015). Farming tools and implements were developed and then modified through experience over generations for self-subsistence and to meet emerging socio-economic and farming challenges (Sarkar *et al*., 2015). Usually, for similar purposes, similar types of farming tools are used. However, they may differ in name and in the way they were made. For instance, in the Gurage zone, tools to scrape the leaf sheath are made out of bamboo wood, but in Gedeo it is made up of metal (Figure 4; Pijls *et al*., 1995).

According to the respondents, almost all tools used for kocho extraction were traditional (Table 5). These tools were easy to move and flexible to work in a stand or sit without damaging the enset plant or the products (Table 5). In other enset farming areas, similar trend of using traditional tools were observed (Pijls *et al*., 1995; Garedew *et al*., 2017; Yemataw *et al*., 2016).

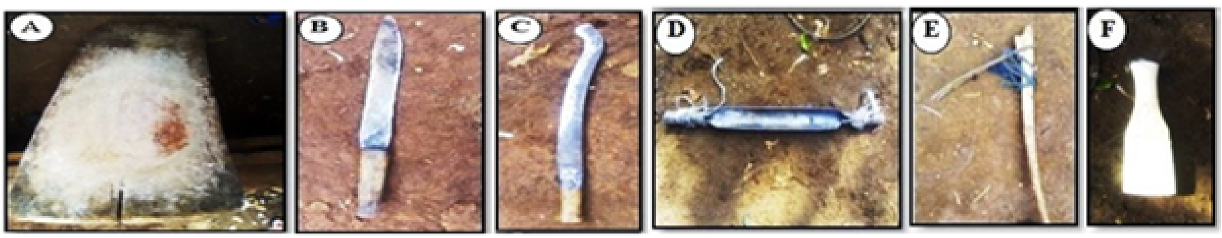

Figure 4. Some of enset farming materials: (A) Wooden chopping board: used for chopping kocho (B) Worme (C) Godesa (D) Sisa: a sharp-edged tool made up of iron used to scrap the leaf sheath (E) Mercha (F) Cheko: about 35cm length used for chopping the corm.

Table 5. The utility of conventional tools in the Gedeo farming system

Description	Category	Respondents' Frequency (%)						
		Haro Welabu	Sika	Wete	Bowcha	Amba	Harsu	Haroresa
Types of *kocho* extraction-tools	Traditional	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Modern	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Traditional tools damage-the plant	Yes	12.0	17.6	0.0	20.0	0.0	0.0	40.0
	No	88.0	82.4	100.0	80.0	100.0	100.0	60.0
Traditional tools are easy-to move	Yes	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	No	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Traditional tools are easy-for working in stand or sit	Yes	72.0	82.4	100.0	100.0	100.0	100.0	100.0
	No	28.0	17.6	0.0	0.0	0.0	0.0	0.0

3.3.2. Technology Adoption

This study showed that the majority of the farmers (94-100%) in the study area used none of the previously improved varieties except in Wete (60%) from the midland (Table 6). On the other hand, most farmers from highlands and midlands agreed on using modern improved tools for increasing yield and income and decreasing risk. In the lowland, farmers have limited knowledge about the difference between the traditional and modern tools due to less exposure to the tools. It is also unfocused areas for enset production and government support. According to the farmers, high cost was the main problem that hinders the adoption of modern tools, except for farmers from Wete and Bowcha (Table 6).

Table 6. Adoption and outlook of modified enset farming technology

Adoption of new enset technology	Category	Respondents' Frequency (%)						
		Haro Welabu	Sika	Wete	Bowcha	Amba	Harsu	Haroresa
Use of improved varieties	Yes	0	0	60	5.9	0	0	0
	No	100	100	40	94	100	100	100
Increased yield	Agree	56	47	94	100	100	100	60
	Not Agree	32	41	4.7	0	0	0	20
	Cannot tell	12	12	1.2	0	0	0	20
Risky for usage	Agree	36	41	33	12	0	0	30
	Not Agree	48	47	67	85	0	0	60
	Cannot tell	16	12	0	2.9	100	100	20
Increased income	Agree	44	53	90	97	0	0	0
	Not Agree	40	35	4.7	2.9	0	0	40
	Cannot tell	16	12	5.8	0	100	100	60
High cost	Agree	60	59	0	29	0	0	60
	Not Agree	24	24	92	71	0	0	40
	Cannot tell	16	18	8.1	0	100	100	0

Traditionally, farmers used different tools in their day-to-day life for agricultural operations to save labor, money, and time (Karthikeyan *et al*., 2009). Women use conventional tools for laborious and tiresome enset processing activities (Kibatu *et al*., 2021, Borrell *et al*., 2020). Modified tools can increase work efficiency and production (Sarkar *et al*., 2015). In Gedeo, farmers use locally available materials to make farming tools. (Nijra and Daimary, 2017).

4 Conclusion

This study provides an overview of enset based farming systems, farming tools, soil erosion and conservation activities, and technology adoption in the Gedeo Zone. The study revealed that as altitude increases, the enset cropland coverage increases compared to other existed crops. In lowland areas, the land cover of enset was lower. Comparative enset-coffee land covers mainly maters in the midland. The type and the number of animals holding differ across and within the households. Soil erosion problem was minimal. Thus, the practice of soil conservation was also minimal. Improved varieties coverage in most of the study areas was low. Women used conventional tools for harvesting and processing of enset. Therefore, it would be better if the district agricultural office collaborates with research centers and other concerned bodies to introduce and disseminate improved technology in the area by considering the agroforestry system and mixed crops.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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E J E D

DRIVERS, PRACTICES, AND CHALLENGES OF URBAN AGRICULTURE: EMPIRICAL EVIDENCE FROM DILLA TOWN

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Abstract
In Ethiopia, the significance of urban agriculture as a source of livelihood is well-recognized. However, the benefits of urban agriculture have not yet been realized to a satisfying degree. This article aims to understand the drivers, practices, and challenges of urban agriculture in Dilla town. The empirical data upon which the author draws was gathered through repeated periods of qualitative fieldwork carried out in 2020 with 36 farmers in Dilla town, Southern Ethiopia. Direct observation, interviews, and focus group discussions were used to obtain the required empirical data. This study has also benefited from various secondary sources. As the study shows, direct food supply, increased economic security, improved social inclusion, and regulated urban microclimate are the logic behind the involvement of farmers in urban agriculture. Urban agriculture is characterized by mixed-type of farming and includes crop production (mainly horticulture production) and livestock production (mainly poultry and dairy farming). Crop production in the town takes different forms and it includes home-garden farming, open-space farming, and peri-urban farming. As the study further shows, lack of access to urban agricultural land, land tenure insecurity, lack of urban farming skills, lack of access to credit facilities, lack of basic agricultural supplies and extension services, and limited attention given to urban agriculture from relevant state structures are major challenges facing urban agriculture. The policy implication of the study is that the government should work to promote urban agriculture and ensure its productivity in a way that benefits all for whom it is intended.

Keywords: Dilla, Home-garden farming, Open-space farming, Peri-urban farming, Peri-urban land, Urban agriculture

1 Introduction

The twenty-first century has often been described as 'the first urban century'. UN (2014) projected that by 2050, more than 66 percent of the global population will live in urban areas and urban expansion will occur more in the global south. The growth of urban areas has been due to the natural growth of the urban population and to the large migration of people from rural to urban areas. UN (2014) projections clearly show that urban populations will continue to grow rapidly in most countries in the global south in the decades to come. However, due to their week economic base, countries in the global south are not capable enough to provide sufficient food demanded by the expanding urban population which in itself contributes to the urbanization of poverty. As studies have shown, food absorbs a large share of urban poor households' incomes (Mersha, Gebremariam and Gebretsadik, 2021) and household food insecurity has been worsening in recent years. At a time of increasing urbanization, dwindling agricultural resources, increased food insecurity, and accelerating deterioration in the quality of life for those living in urban areas, cities may need to consider existing and future urban agricultural activities to reduce the food insecurity and prevalence of urban poverty (see Firdissa, 2007).

In cities of the global south, urban agriculture (loosely defined as the practice of food production within the city boundary or on the immediate fringe areas) has a long history (Ashebir, Pasquini, and Bihon, 2007). Africa, a continent exceptionally rich in biodiversity, is rapidly urbanizing, and the increase in the urban population of the continent is accompanied by an expansion in urban land and urban agriculture. As studies show (Kessler *et al*., 2004), in many West African countries, for example, temperate vegetable production was introduced in colonial times. However, in many of these countries, urban agriculture has been strongly opposed by municipal authorities, and activities were either banned or severely restricted. It is only in the last 10 or 15 years that governments in the global south have started revisiting urban agriculture (Mougeout, 2006), and in some cases revising urban zoning by the laws and integrating urban agriculture in zonification plans (see also de Zeeuw *et al*., 2011). As Food and Agricultural Organization (2004) indicated, urban agriculture in African cities has been increasing with examples from Bissau (Guinea Bissau), Dakar (Senegal), Kumasi (Ghana), Lome (Togo), Nairobi (Kenya), and Dar-es-Salam (Tanzania). Over the years, many studies have demonstrated the significant contribution of urban agriculture to people's livelihoods. Million urban dwellers are actively engaged in urban agriculture and million are providing food for marketing (Ashebir, Pasquini, and Bihon, 2007).

In Ethiopia, urban areas are growing fast and facing many social, economic, and ecological challenges, one of these is how to give to eat their growing population. Despite the formal employment gravity of urban areas, poverty persists and in this context, urban agriculture emerges as a lucrative livelihood strategy. Meeting future demand for food would require a big increase in supply. Bryceson and Potts (2005) argued that urban agriculture in Africa was evolved as a response to scant sources of urban economic sustenance. In other words, urban agriculture was evolved as a response to the insufficient supply of staple food to urban areas coupled with a declining purchasing power of the urban dwellers. Currently, millions of urban dwellers are reinforced to restore farming in urban areas either to supplement their household income or because they cannot afford to meet their daily food needs (Bryceson and Potts 2005). Urban agriculture (field crops, horticulture, floriculture, forestry, fishery, poultry, and livestock) takes place in various parts of cities, both within the built-up areas (in back yards, along stream-sides, in vacant public or private land) as well as in the rapidly changing peri-urban areas (Messay, 2010).

Urban agriculture has been growing in the urban areas as a result of rapid urbanization, rising inflation and unemployment, and declining purchasing power, (see Messay, 2010). To meet part of the food needs of urban dwellers, urban farming has come to be a familiar feature in both intra-urban and peri-urban areas. Urban agriculture continues to be a source of food supplies for urban areas and a means of income for many urban poor. Nevertheless, the subject has attracted little work of scholarship and urban agriculture has been single-handed for a long time. Insufficient attention has been paid to the contribution of urban agriculture to the livelihoods of urban farmers and the health of urban ecology. Little is known about the factors that drive urban agriculture and the multiplicity of challenges that the sector is currently facing. Based on farmer-focused qualitative research methods, the author argues that the drivers and practices of urban agriculture as well as challenges that farmers are facing are highly contextual to the economic, social, political, and ecological realities of the urban areas concerned. With this understanding, this paper looks into the drivers, practices, and challenges of urban agriculture based on an in-depth qualitative study of urban farmers in Dilla town, Southern Ethiopia.

The article is structured as follows. First, the theoretical framework of the study focusing on the social rift perspective in understanding the drivers, practices, and challenges of urban agriculture is discussed. Second, the article briefly outlines the research methodology and fieldwork context. This is accompanied by the presentation of empirical findings focusing on the drivers of urban agriculture, the contribution of urban agriculture to the livelihoods of urban farm households, and the challenges of urban agriculture in Dilla. Finally, the article presents the conclusion and its implication for policy.

Social Rift Perspective

This paper is anchored on the idea of the social rift, which draws our attention to issues of commodification of land, labor, and food and how it drives the emergence of urban agriculture in the global south. Understanding this social rift is not only essential to explaining urbanization, but to elucidating the linkages between urbanization and the agri-food system. In the global south, a host of pressures-land consolidation, poverty, drought, war, expansion of natural resource extraction-has dispossessed rural populations over the last several decades and fueled the growth of cities and their slums across the globe (Davis, 2006). Indeed, part of the rural poor is therefore moving to the urban areas to join the urban poor. As observed by McClintock (2010), a social rift is a central driver of urban agriculture in the global south, where the production of food is often a subsistence activity, of course notwithstanding the ecological rift (driven between human beings and nature) that undermine the conditions of sustainable existence and thereby inform urban agriculture. For example, in a survey of urban agriculture in Africa, 70 to 75% of farmers produced for household consumption, citing the need for food as their principal motivation (Egziabher *et al*., 1994; Mougeot, 2005; van Veenhuizen, 2006).

Rural migrants often discover on arrival in urban centers that prospects for employment are slim. Many must therefore improvise new means of survival. They embark on small-scale agriculture on marginal plots of land within the city itself or in its immediate hinterlands (peri-urban areas), to buffer themselves from the socio-economic upheaval of dispossession from their land and the lack of livelihood opportunities in the city and its peripheral slums. Many, particularly those who live in the shadow of poverty embark on urban agriculture projects to augment their food, and for those selling on informal local markets, to supplement their income. Social rift explains the rise of urban agriculture and its continued presence in the global south. Its continued presence is also linked with the integration of poor countries into the global economy and 'enclosing' of land (communally property) by titling arrangements and emerging land markets (McClintock, 2010). Drawing on these accounts, this paper takes a social rift perspective to shed light on the drivers, practices, and challenges of informal land transformation in Ethiopia.

2 Methodology

The empirical data used to achieve the objective of this study were gathered through qualitative fieldwork that was carried out in 2020 in Dilla, Gedeo. This study used a case-study research design. Case study research is a powerful methodological approach for analyzing and researching urban agriculture. A case study is a preferred strategy when how and why research questions are posed, and when the focus is on a contemporary social phenomenon within a real-life context. The researcher selected a qualitative research approach and explanatory case study research design for the reason that it helps to conceptualize the farmers' personal experiences and their way of looking at their farming practice and livelihoods shaped by the socio-economic conditions which are unique to them. Using a case-study approach also allows the researcher to use mixed and multiple sources of data (Yin, 2014). Thus, a case-study approach is appropriate for examining the drivers, practices, and challenges of urban agriculture in Dilla. The researcher used insider perspective as an analytical tool, recognizing urban farming farmers and concerned experts as key informants of the research. In other words, the paper addressed the drivers, practices, and challenges of urban agriculture based on the knowledge and personal experiences of those who are directly involved in it.

The purpose of the study and the research approach and design selected for addressing the problem played a role in the decision as to whether the author should consider all kebele administrations of Dilla or concentrate on a specific one. Since the intention was to deeply understand the drivers, practices, and challenges of urban agriculture, one Kebele administration (*Hara wolabu* where *Asedela ketene* is part) was selected for in-depth investigation. The selection of this specific Kebele administration was based on the practice of urban agriculture. It is part of the town where home-garden, open-space, and peri-urban farming is widely practiced. Then, 36 urban farming farmers were purposely selected (from different urban farming categories along the center to the periphery continuum) using the purposive (snowball) sampling technique to obtain data about the drivers, practices, and challenges of urban agriculture in Dilla. Snowball sampling was used mainly because it was hardly possible to get the exact number of urban farmers in the study sub-city. As qualitative research, the sample size was determined based on the principle of data saturation.

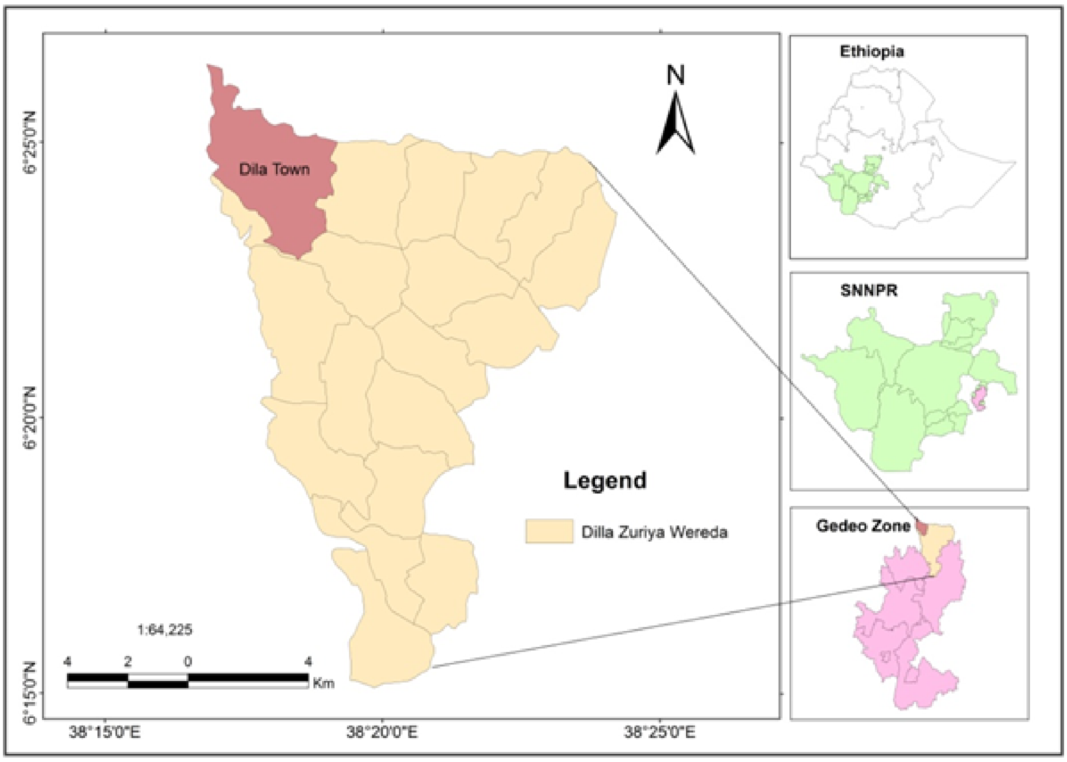

Figure 1. Map of the Study Area

A total of 36 in-depth interviews were conducted with representatives of urban farmers (they represent different sex, age, and urban farming activities). Besides, 8 in-depth semi-structured interviews were conducted with experts from the relevant state structures in the town. These experts were selected based on their expertise and experience in the area being studied. Three different focus group discussions (consisting of 6–8 individuals) were carried out at different stages of the research. On average, each interview and focus group discussion session lasted for 1 hour. Information from the in-depth interviews and focus group discussions were considered to be valuable for the way that it expressed the views of urban farmers, urban agriculture, urban land management experts, urban planners, and urban sociologists regarding the drivers, practices, and challenges of urban agriculture in Dilla. Moreover, the views of urban farmers and experts about the ways forward to enjoy the beneficial effects of urban agriculture were formed a valuable input into this study. Direct field observations were carried out to have a first-hand view of urban agriculture systems and land use patterns. The study also employed a desk review research approach and has benefited from various secondary sources. Accordingly, various published and unpublished documents were incorporated and used as inputs to the study. In this study, the data collected through various methods were presented, analyzed, and summarized through a qualitative method. Analysis of data was conducted using the thematic analysis method. The first task in the analysis was to become familiar with the initial mountain of data and reduce it to an ordered set of themes (Yin, 2014). Following a thematic analysis tradition, the main themes from the data were developed, synthesized (integrated and interpreted), and harmonized (Yin, 2010) and used in the analysis and write-up. During fieldwork, consent was sought from the research urban farmers/ participants. This was preceded by an explanation of the kind of research the author intended to do. The purpose was twofold: (1) to tell participants what the study was about, and (2) to ease the skepticism participants might have had about the research. Interviews/dialogues and focus group discussions were held in places where the participants felt safe and comfortable.

3 Results and Discussion

3.1 Drivers of Urban Agriculture

In the study area, urban agriculture is practiced for three major reasons. These are household food self-sufficiency, commercial production, and environmental protection; forces that drive people from all walks of life to engage in urban farming (see Mougeot, 2005). As interviews data revealed, urban agriculture appears to be used as a support structure through different channels: improving (direct) consumption of food, generating income, and improving the livability of the urban neighborhood (preserving the viability of the urban environment). Many low-income urban farmers are involved in urban agriculture because urban agriculture reduces households' vulnerability to severe food insecurity. Of course, growing one's food makes the best economic sense. Alemitu (35, female, farmer) explained the role of urban agriculture in household livelihood.

> "*I know that these days there is a growing interest in urban agriculture [home-garden farming, open-space farming, and peri-urban farming]. The fear of not having the products they are used to eating has motivated many people, particularly those in the low-income group, to start thinking about growing their food. Of course, many people living in Dilla can grow their food and increase their food security. I think it is necessary to be more self-sustainable*".

When urban farmers in this study are asked why they are involved in urban farming, they cite "additional food source" as one of their major reasons. They can reduce their food expenditure because vegetables/crops from their small urban farms supplement their food consumption. This is particularly significant in the urban context where farmers spend 40-50% of their income on food. For these households, particularly for farmers who are engaged in home gardening in the intra–urban areas, urban farming is the 'logic of survival.' It improves households' 'food regime' (Landon-Lane, 2004), and hence their vulnerability context is somehow reduced. Urban agriculture contributes to food diversification through increased availability of household disposable income (Zezza and Tasciotti, 2010, Onyango, 2010; Mpofu, 2013). With more diverse foods available, farmers become more food secure (Swindale and Bilinsky, 2006). Thus, self-grown food can reduce well-known challenges that the urban poor face, especially the dangers of meeting their household food and nutrition security entirely through the market.

Urban agriculture is used as a support structure through increased economic security, primarily through the sale of farm produces. It is practiced by the urban poor who supply the market with what is left from their consumption. As Marta (34, female, farmer) puts it, 'urban farming improves economic security and strengthens resilience against livelihood shocks'. Many farmers in this study can combat the livelihood dilemma through what they commonly call 'subsistence saving.' Urban agriculture serves as a 'means of saving on expenditure' (Prain, & Lee-Smith, 2010). It provides food that would otherwise be available through purchase and hence contributes to household savings, which can be spent on other basic needs. Put differently, urban agriculture enables farmers to generate income and substitute their household expenditure. During the interview, Obse (32, male, farmer) said the following:

> "*Urban agriculture is a good source of income. I strongly believe that participating in urban agriculture impacts poverty by providing employment and incomes to those who do not have a regular source of income. Urban agriculture releases money that would have been used to purchase food for other household uses. It can also be a secondary source of income for people who have a regular source of income but not enough to cover the cost of living. In this way, urban agriculture eases the poverty burden experienced by (poor) urban households*".

During the focus group discussion, Aklilu (36, male, planning expert) indicated that food items that cannot be produced in the home garden or on other family lands can be purchased from the sale of other items produced in the home garden.' Farmers obtain food supplies either through their food production or food purchases, but more often through a combination of both. This supports the idea that urban agriculture is a survival strategy adopted by people on the margins of society, particularly women who suffer from the 'urbanization of poverty.' Urban agriculture is also a fallback area for those who live in relative poverty (deprivation) (FAO, 2012). This indicates that urban agriculture is driven by what Bayeush (36, female, farmer) called 'real community needs', a response to inadequate access to food and lack of purchasing power. The mismatch between the mounting urban populations and the availability of employment opportunities in the study area renders urban agriculture a vital source of employment. During the focus group discussion, experts boldly indicated that urban agriculture is a particularly important source of employment for people who may not successfully compete for formal sector jobs due to their low skill levels. Thus urban families without formal employment can enhance their labor productivity by engaging in urban agriculture as Zezza and Tasciatti (2010) confirmed.

During the focus group discussion, Tariku (47, male, farmer) emphasized the 'multiplier effects of urban agriculture'. He emphasized the employment opportunities urban agriculture creates for many urban dwellers, particularly for the elderly. Many urban farmers in this study viewed the 'involvement of the elderly in urban agriculture as a positive step that enabled them to support their fragile economic base while at the same time strengthening their inclusion into their society. As this study shows, urban agriculture in the study area is a part of the green landscape and many farmers develop green plants in the home compound for different reasons. As interview and focus group discussion data revealed, urban farming regulates the town's micro-climate which confirms the findings of Veenhuizen (2010) and Magigi (2013). In this regard, the experience of experts has been quite extensive. Kepie (46, male, agriculture expert) said the following:

> "*Urban agriculture, in combination with the addition of other types of green spaces, offers the most potential for improvement of the urban microenvironment in terms of reducing stormwater (by promoting storm-water infiltration), improving air quality, reducing urban heat, promoting biodiversity, reducing waste (by utilizing food waste as compost), and decreasing carbon emissions*".

Comments that are made during the focus group discussion highlighted that as long as urban farming is eco-friendly; it preserves the viability of ecosystems and reduces the loss of biodiversity'. The use of (organic) manures in urban farming is common in urban and peri-urban areas of the study area, which in itself benefits the environment and enhances agricultural productivity which Lee-Smith (2010) confirmed. Urban farmers explained waste as a 'resource' from a contemporary perspective. Urban farming provides aesthetic and recreational functions. It also protects productive areas from being used as dumping sites for 'environment-unfriendly wastes' which would be a pathway for negative human and environmental health effects if proper precautions are not taken. As observed, there is a culture of cultivating green plants for shading and reducing the 'heat island effect' (Ohmachi & Roman, 2002) and improving the health of the microclimate (see Heather, 2012; Prain and Lee-Smith, 2010). It also contributes to the development of a 'green urban landscape'.

3.2 Urban Agriculture Practice

One would think that urban areas are not places where agriculture is undertaken, but as indicated elsewhere, urban agriculture has come to life due to the urbanization of poverty. Many people in the study area (in Dilla town extended) are engaged in urban agriculture. As observed, urban agriculture is located within (intra-urban) or on the fringe (peri-urban) of the study area and takes different forms: home-garden farming, open-space farming, and peri-urban farming. These agricultural activities use resources, products, and services of the town. Home-garden production involves farming in backyards. Plots are generally small. 'Gray' water and rainwater are major sources of water for home-garden farming. The home-garden production is predominantly a small-scale subsistence urban farming system, and as indicated by the farmers in this study, it is mainly used for home consumption. Selling part of one's produce occurs more frequently when plots are bigger or intensively cultivated. As Tsegay (37, male, farmer) puts it:

> "*Back yard gardening/farming is easy to start and each member of the household is responsible for the production. In our context, home gardens are more diverse and provide multiple products for farming households. Vegetables such as cabbage, tomato, carrot, onion, garlic, pepper, sweet potato, potato including Enset, medicinal plants, and fruits such as banana, mango, sugarcane, and avocado widely grow in home gardens*".

During fieldwork, the author came to know that home-garden farming is mainly 'family farming' and every member of the household takes part in the farming practice. It is worth mentioning that horticulture is a part of the 'local food system' that provides horticultural crops for needy households. Farmers and experts covered in this study indicated that the broad diversity of horticultural crop species allows year-round production, employment, and income. Farmers are now realizing that intensive horticulture can be practiced on small plots, making efficient use of limited water and land resources. Horticultural species, as opposed to other food crops, have a considerable yield potential depending on the input applied. In addition, due to their short cycle, they provide a quick response to 'emergency needs for food'.

In the study area, there are open-spaces and peri-urban farming. Open-space farming covers limited areas within the built-up space. Plots within the built-up space and peri-urban areas are bigger than backyard farms. Open-space cultivation in the intra-urban is largely located in open spaces, along river/ stream sides and other abandoned urban land where land is not suitable for building construction, which itself shows 'opportunistic use of open-spaces.' Rainwater and urban drains are major sources of water for open-space and peri-urban farming. Vegetables, fruits, and crops are widely grown within built-up and peri-urban areas. As Marta (34, female, farmer) indicated, farmers grow different types of crops.

> "*In both open-space and peri-urban farms, there is a diversity of vegetable crops and fruits, but tomato, onion, cabbage, pepper, mango, avocado and banana are the most widely cultivated in both open-space and peri-urban farms. Enset and maize are widely grown crops in the peri-urban farms. Intercropping is one of the agronomic practices that are followed by many urban farmers in the study area. Both open-*

space and peri-urban farming are characterized by inter-cropping where vegetables, fruits, and crops grow in different combinations to make effective use of limited urban space".

However, as observed, the smaller plots are located in the inner part of the town and show the highest crop diversity. The choice of crops for production in urban areas could be determined by whether food is being produced for household consumption, or subsistence, or for the market sale (Cofie, 2009). As the current study shows, in all farming systems in the study area, the choice of crops cultivated is shaped by the growers' consumption preferences, the amount of input needed for growing the crops (low input crops), the cultivation period (short cycle), and the market (high demand crops). The decision to undertake urban agriculture is also influenced by location and resource availability. As the current study further indicates, a variety of vegetables and fruits are favored by urban farmers, although food crops are also cultivated.

Poultry and dairy farming are suitable businesses for people who are passionate about livestock farming, keeping livestock and comfortable with farm life. Poultry and dairy farming are highly profitable businesses if farmers can run it properly under acceptable methods and conditions. For traditional and economic reasons, poultry and dairy farming are an integral part of the urban farming system in the study area. Both are mainly market-oriented. A small-scale traditional or backyard poultry production system is common. Farmers feed chickens home grain and leftovers (as it is cost-effective) but mostly rely on scavenging. Poultry farming has been a source of income generation and food for many farmers in both urban and peri-urban areas. Tesfa (39, male, social expert) said the following:

"*For low-income urban farmers, poultry is one of the few opportunities for coping with vulnerability (livelihood risks). Nonetheless, due to the limited number of chickens they have, farmers are not committing their working time to the activity. In addition to poultry farming, dairy farming has been a traditional activity of many households, though many of them still have a limited livestock population*".

As urban farmers in this study indicated, though dairy farming is a 'capital intensive' activity, farmers consider the multiple functions of dairy farming in their household economies such as source of food, input for soil fertility management, source of income, source of energy, and source of household saving (see also Kassahun, Snyman, & Smit, 2008). As focus group discussions data revealed, in the space-constrained inner-city areas, dairy farmers have no access to natural grazing systems. Because of 'zero-grazing,' dairy farmers follow what they called 'confined dairy management practices.' As observed, most urban farming activities are privately managed and family labor is the most common input for all urban farming activities though women frequently carry out the majority of urban farm labor along with their care-taking and house-holding roles.

As already said earlier, produces of urban farming are used for both home consumption (to supplement their families' diets) and the market (to generate income). Products need to be marketed if farmers are to derive income from urban farming. As observed, if a farm produces are to be traded, they are directly sold to consumers. It is delivered to the market close to the farmers. Tadesse (42, male, farmer) explained the transportation and marketing of agricultural products.

"*Once urban farmers harvested their vegetables and crops, they usually delivered them to the marketing outlets on the same day, or the next depending on the 'perishability of the products.' They mostly use human labor to transport farm products to the marketing outlet where the urban dwellers have access to purchase including mola gol'ja and bus station. Sometimes, farming farmers take their produces to the doors of urban dwellers and exchange them at bargain prices*".

In the market, both buyers and sellers are mostly low-income people who try to make ends meet through cheap bargains. In this way, one section of the urban poor helps another section to survive. For most of the farmers in this study, 'using human labor to transport farm products is cost-effective as it buffers from transport-related problems.' In other words, urban farmers accept the long travel to the marketing outlet although it takes a long time and create inconvenience. When marketable farm products are to be delivered in large, donkey-drawn carts are used, but it charges a higher price. The farmers in this study are "not comfortable" with the existing market that is essentially 'poor,' thereby weakening the ability to save and invest, and making 'moving out of poverty' less likely.

3.3 Challenges of Urban Agriculture

The expansion of urban agriculture is arguably necessary to feed the urban population, especially as the influx of migrants to urban areas continues. However, there is a range of hindrances preventing its full utilization, all of which are not necessarily exclusive to urban production systems – especially challenges associated with lack of foresight. As this study shows, there is a range of challenges that often prevent the beneficial effects of urban agriculture from happening in an effective manner. First, there was no conscious planning for urban agriculture. Urban farmers are often 'ignored' by the local authorities highlighting urban agriculture-urban governance disconnect. Lack of recognition of urban agriculture often leads to a feeling of insecurity among urban farmers.

In the study area, urban land use planning has failed to tap adequately into urban agriculture as a viable strategy to increase urban food supply and ensure food security. This failure is compounded by rapid urbanization and urban growth, urban sprawl, and the conversion of agricultural lands to residential uses in both urban and peri-urban areas. I argue that urban agriculture does not get the status it deserves as it is mostly considered a 'rural' activity which clearly shows the indifference with which the sector is treated, which validates the findings of Bryceson and Potts (2005). There is no clear strategy concerning current and future issues related to urban agriculture. As a result, the sector suffers from policy bias. There is also poor coordination among concerned state structures. According to Bayeush (36, female, farmer)

> "*Urban agriculture encourages the use of land to feed people. However, urban farmers are not adequately encouraged to participate in the urban agriculture sector through sensitization, training, and demonstration. Even those who are involved in urban agriculture remained reluctant to expand their agricultural activities because of lack of support from relevant state authorities. As a result, the functions of urban agriculture remained 'invisible'*".

Land, in terms of availability and access, is one of the major institutional constraints to urban agriculture (Mpofu, 2013). While demand for land has been steadily increasing, supply of the same is inadequate, thereby creating a shortage of land in the town and affecting the availability of land for urban agriculture. As Marta (34, female, farmer) observed, 'land' is a problem, particularly in the inner part of the town. Moreover, land delivery is not transparent. While some people are denied, others are allowed to know where they can farm or how they can gain permission to farm even in restricted places.' This observation is consistent with the studies by Maxwell and Zziwa (2002), Mbiba (2005), and Mougeot (2005). Farmers have no minimum use rights of farmlands (roadsides, riverbanks, idle public lands) and hence, suffer from land-tenure insecurity. For Kebede (32, male, land expert) land is a major constraint to urban agriculture.

> "*Land holds a central position in people's livelihood. But, in urban areas where land is in short supply, accessing land to work on is very difficult. The population of Dilla is growing. This leads to additional land being put to use. Many urban farmers are kicked out from urban farming in and around the town due to rapid land-use conversion. The patterns of location have been changing over time, as cultivated land is pushed outside by the housing demands that out-price urban farms as urban land use*".

As the demand for land continues to increase, the town's administration takes land occupied by the urban poor within the city and pushes for the annexation of peri-urban areas, and turns them into the town districts through a series of legislative actions (expropriating the land and reallocating the expropriated land to different users through the lease contract). In a context where investors have unrestricted access to land, farmers within and in the peri-urban areas live in perpetual fear of eviction. Evicted people embark on small-scale agriculture on marginal plots of land within the town or in the peri-urban areas to buffer themselves from the socio-economic upheaval of dispossession from their land and the lack of livelihood opportunities in the town. Farmers also lessen input and productivity due to the risk of 'eviction.'

On the other hand, smallholder farmers in this study seem to have very little idea of intensive land utilization or urban farming skills. Put differently, urban farmers have a limited idea about the very nature of urban farming, which is 'super intensive' (Mesay, 2010) and can be practiced on small areas and the roof of containers and buildings; what is called 'vertical farming'.

The existence of good marketing opportunities will be crucial for the further development of urban agriculture. As Tadesse (42, male, farmer) indicated, 'market access is important as is access to land.' Nonetheless, there is a poor local market for agricultural products. This is due to the existing food culture in the town. According to Tesfa (39, male, social expert), 'residents of Dilla prefer protein foods. Because of this, there is low consumption of vegetables in the town'. This in itself affects both the production and marketing of urban farm products'. The national picture is also the same. Per capita consumption of vegetables (about 25 kg per year) is amongst the lowest in sub-Saharan Africa, which is well below the recommended WHO/FAO minimum per capita consumption of vegetables (146 kg per capita per year) (Ruel et al., 2004). Kepie (46, male, agriculture expert) explained the challenges that urban agriculture is currently facing:

> "*High-value vegetable crops are not dominant in urban and peri-urban production and marketing. No adequate efforts have been made to encourage large vegetable production in urban agriculture. Even those efforts that have been made have brought limited change as they have not been accompanied by a program of sensitization amongst urban farmers to develop 'vegetable and fruit culture' [a culture of eating vegetables and fruits]*".

For one farmer, 'little effort has been made in finding ways to connect farmers even to the existing markets to help them generate income.' As a result, the situation for urban farmers is far from being any better. During focus group discussion, farmers and experts confidently indicated that following the rapid population growth, the demand for horticulture crops (vegetables, fruit crops, root, and tubers) and poultry and animal products is to some extent increasing over time, and this would create a strategic opportunity that urban farmers can exploit. Farmers and experts who participated in the focus group discussions believed that, if properly explored, the emerging market niches can provide important income sources for the urban poor.

Small-scale urban farmers are prone to lack of basic agricultural supplies, extension, and veterinary services. Although some farming equipment is available, it is rare to find specialized farm tools. It is the urban poor who need tools most who must do urban farming without them as prices of it are too costly to afford. As the current study shows, urban farmers have no access to credit facilities; one of the big hurdles to urban agriculture as Mpofu (2013) confirmed in his study of the performance of urban agriculture in Addis-Ababa. Urban farmers need capital/ financial resources to invest in urban agricultural inputs for the intensification of crop, poultry, and dairy production. But, no well-developed legal and institutional framework to unlock critical technical and financial support services for the sector. As Alemu (43, male, farmer) explained the challenges farmers face to access to credit:

> "*Farmers face many challenges when they want to access credit. First, they lack sufficient assets to put up as collateral (a prerequisite for borrowing from financial institutions). This makes it more difficult for farmers to obtain credit from formal credit sources. Second, poor farmers are unable to repay loans they obtained from financial institutions because of higher interest rates imposed on loans and their short repayment period. This makes it more difficult for farmers to obtain credit from formal credit sources*".

Banks often find it very risky to provide credit to urban farmers because agricultural credit is perceived as a risky venture (Rahji & Fakayode, 2009) and urban farmers are perceived as 'high-risk borrowers' (Daniel, 2019). Besides, high-interest rates (that ignores profitability levels of urban agriculture) and short loan repayment periods are still impeding farmers' access to credit services. Obtaining loans from friends and relatives is also very difficult since loans to family and friends are mostly open-ended [lenders are not sure when their money will be returned]. During the focus group discussion, farmers commented that access to adequate supply of water, manure, compost, and fodder is crucial to urban agriculture, but all are difficult to obtain for urban farmers in the study area. Besides, urban farmers are not organized in a formal way, which in itself limits their capacities to improve their farming systems and marketing opportunities. As a result, farmers are unable to enjoy the returns from the resources they put into urban farming.

4 Conclusion and Suggestive Remarks

4.1 Conclusion

This article provides insight into the drivers, practices, and challenges of urban agriculture based on a case study in Hara wolabu Kebele administration, Dilla town. Urban agriculture is a productive and income-generating farming system that should be seen as an integral part of the urban system, contributing to household livelihoods and the health of the urban ecosystem. As learned from the discussion, there are different reasons for farmers to be engaged in urban agriculture. These include household food self-sufficiency (direct consumption of food), economic security (increased income through the sale of agricultural produce), and environmental protection (improves urban microclimate/ ecosystems). As regards the practice of urban agriculture, smallholder urban farmers are mainly engaged in crop cultivation (horticulture), and livestock production (dairy and poultry production). As this study has made it clear, the urban agriculture sector faces many challenges. Lack of access to urban agricultural land, land tenure insecurity, little idea of intensive land utilization or urban farming skills, lack of access to credit facilities, lack of basic agricultural inputs and extension services, and limited attention given to urban agriculture from concerned bodies (relevant stakeholders) are to mention. As a result, the farmers are not enjoying the benefits of urban agriculture as expected. At its current situation, urban agriculture in the town is entirely resource-poor and disorganized, and those in a position to develop it, notably the state authorities, have done nothing about it.

4.2 Suggestive Remarks

The findings of the study reveal that urban agriculture could play a great role in the overall development of the study area (Dilla town extended) if the state authorities, practitioners, non-governmental actors, and the urbanites at large are well aware of the value of the sector. It seems that the contribution of the sector is likely to expand owing to rapid population growth and soaring food prices in the town. The sector needs to be well-organized and land should be provided for urban farmers on a usufruct basis (but the land can be used for the intended urban development purpose when needed). For urban agriculture to become part of the solution to livelihood deprivation, it is necessary to address the problems observed in the provision of appropriate technical support, training, modern farm inputs (including appropriate and affordable locally developed technologies), credit facilities, and extension services all of which are vital to the sustainability of urban agriculture thereby enabling farmers to make change for the better of their life and the lives of others around them. Integration of urban agriculture into the urban planning vision should also be accompanied by policies that seek to expand the water supply infrastructure to accommodate urban agriculture.

It is identified that the inclusion of a well-staffed and equipped urban agricultural development bureau in the administrative structure of the town is highly required. The identification and establishment of specialized intensive urban farming zones may result in a more productive and eco-friendly urban agriculture in the town. Back yards, roadsides, and other open areas along the urban and peri-urban continuum can be used for the production of temporary vegetables, crops, salable flowers, and seedlings; of course, integrating urban farming in harmony with the environment. This will place urban agriculture on the agenda of reducing urban poverty and improving livelihoods. In this regard, concerned state-level actors particularly urban planners and non-state and other informal actors as well as the urban community are expected to give appropriate attention to urban agriculture and mainstream it into urban livelihood policy strategies so that urban agriculture could play its optimal role in making Dilla a more food-secure, green, and livable town.

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Conflict of Interest

The author declares that there is no conflict of interest.

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FOOD INSECURITY IN SMALL URBAN CENTERS OF EAST GOJJAM ZONE, AMHARA NATIONAL REGIONAL STATE, ETHIOPIA

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Abstract

Food insecurity has become one of the daunting challenges that the urban areas of the developing countries have been grappling with. Small urban centers, in particular, have faced with a serious challenge of food insecurity. The present study aimed to identify the food insecure households and the determinants of food insecurity based on the household survey consumption data. Two-stage sampling technique was used to select the study towns and 328 households. Mean, independent sample t-test, one-way ANOVA and logistic regression were employed to analyse the data. The computed result from the survey consumption data revealed that over one-third of the surveyed households were food insecure while nearly two-third were food secure. This high incidence suggests the severity of food insecurity in these towns. The results further revealed that the incidence and severity of food insecurity varies among the study towns. The logistic regression result also showed that six out of the twelve regressed explanatory variables were found statistically significant determinants of food insecurity. Among the statistically significant variables; migration status of household head, acquired skills of household head, radio/television possession of the household and monthly income of the household have negative association with food insecurity while educational status of the household head and round trip distance from the source of drinking water point have positive association with food insecurity. It is therefore recommended that the local government should work on reducing the extent of food insecurity in the study towns by helping households to diversify their income sources. A productive safety net program launched in the major urban areas should also be scaled up.

Keywords: Determinants, Food insecurity, Households, Small towns

1 Introduction

Food insecurity is one of the pressing issues in the world. Countries are striving to achieve food security by 2030. This is reflected in Sustainable Development Goal Two. It says "End hunger, achieve food security and improved nutrition and promote sustainable agriculture" (UN, nd). According to FAO (2020), food insecurity is "a situation that exists when people lack secure access to sufficient amounts of safe and nutritious food for normal growth and development and an active and healthy life". Food security has availability, access, utilization and stability components. Napoli (2011) indicated that food might be available but that does not determine access; similarly, access might be viable but does not guarantee utilization, and all three can be disrupted by lack of stability caused by climate change, conflict, unemployment, disease or other factors. Stability or instability can affect any or all of the other three components (Napoli, 2011). Food insecurity is either chronic which can sustain a long period of time (more than three months) or transitory or short period of time/temporary (less than three months). The causes are lack of assets and inadequate access to productive or financial resources for the first and short-term shocks and fluctuations in food availability and access for the later (Napoli, 2011).

The results of food insecurity are famine and hunger (Napoli, 2011).The number of people affected by hunger in the world continues to increase slowly caused the greater number of conflicts and climate-related shocks (FAO, 2020). Sixty million more people are undernourished in 2020 than in 2014 (FAO, 2020). The figure will reach from 690 million in 2014 to 840 million by 2030. The same source revealed that the figure was 17.6% (250 million) in Africa in 2014, which was twice the world average (8.9%) undernourished people. Globally 750 million (9.7%) people were severely and 1.25 billion (16%) people were moderately food insecure in 2019 (FAO, 2020). These together accounted for 2 billion (25.9%) people. The same source revealed that Africa is the hardest hit with an estimated population of 675 million.

Despite the reported double-digit growth, the Ethiopian economy is among the most vulnerable in Africa due to the recurrent droughts (Bamlaku & Solomon, 2013, Alemayehu & Addis, 2016). In spite of this, hunger and food shortages were not in a policy discourse in Ethiopia until the Derg regime (Alula & Desalegn, 2013). Consequently, poverty and food insecurity are prevalent in Ethiopia. About 30% of the total population and 26% of the urban population of Ethiopia were absolute poor in 2010/11(CSA, 2011) and 10% of Ethiopian cities are chronically food insecure (Care, 2014) resulting from price fluctuations as 80% of urban households depend on purchased goods from different markets which is affected by high inflation as of 2005 (Bamlaku & Solomon, 2013; Alemayehu & Addis, 2016). Though they were not effective in reducing the problem; growth in food production, environmental protection, water management and irrigation projects, employment creation and resettlement were some of the government programmes in reducing food insecurity during the Derg (Alula & Desalegn, 2013). Due to this a major policy shift was made in 2003 by introducing food security programme (FSP) which incorporates Productive Safety Net Programme (PSNP) launched in 2005 in rural areas, Household Asset Building Program, Complementary Community Investment and Resettlement Programme (Alula & Desalegn, 2013; Berhanu, 2013). The extent of food insecurity in the country is escalating in the major urban areas, which is the cause for the beginning of urban productive safety net programme in the major urban areas in 2017.

The causes and coping strategies of food insecurity are different for different people and areas (Ramakrishna & Assefa, 2002). Little empirical evidences on the incidence and determinants of food insecurity are available in small urban areas so far. Any food security study in Ethiopia concentrated earlier on rural areas (Devereux & Sussex, 2000; Kedir, 2017; Alem-meta & Singh, 2018; Mebratu, 2018; Admasu et al., 2019) and later on the major urban areas (WFP, 2009a; WFP, 2009b; Yared, 2010; Ejigayehu & Endris, 2012; Girma, 2012; Bamlaku & Solomon, 2013). Studies of D'Souza and Jolliffe (2016) and Mesfin (2014) were on rural and small urban areas in which the results were not presented independently for the first and the size of the town is not indicated for the latter. The gap is that food insecurity is seen as a problem only rural and major urban areas are facing. However, it is also the problem of small urban areas, which equally needs government and researchers' attention.

The objectives of this study were to measure food insecurity and identify the determinants of food insecurity at the household level. The results of this study will improve the efforts of the government in reducing the problems of food insecurity and add knowledge to the existing literature by unearthing the problems of food insecurity. The rest of this article is organized by four major sections. The first section deals with the description of the study area. The second section presents methods and materials.

The third section entertains results and discussion. The last section contains conclusions and some recommendations.

2 Materials and Methods

2.1 Description of the Study Area

Location and Physical Setting

The absolute location of Felege Birhan is 11°88′ North latitude and 37°04′ East longitude (Figure 1). Relatively, Felege Birhan is found approximately 7*km* West of Addis Ababa-Motta-Bahir Dar all-weather gravel road in Enarj Enawga *Woreda*, 315*km* North West of Addis Ababa and 166*km* South East of Bahir Dar through Addis Ababa-Motta-Bahir Dar road. The exact location is 10°30′ North latitude and 37°45′ East longitude for Wojel and 11°42′ North latitude and 37°04′ East longitude for Yetmen. Relatively, Wojel is found along Addis Ababa-Debre Markos-Bahir Dar asphalted road in Awabel Woreda, 251*km* North West of Addis Ababa and 314 kilometers South East of Bahir Dar. Relatively, Yetmen is located along Addis Ababa-Motta-Bahir Dar all-weather gravel road in Enemay *Woreda*, 247*km* North West of Addis Ababa and 238*km* South East of Bahir Dar. All towns are found within the South East Woyna Dega Teff Livelihood Zone (Amhara Livelihood Zone Report, 2007). According to this report, this livelihood zone is a surplus producing zone with good road access.

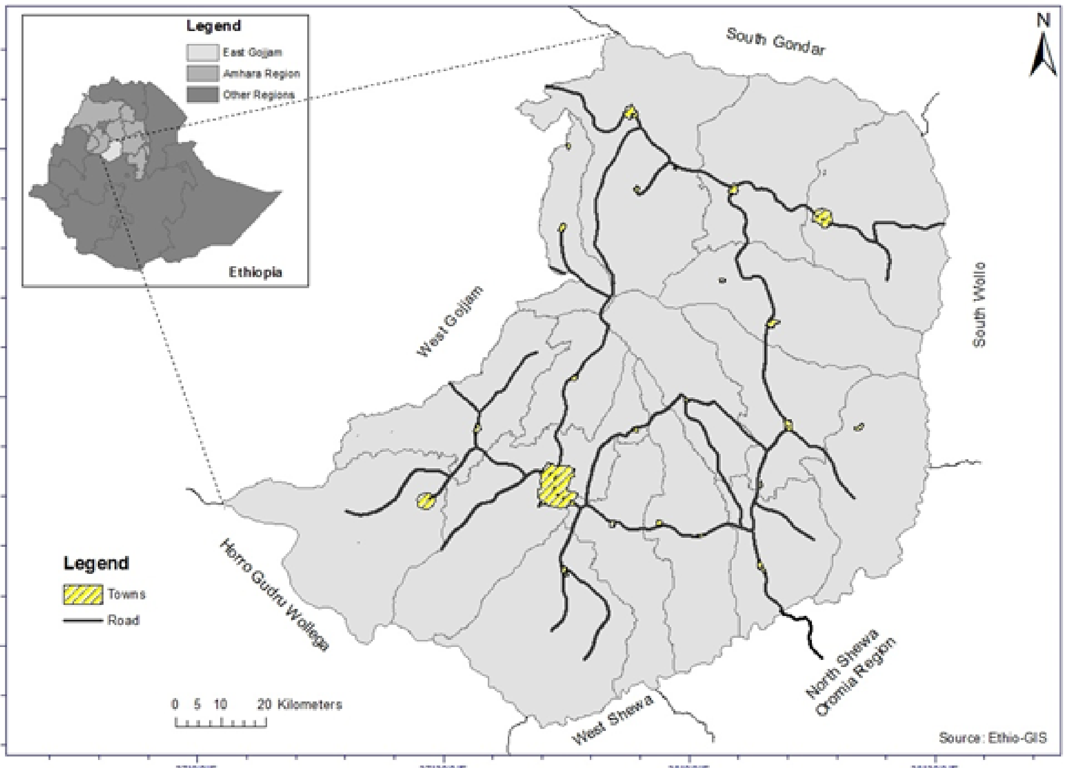

Figure 1. Location Map of the Study Towns

The altitude of Felege Birhan is 2790 meters above sea level (masl.). Its topography is not plain but rather rugged unlike the other study towns. The altitudes of Wojel and Yetmen are 1975 and 2425 masl., respectively. The topographies of Wojel and Yetmen are plain. The average annual rainfall of Felege Birhan is 1175*mm* and the monthly average temperature is $14°C$. The climate of this town is cool temperate (Dega). The mean annual rainfall and the mean monthly temperature of Wojel are 1158mm and 18°C, respectively. The town, therefore, lies within temperate (Woyna Dega) climatic zone. The average annual rainfall of Yetmen is 1063mm and the monthly average temperature is 16°C. The climate of the town is, therefore, temperate (Woyna Dega).

2.2 Demography, Economic Activities and Infrastructure

Based on the 2011 CSA data, the population size of Felege Birhan was 8197 of which 4000 were males and 4197 were females. The population size of the town accounted for 4.5% of the total population of Enarj Enawga Woreda and half (50%) of the total urban population of the woreda. The same source indicated that the population size of Wojel was 3176 of which 1492 were males and 1684 were females. The total population of Wojel accounted for 2.4% of the total population of Awabel Woreda and less than a quarter (22%) of the total urban population of the woreda. The CSA data further revealed that the population size of Yetmen was 3276 of which 1455 were males and 1821 were females. The total population of Yetmen accounted for 1.8% of the total population of Enemay Woreda and 14% of the total urban population of the woreda. People in all the study towns engage in different economic activities. Some of the major economic activities are retail trade, services (bars, restaurants and teashops), agriculture and handcrafts. The majority of residents of these towns engaged directly and indirectly in agriculture. Modern manufacturing industries are nonexistent in these towns. However, handcrafts such as weaving, pottery and carpentry are available.

During the field survey, all the study towns were in the same level of infrastructural provision and development. Felege Birhan was not crossed by any main all-weather road in contrast to the other study towns. Yetmen is crossed by Addis Ababa-Motta-Bahir Dar all-weather gravel road. Similarly, Wojel is crossed by Addis Ababa-Debre Markos-Bahir Dar asphalted road. The town was also connected with Lega rural market center through secondary gravel road. All the study towns had some other basic infrastructures such as education (one elementary and junior secondary school and one high school), health (one health center for each and private clinics), water supply (except in Wojel), 24 hour hydroelectric power supply, digital telecommunication and post agent. Above all, these towns had no basic soft infrastructures like banks during the field survey. Furthermore, these towns had no public amenities such as a sport field, a library, a public toilet, a waste disposal site and butchery and their associated services mainly resulting from the absence of a municipality in Wojel and well-functioning municipalities in Yetmen and Felege Birhan.

2.3 Study Design, Approach and Sampling

Quantitative research approach and cross-sectional survey design were employed for this study. This is because the approach helps to identify the explanatory variables by generating data drawn from a representative sample (Creswell, 2012). Primary and secondary sources were used to generate data. The primary sources were household heads and the secondary sources were books, journals and other published and unpublished materials. The target population of the study was 2230 households. It was 617, 621, and 992 in Wojel, Yetme,n and Felege Birhan, respectively. The lists of households were obtained from kebele administrative and health extension offices of each town. The list of households obtained from all towns were alphabetically arranged and renumbered. The sample size for the survey was determined by Kothari's 2006 formula. This method of sample size determination is known as determination of sample size through the approach based on precision rate and confidence level (Kothari, 2006). Mathematically;

$$n = \frac{(Z^2.p.q.N)}{(e^2(N-1)+Z^2.p.q)}$$

Where,
n is size of sample; p is proportion agreeing (0.5), q is $1\breve{}p$ (0.5); Z is the value of the standard variate at a given confidence level (1.96); e is the desired margin of error (0.05) and N is total population (2230).

The calculated sample size (n) based on this formula was therefore 328 households.

Two-stage sampling was used to select the sample. The towns were selected in the first stage followed by households. The total number of non-capital small towns in East Gojjam was six. Out of these six small towns, three were purposively selected on the basis of their population size and location in relation to the main roads to see the effect of population size and road on food insecurity in these towns. The towns of population size greater than or equal to 2000 and towns located far from the main roads and along the main roads were selected. Thus, the selected towns on the bases of these criteria were Wojel (found along all-weather asphalted road), Yetmen (found along all-weather gravel road) and Felege Birhan (found far from all-weather road). In the second stage sample households were drawn from these selected small towns using a simple random sampling technique, specifically random number table, as this technique gives every member equal chance to be selected. A sample was selected proportionally by using the procedures of a simple random sampling technique from each town. The selected sample was 91, 91, and 146 households from Wojel, Yetmen, and Felege Birhan, respectively.

2.4 Survey Instrument

The household questionnaire survey was used for the study. Before the development of the questionnaire, focus group discussions were conducted on unstructured questions. These were valuable in the development of the questions and helped the researcher understand how people talk about the survey issues, which were helpful in choosing vocabulary and in phrasing questions. Focus groups can often suggest issues, concerns or points of view about the topic that the researcher had not considered (Ary *et al.*, 2010). After this, a questionnaire with open and close-ended questions was designed. It was designed to generate demographic information, economic information, food consumption (7 days consumption data on thirteen food groups such as cereals, pulses, cereal preparations, oil seeds, vegetables, fruits, tubers and stems, meat, milk and milk products, sugar and honey, stimulants, spices and oils and fats), assets, and livelihood strategies. Ambiguities, misunderstandings and other inadequacies of the questions were identified and corrected using a pilot survey on 30 households. The pilot survey also helped to improve the reliability of the questions by repeating the same questions purposely. To ensure the construct validity, the questions were given to experts who were familiar with the research issues. The corrected questionnaire after the pilot test was administered using a face-to-face interview. This is because this method has a high response rate and is useful for respondents who do not read and write (Ary *et al.*, 2010).

2.5 Data Processing Procedures and Analysis

Quantitative techniques of data analyses were employed in the study. Firstly, the numerical data were coded and entered SPSS version 20 software. Secondly, the data entered the software were cleaned using descriptive statistics to make it ready for analyses. Thirdly, the food security status of the households was measured. Daily calorie per adult equivalent was employed to measure food insecurity. This is a common measure of food insecurity, which is related to food access (D'Souza & Jolliffe, 2016). The predetermined adequate nutrition for a healthy or normal life by Ethiopian Nutrition and Health Research Institute (EHNRI), 2200 calories per adult person per day, was used. Households below and above this amount are food insecure and secure, respectively. Different individuals in a household have different needs. A young child typically needs less food or calories than an adult, and similarly, the need for women differs from men. There are also economies of scale in consumption. A large family size may benefit in price from bulk purchase (Haughton & Khandker, 2009). These differences in household size and composition were normalized or adjusted by using AE = (N adults + (0.7*N children below 15 years)) 0.8. AE refers to adult equivalent and N is a number. From the formula, 0.7 is the cost of a child relative to an adult presumably reflects the lower needs for food of children and 0.8 compares the effects of economies of scale, which significantly reduce the size of large-size households.

After the calculation of AE using this formula, the daily per adult equivalent energy intake of households was calculated. The daily energy consumption for a household was determined using the quantity of food items obtained from households and the energy assigned to each food item taken from EHNRI (1997) food composition table. The amount of calories per 100 grams of some food items such as biscuit, spaghetti, macaroni, etc which were not available in EHNRI food composition table were obtained from the packages of the manufacturer of each food item. For the item consumed in different forms (raw and cooked) by the household, the average energy was used. The real daily food consumption per adult equivalent was computed from the seven days food consumption data. Firstly, the total quantity consumed within seven-day was divided by seven to find the daily food quantity consumed by the household. Secondly, this daily total quantity was divided by the adult equivalent size of the household including the guests to find the daily adult equivalent consumption assuming that if the guests are available throughout the week. Thirdly, the daily adult equivalent consumption was multiplied by the adult equivalent size of the guests and the number of days they consumed in the household in order to know the total food quantity consumed during their stay in the household. Then in order to get the households real consumption, this amount was subtracted from the total quantity a household consumed in seven days proportionally from the total quantity of each food item by assuming that guests consumed from every item the household consumed in the seven days. Finally, the real household's seven-day consumption was changed into daily per adult equivalent.

Lastly, mean and range were used from the descriptive statistics to measure consumption variation and t-test, one-way ANOVA and logistic regression were employed from the inferential statistics to test the variation of daily average calorie consumption and identify the determinants of food insecurity. All the necessary assumptions such as linearity, normality, multiccollinearity, hetroscedacticity were tested. Though the calculated sample size was 328, the analyses were made on 323 households because the food consumptions of five (1.5% non-response rate) of the sampled households were not properly filled.

The logistic regression model used is:

$$P(Y=1) = \frac{e^{(\beta_0+\beta_1 X_1+\beta_2 X_2+...+\beta_n X_n)}}{1+e^{(\beta_0+\beta_1 X_1+\beta_2 X_2+...+\beta_n X_n)}} \quad (1)$$

Where P is the probability of occurring the dependent variable Y, food insecurity, where 1 was assigned for the food insecure and 0 was assigned for the food secure households, e is the Euler number which is the base of the natural logarithm which helps for the transformation of the non-linear relationship of the dependent variable with the explanatory variables, β_0 is constant or the Y-intercept when X is zero and β_1, β_2, ... β_n are coefficients of the independent variables. Maximum-likelihood estimation was used to estimate the constant and coefficients of the independent variables. This could select coefficients that make the observed values most likely to have occurred (Field, 2005). However, the odds ratios (odd ratio or change in odds is the change in odds resulting from a unit change in the predictor) were interpreted instead of the coefficients as these are simple to interpret as the values are standardized. The odds ratios were determined after the odds of an event were calculated. The odds of an event occurring are defined as the probability of an event occurring divided by the probability of that event not occurring (Field, 2005). The odds of an event were computed using the model:

$$Odds = \frac{P(becomingInsecure)}{P(notbecomingInsecure)} \quad (2)$$

Where the probability of being insecure can be computed using equation 1 while the probability of not becoming insecure or $P(Y=0)$ is 1˘$P(Y=1)$. The model of odds ratio is therefore:

$$OddsRatio = \frac{Oddsafteraunitchangeinthepredictor}{Originaloddsbeforeaunitchange} \quad (3)$$

The values of the numerator and denominator for the odds ratio were obtained through equation two before and after a unit change in food insecurity. The method of logistic regression used was backward: likelihood ratio since the purpose of logistic regression in this study is to explore the most important factors of food insecurity and the method is free of type II error (accepting the null hypothesis when it is false) as it identifies the most significant factor backwards rather than ignoring the insignificant one forward (Field, 2005). Indicator was the method of contrast employed as this is the standard dummy variable coding method and the zero coded categories were the reference categories for the categorical variables. Food insecurity is a dependent variable which can be explained by twelve selected factors for the present study. These selected factors were socio-demographic factors such as sex, migration status and marital status of the household head as well as household size that have positive association with food insecurity; the human capitals such as level of education, acquired skills and health status of the household head that have negative relationship with food insecurity; entitlement or economic factors such as monthly income, radio/television possession, agricultural land possession and savings of the household that have negative association with food insecurity; and roundtrip distance from drinking water point, which influences food insecurity positively.

3 Results and Discussion

3.1 Socio-Demographic Characteristics and Calorie Intake

Presenting and describing the demographic and socio-economic data are essential for any study in achieving the objectives of the research as these help in contextualizing the interpretation of the results to achieve the objectives. These demographic and socio-economic variables have either positive or negative relationships on the food insecurity status of households for this study. To show this average daily consumption of households per adult equivalent is presented with the demographic data. In connection with the description of these data, the mean daily calorie consumption of each category of each variable was analysed, and the variation of the average intake was tested using t-test and one-way ANOVA.

Table 1. Percentage Distribution of Household Heads (HHHs) by Sex and Calorie Consumption

Sex	Town						Total		Mean & *t*- value		
	Wojel		Yetmen		Felege Birhan				Total		
	Number of HHHs	%	Number of HHHs	%	Number of HHHs	%	Number of HHHs	%	Mean Daily Calorie	*t*	*p*
Female	24	26.4	24	26.7	48	33.8	96	29.7	3001.16	1.587	.11
Male	67	73.6	66	73.3	94	66.2	227	70.3	2751.98		
Total	91	100.0	90	100.0	142	100.0	323	100.0			

Source: Field Survey, 2014

As presented in Table 1, the majority (70%) of the surveyed households was male-headed and the remaining 30% was female-headed. The proportion of male-headed and female-headed households differs across the study towns. It was higher and lower than the study towns' average in Felege Birhan and the other study towns, respectively (see Table 1). The study further revealed that the mean daily calorie consumption per adult equivalent was 3001.16 for female-headed households and 2751.98 for male-headed households. The difference however was not statistically significant at the desired level. Most household heads in these towns are self-employed rather than government and private sector employed in which males are dominant than females. Females in small towns engage in petty trade like selling of local drinks like tella and areki. These are the main sources of income for many female-headed households in the study towns. Besides, females are better in managing the household resource than males. Females invest their income to meet their family needs. They are not extravagant.

Regarding the age of the household heads, a third (33%) of the household heads were ages from 30 to 39 years followed by 40 to 41 years and 20 to 29 years accounting for 21% and 19%, respectively (Table 2). These three age groups together accounted for nearly three-fourths (73%) of the household heads. The share of the remaining age groups was relatively small. The age of a significant proportion (91%) of the household heads was within the productive age group while only a little proportion (9%) was within the non-productive age group. As depicted in Table 2, there was variation in the percentage of household heads in these age groups among the study towns. The average daily calories consumption per adult equivalent also indicated this reality on the ground. It was 2404.02 and 682.33 calorie per adult equivalent for ages from 15 to19 years and above 64 years, respectively. The average consumption of these age groups was lower than the other age groups (see Table 2). This is consistent with the study results of Mesfin (2014). He found that the average age of the food insecure households was smaller than the food secure households. Keeping other factors constant like health, huge proportion of households were headed by a productive age group that can at least sell their labour in order to meet the food needs of the households. In addition, this age group has better capacity to engage in income generating activities to meet the food requirements of the household. The consumption of households headed by old age groups was lower than the other age groups due to the fact that this age group has no ability to work long hours and engage in productive economic activities.

Table 2. Percentage Distribution of Household Heads by Age and Average Calorie Consumption

Age in Years	Town						Total		Mean & F- value		
	Wojel		Yetmen		Felege Birhan				Total		
	Number of HHHs	%	Number of HHHs	%	Number of HHHs	%	Number of HHHs	%	Mean of Calorie	F	p
15-19	0	0	1	1.1	0	0	1	.3	2404.02	.715	.638
20-29	19	20.9	12	13.3	30	21.1	61	18.9	2880.27		
30-39	22	24.2	28	31.1	56	39.4	106	32.8	2854.14		
40-49	21	23.1	22	24.4	25	17.6	68	21.1	2906.38		
50-59	15	16.5	13	14.4	20	14.1	48	14.9	2874.31		
60-64	7	7.7	5	5.6	5	3.5	17	5.3	2694.74		
>64	7	7.7	9	10.0	6	4.2	22	6.8	682.33		
Total	91	100.0	90	100.0	142	100.0	323	100.0			

Source: Field Survey, 2014

As depicted in Table 3, about two-thirds (66%) of the household heads were married followed by divorced which accounted for 21 percent. The proportions of single and widowed heads of households were very small. The percentages of married and divorced heads of households were almost the same across the study towns with little variations. The average daily calorie consumption of households by marital status of heads of households indicated some variation. The consumption was the highest for single household heads followed by divorced ones (see Table 3). One-way ANOVA confirmed that these variations were statistically significant (F=4.886) at 0.002 level of significance. The consumption of households headed by divorced marital status was unexpectedly higher than households headed by married marital status. Though this needs further research this might be related to the length of divorce and recovery periods. Divorced household heads might recover from the shocks they faced through different strategies. These households might immediately invest their share from their former partner in a new livelihood strategy or meet their food needs by selling other assets. In addition, these households might use their human capital (assistance from relatives/friends), which has the greatest return to the household in meeting the food needs of the household.

Table 3. Marital Status of Household Heads and the Mean Daily Calorie Consumption

Marital Status	Town						Total		Mean & F- value		
	Wojel		Yetmen		Felege Birhan				Total		
	Number of HHHs	%	Number of HHHs	%	Number of HHHs	%	Number of HHHs	%	Mean of Calorie	F	p
Single	3	3.3	5	5.6	5	3.5	13	4.0	3425.06	4.886	.002
Married	59	64.8	59	65.6	94	66.2	212	65.6	2741.54		
Divorced	18	19.8	19	21.1	32	22.5	69	21.4	3194.64		
Widowed	11	12.1	7	7.8	11	7.7	29	9.0	2298.25		
Total	91	100.0	90	100.0	142	100.0	323	100.0			

Source: Field Survey, 2014

With regard to the size of the households, the household size of over half (55%) of the households were from 1 to 3 followed by 4 to 6 that account for 37 percent. The percentage of each household size category differs across the study towns (see Table 4). Though some differences were observed, the percentage of households with household sizes from 1 to 3 was over half of the households in each study town. The mean daily calorie consumption per adult equivalent in each household size category also differs. It was highest in the 1 to 3 household size group and lowest in the 7 to 9 household size group. The one-way ANOVA confirmed that the difference was statistically significant ($F = 5.086$) at the desired level of significance. This is consistent with the result of Mesfin (2014) on research conducted in the Amhara Region. He found that food insecure households have large household size (average 4.76) than food secure households (average 2.56). The same source revealed that large family size puts pressure on household consumption. Despite the availability of labour in large-size households, household size has a direct relationship with food insecurity. As household size increases, the tendency of households falling below the recommended daily calorie intake is high. These indicate that labours in these towns are not properly managed at the household level in order to diversify income sources and meet the minimum daily calorie consumption of the household. Large family size might have high dependency ratio if the human capital is not properly managed.

Table 4. Size of the Households (HHs) and Mean Daily Calorie Consumption

HH Size	Town						Total		Mean & *F*- value		
	Wojel		Yetmen		Felege Birhan				Total		
	Number of HHHs	%	Number of HHHs	%	Number of HHHs	%	Number of HHHs	%	Mean of Calorie	*F*	*p*
1-3	54	59.3	52	57.8	71	50.0	177	54.8	3031.59	5.086	.007
4-6	31	34.1	33	36.7	56	39.4	120	37.2	2583.39		
7-9	6	6.6	5	5.6	15	10.6	26	8.0	2546.70		
Total	91	100.0	90	100.0	142	100.0	323	100.0			

Source: Field Survey, 2014

Concerning the educational status of the household heads, 38% of the household heads did not read and write. Over a quarter (29%) of the household heads were grade 5 to 8 completed. The proportion of certificate and above holders was small (see Table 5). The percentage of each category of educational status of the household heads had some variations (see Table 5). Household heads who did not read and write were relatively higher in Felege Birhan and smaller in Yetmen accounting for 42% and 32%, respectively. The highest average daily calorie consumption per adult equivalent was for household heads who read and write was 3155.51 followed by grades 9 to12 accounted for 3004.48. The least was households headed by grades 1 to 4 completed which accounted for 2675.63 calories per adult equivalent. This shows that the variation has no pattern with the level of education and the variation in daily consumption was not statistically significant. This is against the findings of Mesfin (2014) that education has a negative relationship with food insecurity, that is, the increase in the level of education leads to a reduction of food insecurity. Education in these study towns did not generate income for the households because government institutions and private sectors that require the expertise of the educated individuals are absent. Households who produce food from their own agricultural land and off-farm activities are food insecure.

Table 5. Educational Status of Household Heads by Average Daily Calorie Consumption

Educational Status	Town						Total		Mean & *F*- value		
	Wojel		Yetmen		Felege Birhan				Total		
	Number of HHHs	%	Number of HHHs	%	Number of HHHs	%	Number of HHHs	%	Mean	*F*	*p*
Can read & write	32	35.6	29	32.2	60	42.3	121	37.6	2749.86	.559	.763
Not read & write	10	11.1	2	2.2	15	10.6	27	8.4	3155.51		
1-4	11	12.2	13	14.4	11	7.7	35	10.9	2675.63		
5-8	27	30.0	28	31.1	38	26.8	93	28.9	2828.55		
9-12	8	8.9	14	15.6	16	11.3	38	11.8	3004.48		
Certificate & above	2	2.2	4	4.4	2	1.4	8	2.5	2815.23		
Total	90	100	90	100	142	100	322	100			

Source: Field Survey, 2014

3.2 Food Insecurity Status

The existing food insecurity studies in the major urban areas of Ethiopia indicated that food insecurity is profound. A study of Ejigayehu and Endriss (2012) in Addis Ababa and WFP & UNICEF (2009) in the major urban centers of Ethiopia like Addis Ababa, Bahir Dar, Desse, Harar, Diredawa and others indicated that food insecurity status is over 40%. Table 6 below depicts the food insecurity status of the households in the study towns. As displayed in the table, slightly over a third (34%) of the surveyed households were food insecure while nearly two-thirds (66%) were food secure. Therefore, the proportion of food insecure households in the study towns was smaller than the major towns of the country. However, the percentage of food insecurity in the study towns was the same with the food insecurity status of urban areas of the Amhara region which accounted for 34.1% as studied by Mesfin (2014). The result indicates the high levels of food insecurity among the study towns. The incidence of food insecurity would have been higher than this if the data was not collected in the post-harvesting season where the price of the agricultural produces in this season is usually lower than the other seasons.

Table 6. Food Insecurity Status of the Households and Average Daily Consumption

Town		Status		Total	Statistics		
		Food Insecure	Food Secure		Min	Max	Mean
Wojel	Number of HHs	37	54	91	960.12	6758.71	2601.98
	%	40.7	59.3	100.0			
Yetmen	Number of HHs	32	58	90	1293.61	8483.37	2670.97
	%	35.6	64.4	100.0			
Felege Birhan	Number of HHs	42	100	142	578.33	9877.86	3067.91
	%	29.6	70.4	100.0			
Total	Number of HHs	111	212	323			
	%	34.4	65.6	100.0			
Mean Calorie		1671.08	3355.68				

Source: Field Survey, 2014

Though the figure in the present study was smaller than large towns and the same with the regional average, this proportion of food insecure households was very high since these towns are located in the surplus producing region. These households can buy agricultural products at a lower price than large towns and directly from the producers, so that these households might be benefited from the lower prices. In spite of the lower living cost in these towns, the high percentage of food insecure households in these towns might be due to the absence of employment creation in the study towns. According to Getaneh (2017), 90% of the households in these towns are self-employed. They engage in low-return businesses. Moreover, the livelihood of households might be undiversified and government and NGO interventions are rare. Seventy four percent of households in these towns depend on a single source of income (Getaneh, 2017). Lack of government intervention in small towns is another possible reason for the high level of food insecurity in these towns. Most development interventions of the government in urban areas are in large and intermediate size towns. For example, productive safety net programme was launched in the major towns only in 2017. The other possible reason for the high incidence of food insecurity in these towns is lack of resource management at the household level apart from the determinant factors identified through logistic regression. Above all, the high level of food insecurity is due to the high incidence of income and multidimensional poverty, which accounted for 37.5% and 55%, respectively (Getaneh, 2017).

The above table also showed that the level of food insecurity varies across the study towns. The percentage (41%) of food insecure households in Wojel was higher than the other study towns accounting for 36% and 30%, respectively. The levels of food insecurity in Wojel and Yetmen were above the average of the study towns while the level of food insecurity in Felege Birhan was below the average of the study towns. The minimum daily calories consumption per adult equivalent was low in Felege Birhan which accounted for 578.33 calorie per day per adult equivalent followed by Wojel which accounted for 960.12 calories per day per adult equivalent. These results indicate the variation in the severity of food insecurity in these towns. This variation is possibly due to differences in road access. Felege Birhan is a pocket town where its residents have no livelihood strategy in connection with the road by providing services and goods for the travelers and drivers unlike the other study towns. The minimum consumption in Yetmen was 1293.61 calories per day per adult equivalent. This was higher than the other study towns. This implies that the cost of reducing food insecurity in Yetmen is lower than the other study towns. However, the average consumption was high in Felege Birhan followed by Wojel (see Table 6). The average kilo of calories consumption per adult equivalent in urban areas of the Amhara region as studied by Mesfin (2014) was 2424.15 and 421.46 for food insecure and secure households, respectively.

3.3 Determinants of Food Insecurity

The results of the logistic regression analysis indicated that out of the twelve explanatory variables selected only six variables were statistically significant. Out of these, two were socio-demographic variables such as migration and educational statuses of the household head; three variables were entitlements such as monthly income of the household, radio or television possession of the household and acquired skill of the household head, and one variable was infrastructure-related such as round trip distance from the source of drinking water points. The model is fit by any measure of the goodness-of-fit and correctly classifies 86.7% of the cases at the seventh step (see Table 7).

Table 7. Logistic Regression Results

	B	**S.E.**	**Wald**	**df**	**Sig.**	**Exp(B)**	**95% *CI*. for EXP(B)**	
							Lower	Upper
Migration Status (1)	1.859	1.022	3.307	1	.069	6.419	.865	47.620
Educational Status	.262	.138	3.637	1	.056	1.300	.993	1.703
Acquired skill (1)	-2.628	1.301	4.081	1	.043	.072	.006	.925
Radio/television Possession (1)	3.186	1.515	4.420	1	.036	24.184	1.241	471.410
Round trip distance from Water	.149	.048	9.872	1	.002	1.161	1.058	1.274
Monthly Income in Birr	-.002	.001	7.507	1	.006	.998	.997	.999
Constant	-4.140	1.827	5.137	1	.023	.016		
Model Chi-Square	42.377							.000
-2Log Likelihood	36.48							.001
Cox & Snell R^2	.507							
Nagelkerke R^2	0.693							
Number of Cases	323							

Source: Field Survey, 2014

As displayed in Table 7, the probability of households of migrant household heads being food insecure was 6.419 higher than households of the non-migrant household heads. This might be because of the differences in the capitals they have in the towns. That is, the non-migrants might have their own houses so that they are at least free from housing expenditure for sheltering and running home-based business and some of these households able to generate income from this through renting. Besides, households headed by the non-migrants might have better social capital such as idir and equb. These help these households in times of crises.

As demonstrated in the same table, the increase in one unit in the level of education of the household head increases the probability of food insecurity by a factor of 1.3 units. This is against the expectation that education has a negative relationship with food insecurity. Education in these study towns did not generate adequate income for the households because government institutions and private sectors that require the expertise of the educated individuals are absent. However, household heads with at least one of the skills such as carpentry, weaving, pottery and maintenance decreases the probability of being food insecure by a factor of 0.072. People with these skills in these towns have the highest probability of generating enough income to meet the minimum food requirements of the households. These household heads can generate income through manufacturing handicrafts and providing services.

The odds ratio in the possession of radio/television (source of information) indicated that a household with the source of information (radio or television) decreases the probability of food insecurity of the household by a factor of 24.184. These households could receive information related to food prices and marketing through radio/television. This might help them to maximize their profit from the livelihood activities they engaged in. In addition, a tape recorder and television in a service business in these towns are the means of attraction of their customers. This increases the number of customers and the length of time these customers spent, which in turn increases income. Income has an indirect relationship with food insecurity. The odds ratio of the monthly income of the households indicated that an increase in income by a unit reduces the probability of food insecurity of the households by 0.998 units. The odds ratio in round trip distance from the water points showed that a unit increase of the round trip distance from the drinking water points increases the probability of food insecurity by 1.161 units. Infrastructure for drinking water is not well-developed in these towns. These towns have no budget allocated for even the maintenance of this infrastructure. The source of drinking water for 40% and 5% of the households in these towns was a communal tap and an unsafe source, respectively (Getaneh, 2017). The increase in distance from the source of drinking water increases the cost and time in fetching water. The increase in the cost of water reduces the food to be purchased for consumption. The time taken in fetching water reduces the time to be used in income-generating activities.

4 Conclusion and Recommendation

Addressing food insecurity is a very serious challenge for many governments of the world. The present study attempted to measure household food insecurity. It also attempted to identify the determinants of food insecurity at the household level. It is therefore possible to conclude from the results of the food security measurement that the incidence of food insecurity in small towns is very high. Significant proportions of households in these towns are suffering from food insecurity, that is, they are not able to meet the minimum daily food requirements. The result on the minimum daily calorie consumption per adult showed the severity of food insecurity in these towns. However, the incidence and severity of food insecurity and the average calorie consumption per day per adult equivalent varies among the study towns due to variations in economic, social and administrative contexts. For example, Wojel had no municipality to provide services to their residents and Felege Birhan and Yetmen had no well-functioning municipalities so that food insecurity is severe in Wojel than in the other study towns. The logistic regression results also indicate that among the statistically significant variables migration status of the household head, acquired skills of the household head, radio/television possession of the household and monthly income of the household have negative association with food insecurity while educational status of the household head and round trip distance from the source of drinking water point have positive association with food insecurity.

The problem of food insecurity in small towns should be reduced using appropriate intervention programmes at different levels. If the problem is not addressed, the severe problem in small urban areas will have a profound negative effect on the existing efforts of the government in addressing the problem of food insecurity in the country in general and urban areas in particular as many smaller towns contain a significant proportion of urban population in the country. Food insecurity intervention of the government should not be limited to the major urban centers and rural areas. The productive safety net programme and other development programmes should be implemented in all urban centers. In addition, income source diversification, especially urban agriculture like dairy and poultry farming should be promoted in these towns in order to insure food security. Besides, the Woreda government should increase communal water taps in the town to reduce the time being wasted in fetching water. The regional government should establish a municipality for those which have no and strengthen the existing municipalities. Since this study is a cross-sectional study, longitudinal studies on small towns are needed to know the trends and seasonal variations of food insecurity in these towns.

End Note

Definition of local terms

Derg is a geez word which means committee and this committee rules Ethiopia from 1974 to 1991.

Woreda is an administrative area which is found between zone and kebele administrations in Ethiopia. It is equivalent to district.

Kebele is the lowest administrative unit, which is more or less equivalent to a county in Britain.

Tella and *Areki* are very alcoholic homemade local drinks made from different cereals and rhamnus prinoides.

Idir is a local traditional association for the purpose of assistance when a family member of the member of the association dies.

Equb is a traditional local association used for rotated saving of money.

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Conflict of Interest

The author declares that there is no conflict of interest.

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E J E D

ASSESSING ADOPTION LEVEL OF CLIMATE SMART AGRICULTURAL PRACTICES AND TECHNOLOGIES AND THEIR CONTRIBUTION TO FOOD SECURITY OF SMALLHOLDER FARMERS IN ARTUMA-FURSI WOREDA, OROMO-SPECIAL ZONE OF AMHARA REGION, ETHIOPIA

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Abstract

Climate-Smart Agriculture (CSA) is a new agricultural approach designed to improve resilience and food security of farmers in the face of climate change. The study was thus intended to assess CSA adoption level and its contribution to food security of farmers in Artuma-Fursi Woreda, Oromo Zone of Amhara Region, Ethiopia. Two-stage sampling was used to select 259 households, from whom primary data were collected via cross-sectional household survey. Content analysis was used to identify farm level CSA Practices/Technologies (CSAPTs) with close examination of locally specific character of climate-induced food insecurity. Adaptation Strategy Use Index and Composite Score Method were used to assess CSA adoption level and classify households as Low/L, Medium/M and High/H adoption groups (AG). Household Food Balance Model (HFBM) was used to assess food security of households. An ordered Probit regression model was applied to assess factors influencing adoption level of CSAPTs. The study identified 30 CSAPTs. Results showed that Crop and Livestock Management were most frequently adopted, while the later 2 were least frequently adopted CSAPTs. Results also indicated that 22.8%, 32.8% and 44.4% of the households fall under HAG, MAG and LAG with a mean dietary energy scores of 1946.0, 1785.82 and 1692.84kcals/household/day. Results of the one-way between-groups ANOVA showed that the observed differences in mean dietary energy scores of the three adoption groups were larger than what would be expected by chance with $p < .05$ significant level. HFBM showed that 49.2% of HAG were in acceptable consumption category, in which only 4.7% of low adopters were found. On contrary, 64.7% of LAG were in poor consumption category, in which only 13.56% of high adopters were found, implying that increased level of CSA adoption had higher contribution to improve households' food security. Results of the ordered probit model indicated that membership in SACCOs, livestock ownership and education level of household head were significant explanatory variables determining CSA adoption level in LAG, MAG and HAG at 1%, 5% & 10% significant levels, respectively. Marginal effects estimated for the rest of variables were negatively related in LAG, while they were positively related in HAG, implying that increases in these variables make it less likely to find households in LAG and more likely to boost adoption in HAG showing potential entry points for future intervention.

Keywords: Adoption Level, CSA, CSAPTs, Household Food Balance Model

1 Introduction

The challenges of climate change, agricultural productivity and food security are now so inter-twined that any attempt to address them separately makes no sense anymore (World Bank, 2011 & HLPE, 2013). The different food security dimensions (mainly availability and access) and their inextricable links with climate change and agricultural production implies that business as usual will no longer address the inter-connected problems of climate change, smallholder agriculture and food security The strongly pronounced local needs to increase agricultural production and address food security challenges under the new realities of climate change has led to the introduction of the new concept of Climate Smart Agriculture—CSA (Lipper *et al*. 2014; FAO, 2010).

The CSA concept was first launched by FAO at the Hague Conference on Agriculture, Food Security and Climate Change in 2010, when CSA was first defined with reference to its triple goals, namely increasing production (Food security), improving resilience (Adaptation) & reducing GHG emission (Mitigation) through efficient agricultural practices or technologies and institutional support systems (Lipper *et al*., 2014 and UNFCCC, 2015). This does not mean every practice or technology applied in every location ought to produce these triple-goals because the relative importance of each varies depending on circumstances (Lipper *et al*., 2014 and UNFCCC, 2015). For example increasing production (the food security objective) has been given the highest priority in Ethiopia over the goals of adaptation and mitigation (ATA, 2014) as it has been in many developing countries (Arakelyan, 2017 and FAO, 2016). Equally, smallholder farmers in Ethiopia are most interested in CSAPTs believed to increase production, and often reluctant to compromise short-run production losses over long- and medium-term adaptation or mitigation benefits (PIF, 2010). Therefore, it was of paramount to emphasize food security goal when assessing adoption level of CSAPTs in Ethiopian smallholder farmers' context.

The CSA approach is basically designed to reorient agricultural systems to adjust to new climatic conditions that periodically reverse production performance of smallholder agriculture and lead to increased food insecurity in rural areas (ATG, 2014), where large proportion (75%) of households' food requirement comes from own production (World Bank, 2011). The problem has been so serious in Oromo Special Zone of Amhara Region, a drought-prone area in Northeastern Ethiopia. Erratic rainfall, frequent droughts, flood and other weather extremes such as hailstorms and frosts have been major climatic predicaments liable for repeated production failures and resultant food shortages (Degefa, 2002). The study area, Artuma Fursi Woreda has no exception; it has suffered repeated droughts and crop failure due to extreme rainfall variability over the growing periods. As a result, over one-third of the farm households experience wide food shortage gaps (3 to 4 months) even in normal rainfall years. The area has also been recipient of food aid for significant period in past (Zone Statistical Bulletin, 2016/17; Degefa, 2005).

An empirical review made on previous studies indicated that some researches focused on assessing adoption level (Shames *et al*., 2012 in Arakelyan, 2017; Affholder *et al*., 2010; Meybeck and Gitz 2012), while others on factors affecting adoption level of CSAPTs (Tsega A. *et al*. 2018, FAO, 2016, W. Thiong'o, 2016, S. Uzamukunda, 2015, Arslan et al., 2014; McCarthy N. and Brubaker J., 2014). Findings showed that adoption level of CSAPTs remains low for its inherent complexity (Shames *et al*., 2012 in Arakelyan, 2017) and multiple challenges as financial, infrastructural and knowledge, and weak policy and legislation (Tsega A., *et al*. 2018). A study by Zeleke, Bewket and Alemu (2010) indicated that most farm-level CSAPTs have low-to-medium adoption levels in Ethiopia. Only few studies assessed the effect of CSAPTs on food security (Maxwell *et al*. 2014; W. Thiong'o, 2016; Masakha, 2017; S. Partey et al., 2018) or using yield increment as a proxy for food security (Simret M. 2014; Richards et al. 2014 as in Arakelyan, 2017; McCarthy and Brubaker 2014; F. Maguza-Tembo *et al*. 2016). Results indicated that CSA is the way to a more resilient and higher agricultural productivity leading to improved food security, although a study by P. G. Abinye (n.d) concluded that adoption level of CSAPTs did not impact positively on food security of farmers in Uganda mainly due to lack of adequate institutional support systems.

The study is thus intended to assess adoption level of CSAPTs and its contribution to food security of smallholder farmers, and factors affecting adoption level of existing CSAPTs in the study area.

1.1 Conceptual Framework

Like other practical fields of science, a popular discourse in agriculture has limited shelf-life, since a combination of critiques and theoretical evolution drive scholars to adopt new terminology to describe their ambitions and visions for agricultural development. The language of green revolution of the 1960s and 1970s, through the participatory and environmental movements of the 1980s and 1990s, came to be associated with negative ecological consequences and as attention turned to seeing production growth in Africa a new discourse of sustainable intensification became popularized in the 1990s. Reflecting to the growing prominence of climate change within environmental agendas and need for attention to be paid to adaptive capacities within agricultural production to environmental change, the paradigm of Climate Smart Agriculture that was brought into popular use by UN FAO in 2010, has become the well-established usurper of its predecessors (Pretty *et al.*, 2011).

The CSA concept emerged at a moment in time of considerable controversy around the concept and approaches to sustainable agriculture, and when the specificities of agriculture and its role in food security were not well articulated in climate change policy process. It is put forward as a solution to the challenges of climate change and food insecurity focusing on achieving increases in agricultural production, improved resilience or adaptation to climatic change and reductions in agricultural GHG emissions. Nowadays, these three pillars of CSA have not only become well established, but have also driven major research agendas. In practice, CSA is a call for a set of actions by decision-makers from farm to global level, to enhance the resilience of agricultural systems and livelihoods and reduce the risk of food insecurity in the present as well as future (FAO, 2013; Lipper *et al.*, 2014).

Given the above background, IPCC's 2014 Climate Resilient Transformation Pathways adopted for agriculture was thus modified to illustrate the conceptual framework of the study (Figure 1).

Agriculture, smallholders sub-sector in particular has faced a set of biophysical and socioeconomic stressors, including climate change. Actions taken at various decision points in the opportunity space determine which pathway to follow. The opportunity space refers to decision points & pathways that lead to a range of possible futures with differing levels of resilience and risk. Decision points result in actions or failures to act throughout the opportunity space at present constitute the process of managing or failing to manage risks related to climate change. Within the opportunity space, CSA leads to a more resilient agriculture through increasing scientific knowledge, effective adaptation and mitigation measures, and other choices that reduce risks, whereas pathways that lower resilience of agriculture can involve maladaptation, insufficient mitigation, and other actions that lower resilience; and that can be irreversible in terms of possible futures.

As a climate resilient development pathway, CSA aims to transform farming systems to address the dual challenges of climate change and climate-induced food insecurity through increased/sustained agricultural production and income, while reducing agricultural GHG emissions, which will lead to high resilient and low risk future. In contrary, the pathways that lower resilience also described as business-as-usual potentially involve maladaptation and insufficient mitigation resulted from failure to learn and use knowledge, will lead to low resilient and high risk future in terms of climate change, agricultural production and food security (IPCC, 2014).

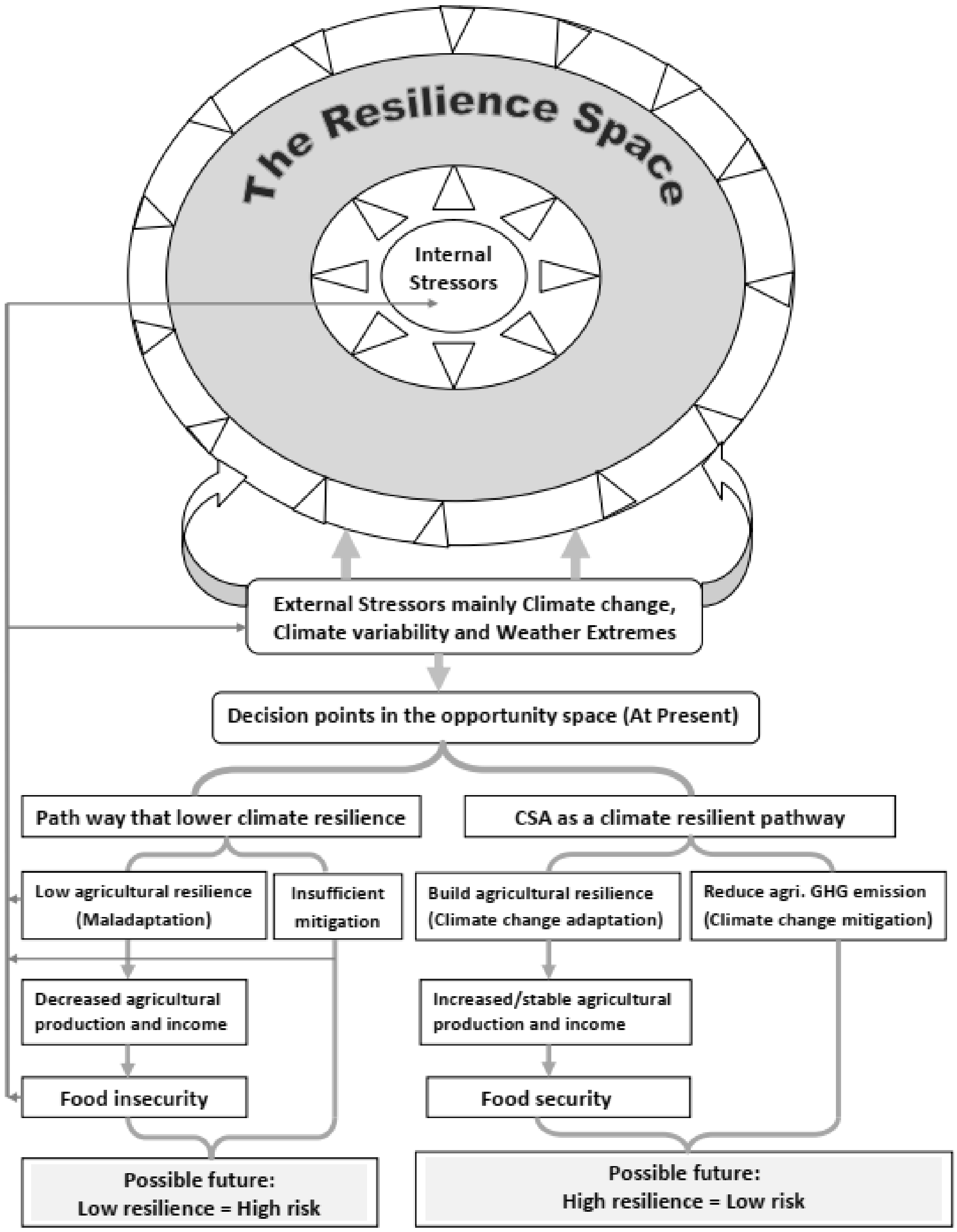

Figure 1. The Conceptual Framework of the Study (Adapted from IPCC's CRTPA, 2014)

2 Materials and Research Methods

2.1 Description of the Study Area

The study was conducted in Artuma-Fursi Woreda, one of the seven (7) administrative Woredas that form Oromo Special Zone of Amhara region, Ethiopia. Relatively, the area is bordered by Semen Shewa zone in the west, Afar regional state in East, Dawa Chefa Woreda in North and Jille Tumuga Woreda in South. The Woreda center, Chefa Robit town is located approximately 300*km* North of Addis Ababa, the federal capital and 560*km* East of Bahir Dar, the regional capital along the main asphalted road from Addis Ababa to Dessie, capital of South Wollo zone in North (WFEDO, 2009/2010).

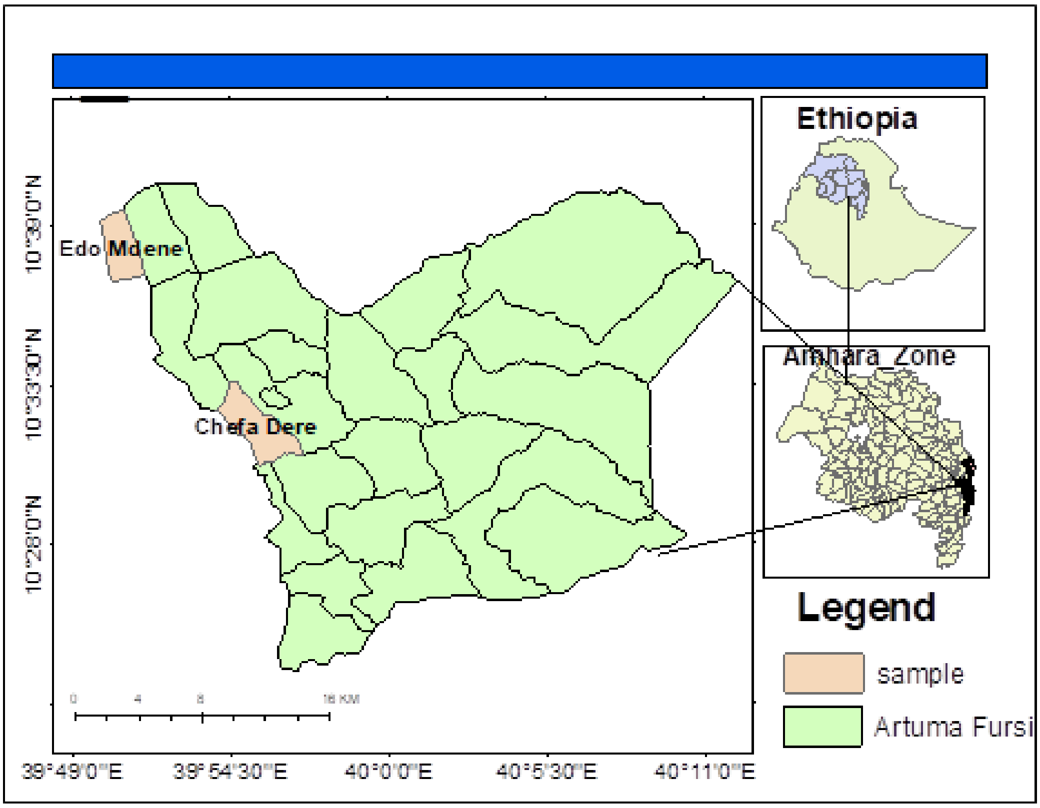

Figure 2. Map of the Study Area

The Woreda experience a uni-modal rain with the main rainy season (Kiremt) occurring between July and September. Total annual rainfall varies from 600-900mm, with high annual and seasonal variability. The annual temperature varies between 15°C and 33°C with a mean value of 21.2°C (Zone DFED, 2007-2017, WFED Office, 2017). The altitude of the Woreda ranges from 1500-2100m asl. According to local climatic classification, about 76% of the Woreda is classified under Kolla agro-climatic zone, while the rest 24% is Weinadega. As to the latest projection (2018), the total population of the Woreda is about 109681 of which about 90% are rural. The total area of the Woreda is 108396 hectares, of which forest and bushlands, grazing land, cultivated land and the land used for construction and other purposes account 62.9%, 18.4%, 10% and 7.8%, respectively. Current Woreda administrative structure is organized in 1 urban and 24 rural Kebeles (WFEDO, 2017/18).

2.2 Sampling Procedures and Sample Size Determination

A two-step sampling method was used to select sample Kebeles and households. Firstly, two rural Kebeles namely Chefa-Dire and Edo-Medene were selected purposely as they were confirmed to be information rich cases in terms of practicing a wide range of CSAPTs. Next, a proportional-random sampling method was employed to select 259 sample households as determined by Kothari (2004):

$$n = \frac{(Z^2 * p * q * N)}{(e^2(N-1) + Z^2 * p * q)}$$

Where,

n is size of sample;

p is proportion agreeing (0.5),

q is 1˘p (0.5);

Z is the value of the standard variate at a given confidence level (1.96);

e is the desired margin of error (0.05), and

N is total population (2230).

Finally, the sample size was calculated to be 259, of which 170 households were selected from Chefa-Dire and 89 households from Edo-Medene from a total sampling frame of 999 households (Chefa-Dire 616 and Edo-Medene 383) using systematic sampling technique.

2.3 Data Collection Methods

The study employed a survey design in which a comprehensive cross-sectional survey questionnaire was prepared to collect the primary data as per the required formats of the different methods used to analyze the data and achieve the objectives. Secondary data were collected from official records and books and journal articles to supplement the primary data collected through the household survey.

2.4 Methods of Data Analysis

Descriptive (mean and composite index scores, and frequency and percentage distribution tables) and inferential (one-way ANOVA and an ordered Probit regression) statistics were used to analyze the data.

2.4.1. Adaptation Strategy Use Index (ASUI)

After a critical identification of existing CSAPTs through content analysis and close examination of local farming practices, a descriptive statistics described by Adesoji and Famuyiwa (2010) in Ojoko *et al* (2017) as Adaptation Strategy Use Index (ASUI) was used to determine the extent of adoption of the identified CSAPTs in the study area as measured by the number of farm households adopting them and their frequency of use as measured by a Four-Point Likert Scale with 3, 2, 1 and 0 for Frequently, Occasionally, Rarely and Not adopted CSAPTs, respectively. The index was expressed mathematically as follows:

$$ASUI = \frac{(N_1 \times 3)+(N_2 \times 2)+(N_3 \times 1)+(N_4 \times 0)}{M}$$

Where:

N_1 = Number of farm households frequently adopt a given CSAP

N_2 = Number of farm households occasionally adopt a given CSAP

N_3 = Number of farm households rarely adopt a given CSAP

N_4 = Number of farm households do not adopt a given CSAP

M = n x 3, and

n = Sample size

2.4.2: Composite Score Method

A Composite Score Method was used to assess farm households' adoption level of existing CSAPs. The resulting composite scores calculated for sample households was used to stratify them in to three adoption groups, namely high, medium and low adoption groups based on the number and frequency of adoption of the identified CSAPs by the sample farm households as applied in the ASUI above. The composite scores ultimately range from 0 to 90, representing hypothetically households adopting none of the identified CSAPs and households adopt frequently all the identified CSAPs, respectively. Afterwards, the sample households were placed in their respective groups as applied by Salimonu (2007), cited in Adepoju *et al.* (2011):

- High adoption group = Composite scores from 90 to (mean + S.D]
- Medium adoption group = Composite scores from (mean + S.D) to (mean – S.D)
- Low adoption group = Composite scores from [mean – S.D) to 0

2.4.3. Household Food Balance Model (HFBM)

Household Food Balance Model (HFBM) initially modified form the Regional Food Balance Model (Degefa, D. 1996 and 2002) was used to assess households' food security status. The rational for using HFBM was that net availability of enough food for a rural household in Ethiopian context and its capacity to acquire food from the market determines its food security status. According to Degefa,

D. (2000 & 2005), households own production is a crucial determinant of the two critical food security components (availability and accessibility) in the Ethiopian context. World Bank (2011) further indicated that about three-fourth (75%) of the household food requirement comes from smallholders' own production.

The model was used to estimate adult equivalent per capita daily kilocalories available for household consumption. The structured survey questionnaire module was made to include questions prepared to call for the data required to capture the net per capita kcal grain available for households over a period of twelve months in the given production year, except for the 5% (Mesay, M. 2001) and 10% (Degefa, 2002) estimates given for the total seed reserve and post-harvest loss, respectively in cases where sample households fail to make their own estimations on these indicators. The model was expressed mathematically as follows:

$$N_{ij} = (C_{ij} + P_{ij} + B_{ij} + F_{ij} + R_{ij}) - (H_{ij} + S_{ij} + M_{ij})$$

Where,

N_{ij} is the net food available for household i in year j

C_{ij} is the total crop produced by household i in year j

P_{ij} is total grain purchased from market by household i in year j

B_{ij} is the total food household i borrowed in the year j

F_{ij} is the total grain received from FFW by household i in year j

R_{ij} is the total relief food received by household i in year j

H_{ij} is post-harvest losses out of total output produced by household i in year j

S_{ij} is amount of grains utilized for seed by household i in year j

M_{ij} is total grain marketed (sold out) by household i in year j

After computing the balance for each grain kind, conversion of the net available grain into dietary calorie equivalent was worked out based on Ethiopian Health and Nutrition Research Institute's food composition table. Next, the calculated per capita calorie was compared against the recommended minimum daily caloric requirement for a moderately active adult ($2100kcal$) to figure out the dietary caloric status of the sample households. The amount of calories a person needs depends on many factors, yet the household size that was obtained from head count of all household members was converted into adult equivalence as derived from Stock *et al.*, (1999) to assess adult equivalent per capita daily kilocalories and net grain available for household consumption based on the recommended minimum daily caloric requirement ($2{,}100kcal$).

2.4.4. One-Way between-Groups Analysis of Variance (ANOVA)

A one-way between-groups ANOVA statistics was used to determine the casual links between farm households' adoption level of CSAPTs and their food security status as measure by the HFBM.

2.4.5. Ordered Probit Regression Model

Finally, since the dependent variable, households' CSA adoption level, assume a natural ordering as Low (Y = 0), Medium (Y = 1) and High (Y = 2) adoption groups as derived from the Composite Score Method, an ordered Probit regression model was used to assess socioeconomic determinants of adoption level of CSAPs among smallholder farm households in the study area. The ordered Probit model was expressed as:

$$Y_i^* = \chi' \beta + \varepsilon_i$$

Where,

Y_i^* is the unobserved discrete random variable ($Y\mu_{0,1,2}$),

χ_i is the vector of independent variables,

β is the vector of parameters of the regression to be estimated,

ε_i is the vector of error term (Greene, 2003).

In this study therefore, the observed ordinal variable Y_i takes discrete values as $Y = 0$ if $Y^* \leq \mu_1$; $Y = 1$ if $\mu_1 < Y^* \leq \mu_2$ and $Y = 2$ if $Y^* > \mu_2$.

To this end, eleven socioeconomic factors assumed to influence smallholder farmers' adoption level of CSAPs in the study area were defined and then tested as explanatory variables for the ordered Probit regression analysis. STATA version 13 and Microsoft excel spreadsheets were used to manipulate the database and perform all statistical analysis.

3 Results and Discussion

3.1 Type of CSAPTs and Extent of Adoption

The study identified some thirty CSAPTs adopted in the study area with significant variations in the number of farmers adopting them and their frequency using the identified CSAPTs. Some of these CSAPTs were recently introduced, while others have long been part of the traditional subsistence mixed farming system in the study area. These CSAPTs were organized into five major categories, namely Crop Management, Livestock Management, Soil and Water Conservation, Agroecological Practices and Integrated Food-Energy Systems. Summary of the identified CSAPTs in each category, number of adopters and their frequency of adoption, proportion as per cent of the total, as well as adoption extent of each CSAPT in the study area was presented in Table 1 below according to their rank orders as determined by ASUI.

Results in Table 1 indicated that Crop Management (30%) and Soil and Water Conservation (33.3%) Practices together account nearly two-third (63.3%) of the total CSAPs adopted by farmers in the study area, while Livestock Management Practices account 16.7%. Relatively, the number of Agroecological Practices and Integrated Food-Energy Systems were few accounting only 10% each.

As can be seen from Table 1 use of improved crop varieties, alley cropping of cereals, applying fodder conservation and mechanical weed control methods, and use of conservation tillage were the five most widely adopted CSAPs in the study area taking on from the 1st to 5th rank orders as listed. Whereas, production and use of biogas, integrating trees in croplands, precise application of chemicals, bee-keeping and use of improved breeds were the least adopted CSAPs in the study area taking on from 30^{th} up to 25^{th} ranks in their order. Thus, Crop Management, Livestock Management and Soil and Water Conservation Practices were widely adopted CSAPTs, while Agroecological Practices and Integrated Food Energy Systems were least adopted CSAPTs in the study area with slight variations in average number of adopters in both cases as shown in Figure 2.

Studies conducted in various places across developing countries including Ethiopia indicated that biogas digesters have shown to reduce fuel consumption within households by up to 40% that would provide a triple win strategy for income, health, and mitigation (AgriFin, 2012). Yet, survey results and secondary statistics indicated that farm households in the study area did not mention it almost at all. As such, adoption level of biogas production and use remained the least ($30th$ rank) in the study area. A key informant at the district agriculture and natural resource office described the reason for this particular case as:

> *"... the least biogas adoption level observed in our locality did not emanate from lack of awareness on the multiple benefits of using biogas energy, but due to the high capital investment initially required and the fact that government is the sole promoter and provider of the package of services required to install biogas plants and use the energy obtained from their operation"*

Table 1. Type of CSAPTs and the Extent of Adoption in the Study Area

No.	Type of CSA practices and technologies	No. of adopters	Percent (%)	Frequency of adoption (Number)				ASUI	Rank
				Frequently	Occasionally	Rarely	Not		
1.	**Crop Management Practices**								
1.1	Use of improved crop	248	95.6	196	37	15	11	0.8713	1^{st}
1.2	Change planting dates	176	68.0	32	123	21	83	0.4672	10^{th}
1.3	Apply contingent planting via early maturing varieties	111	42.9	34	44	33	148	0.2870	15^{th}
1.4	Alley cropping of cereals	227	87.6	150	70	7	32	0.7683	2^{nd}
1.5	Precise fertilizer application (type, timing, amount)	101	39.0	13	36	52	158	0.2098	19^{th}
1.6	Precise application of chemicals (timing, quantity)	41	15.8	2	5	34	218	0.0644	28^{th}
1.7	Apply organic fertilizer-compost, animal/green manure	106	40.9	5	35	66	153	0.1943	20^{th}
1.8	Apply mechanical weed control	228	88.0	57	146	25	31	0.6281	4^{th}
1.9	Apply on-farm diversification	171	66.0	18	114	39	88	0.4131	12^{th}
2.	**Livestock Management Practices**								
2.1	Use of improved breeds	59	22.8	6	32	21	200	0.1326	26^{th}
2.2	Diversify livestock species	176	68.0	80	88	12	83	0.5508	7^{th}
2.3	Keep more resilient species	88	34.0	18	24	46	171	0.1905	21^{st}
2.4	Apply fodder conservation	215	83.0	152	56	7	44	0.7400	3^{rd}
2.5	Use cut and carry feeding	178	68.7	37	118	23	81	0.4762	9^{th}
3.	**Soil and Water Conservation Practices**								
3.1	Use small-scale irrigation	88	34.0	30	34	24	171	0.2342	18^{th}
3.2	Use in situ water conservation	179	69.1	41	132	6	80	0.5058	8^{th}
3.3	Use conservation tillage (reduced, minimum tillage)	171	66.0	135	26	10	88	0.6010	5^{th}
3.4	Mulching (stubble retention and planting cover crops)	160	61.8	43	106	11	99	0.4530	11^{th}
3.5	Apply crop rotation	194	74.9	78	106	10	65	0.5869	6^{th}
3.6	Intercropping	67	25.9	13	44	10	192	0.1763	24^{th}
3.7	Strip cropping	82	31.7	6	18	58	177	0.1441	25^{th}
3.8	Leave vegetative strips or construct Fanya juu	120	46.3	70	44	6	139	0.3912	13^{th}
3.9	Reinforce conservation structures with grasses or trees	114	44.0	60	40	14	145	0.3526	14^{th}
3.10	Establish live barriers on farm boundaries and hedges	62	23.9	30	20	12	197	0.1828	22^{nd}
4.	**Agroecological Practices**								
4.1	Integrate trees in croplands	15	5.8	10	3	2	244	0.0489	29^{th}
4.2	Plant trees around croplands	80	30.9	50	20	10	179	0.2574	16^{th}
4.3	Practice bee-keeping	36	13.9	5	12	18	223	0.0734	27^{th}
5.	**Integrated Food-Energy Systems**								
5.1	Biogas production and use	18	6.6	6	8	4	241	0.0489	30^{th}
5.2	Use efficient biomass stoves	60	23.2	30	20	10	199	0.1802	23^{rd}
5.3	Use Improved postharvest storage facilities, techniques	82	31.7	40	35	7	177	0.2535	17^{th}

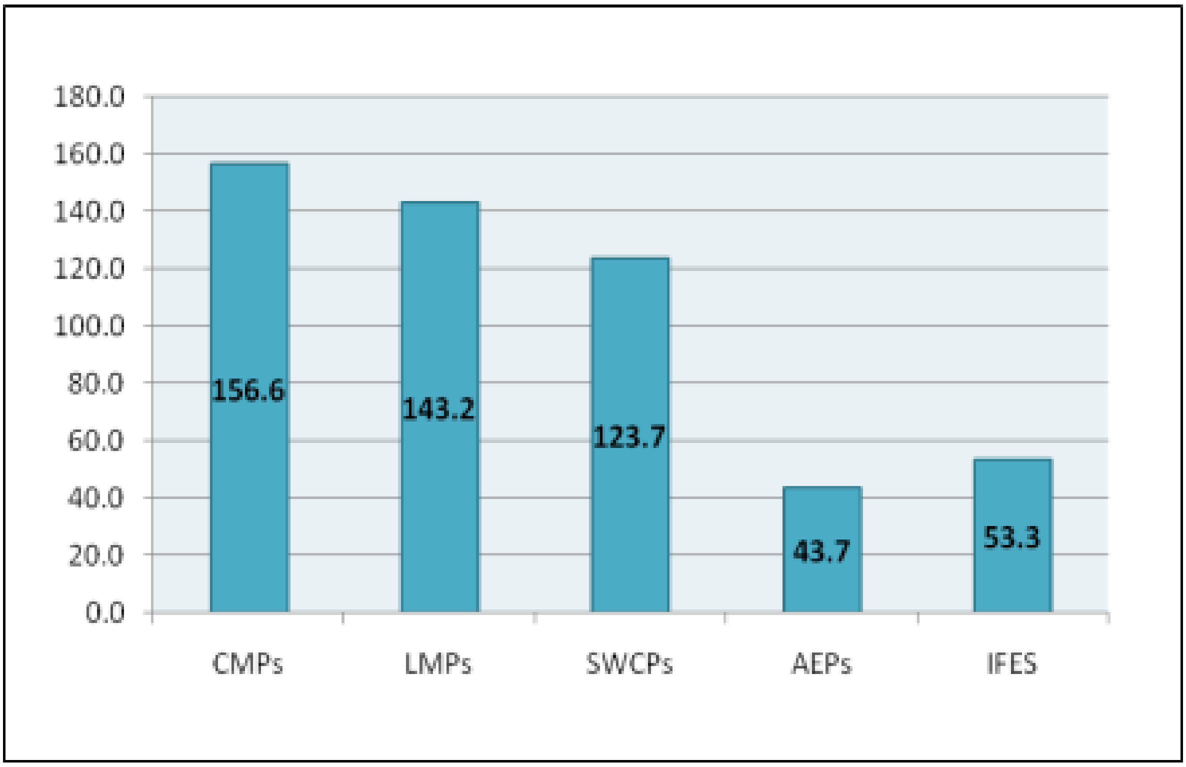

Figure 3. Type of CSA Practices and Average number of Adapters (Source: Household survey, 2019)

3.2 Households' Adoption Level of CSAPTs and their Food Security Status

In this sub-section, farm households' adoption level of the identified CSAPs was determined through the composite score method, which was used to group households in low, medium and high based on their level of adoption of the identified CSAPs. To this end, households were made to respond to questions relating to their frequency of adoption of the identified CSAPs using an ordinal Likert scale by scoring 3, 2, 1 and 0 points for Frequently, Occasionally, Rarely and Not adopted CSAPs, respectively in order to compute the composite score points, which in turn used to group households in Low, Medium and High level adaptors. Results indicated that the mean (μ) and standard deviation (σ) of the distribution of the composite score points were 41.25 and 16.53, respectively.

Thus, households' adoption level of CSAPs was determined as follows:

- High adoption groups: Composite score points between 90 and 57.5
- Medium adoption groups: Composite score points between 57.5 and 25.0
- Low adoption groups: Composite score points between 25.0 and 0

Table 2. Descriptive statistics for Households' adoption Level of CSAPs

CSA adoption groups	Composite score points	Number	Percent (%)
Low adoption group	0.0 - 25.0	85	32.82
Medium adoption group	25.0 - 57.5	115	44.40
High adoption group	57.5 - 90.0	59	22.78
Total	0 - 90	259	100

As can be seen in Table 2, 44.40% of the sample fall in medium adoption group, while 32.8% of them fall under low adoption group. Households included in high adoption group make up 22.78% of the total.

It was also indicated in Table 3 below that the amount of food energy available for the total sample households was 2,105,952.03*kcal* with a mean and standard deviation daily per capita *kcal* of 1795.6 and 446.2, respectively. When compared to the minimum recommended allowance (2100*kcal*), the available dietary energy could cover 85.51% of the recommended daily allowance. Compared to the minimum recommended allowance (2100*kcal*), the available dietary energy could cover 92.67% of the recommended daily allowance for households in the high adoption group, whereas the coverage was 85.04% and 80.61% for households in the medium and low CSA adoption groups, respectively implying that households' increasing level of CSA adoption was likely to improve their food security status.

Table 3. Distribution of mean dietary energy available by adoption level of CSAPTs

Adoption level	Households No and %	Av. family size in AE*	Population in AE	Total dietary energy/*kcal*	Mean DE in *kcal*	Std.	% of the MRA
Low	85 (32.8%)	4.31	366.35	620,171.93	1692.8	462.4	80.61
Medium	115 (44.4%)	4.54	522.1	932,376.62	1785.8	440.6	85.04
High	59 (22.8%)	4.82	284.38	553,403.48	1946.0	422.8	92.67
Total	259/100%	4.5	1172.83	2,105,952.03	1795.6	446.2	85.51

Results in Table 3 also showed that mean dietary energy available for households in high, medium and low adoption groups was estimated to be 1946.0, 1785.82 and 1692.84*kcals*, respectively. Besides, results of the one-way between-groups analysis of variance with post-hoc tests conducted to assess contribution of households' adoption level of CSAPTs on their food security status indicated that there was statistically significant difference at the $p < .05$ level in the mean HFBM scores for the three adoption groups $F(2,256)=3.96$, $p=.013$. The actual difference in mean scores between the groups appears to be large enough, the calculated eta squared value was .07 would be considered as a medium effect size according to Cohen (1988). Post-hoc comparisons using the Tukey HSD test showed the mean HFBM score of the Low adoption group ($\mu=1692.8$, $\sigma=462.4$) was significantly different from the High ($\mu=1946.0$, $\sigma= 422.8$) adoption group, whereas the mean HFBM score of the Medium adoption group ($\mu=1785.8$, $\sigma=440.6$) did not vary significantly from either the Low or High adoption groups. Thus, the difference in food security status of households in the low and high adoption groups was not just a matter of chance, but attributed to the variation in adoption level of existing CSAPTs.

There is no consensus among literature in measuring household food security on specific calorie consumption thresholds to define levels of calorie intake, it was decided at a World Food Program Workshop to use the thresholds of 0 and 20% shortfalls below the average 2100$kcal$ per person per day (Lovon and Mathiassen, 2014). This was used to establish the following calorie consumption ranges:

- Poor calorie consumption ($\leq$1680 $Kcal$ per capita per day);
- Borderline calorie consumption (>1680 – <2100$Kcal$ per capita per day, and
- Acceptable ($\geq$2100$Kcal$ per capita per day)

Summary of the descriptive statistics showing distribution of households under each adoption group in the poor, borderline and acceptable calorie consumption ranges is presented in Table 4.

Table 4. Distribution of Households' Calorie Consumption by adoption level of CSAPTs

Calorie consumption	Consumption ranges	N	%	Mean $kcal$	Calorie consumption by adoption levels LAG (%)	MAG (%)	HAG (%)
Poor	leq1680	103	39.8	1588.4	64.71	34.78	13.56
Borderline	>1680 – <2100	111	42.9	1847.6	30.59	54.78	37.29
Acceptable	geq2100	45	17.4	2119.2	4.71	10.44	49.15

The results in Table 4 indicated that 49.15% of households in the high adoption group were found out to be in the acceptable calorie consumption range ($\geq$2100), in which only 10.44% and 4.71% of the households were included from the medium and low adoption groups, respectively. Contrary, results also showed that 64.71% of the households in the low adoption group were found out to be in the poor calorie consumption range ($\leq$1680), in which only 34.78% and 13.56% of the households were included from the medium and high adoption groups, respectively. Besides, (54.78% of the households in medium adoption group were found out to be in the borderline calorie consumption range (>1,680 – <2100), in which only 30.59% and 37.29% of households were included from the low and high adoption groups, respectively.

Proportion of households (%) according to different calorie consumption ranges in the low, medium and high CSA adoption groups was presented in Figure 4.

Figure 4 indicated a shift of farm households from the low to medium CSA adoption level filtered some 5.73% (10.44%-4.71%) of households from borderline to acceptable calorie consumption range, but 29.93% (64.71%–34.78%) of households from poor to borderline calorie consumption range. However, the implication of CSA adoption level of households on their calorie consumption, and thus food security status was larger when households were shifted from low to high adoption levels as it transferred all the households (100%) from borderline to acceptable and also enabled 13.85% of the households to leapfrog from the poor to acceptable calorie consumption range by escaping over the borderline calorie consumption range. Similarly, the shift also poured 13.57% of households from poor to borderline calorie consumption level. Results in this regard also indicated that CSAPTs contributed substantially to improve the food security status of farm households in the study area.

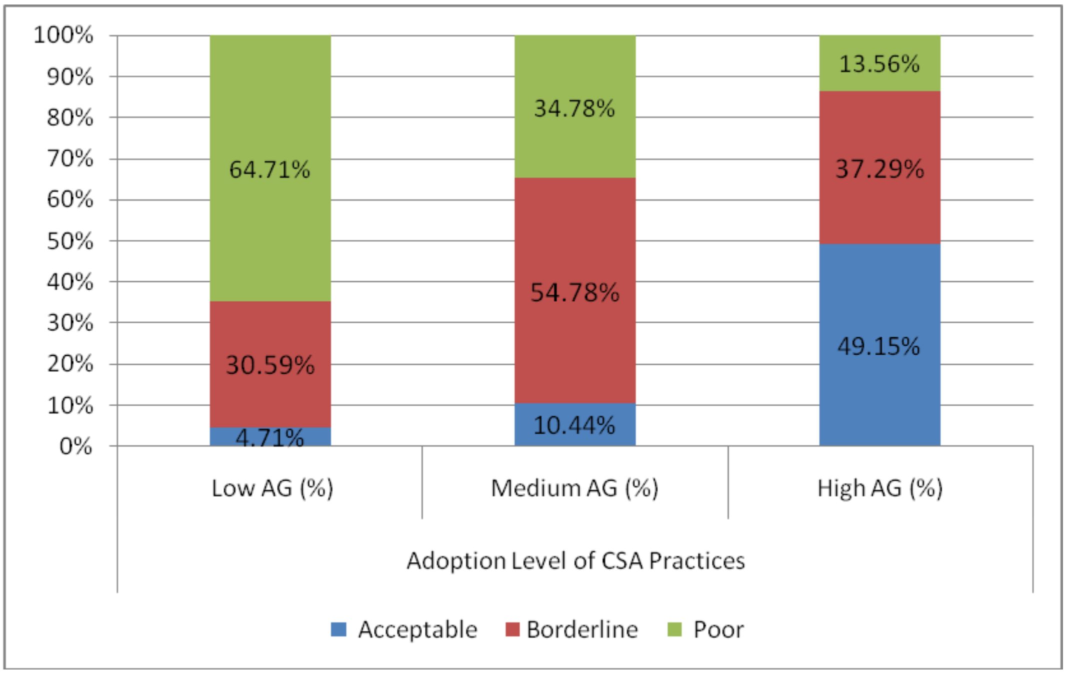

Figure 4. Proportion of households (%) in different CSA adoption groups, (Source: Computed from the Household survey, 2019)

3.3 Factors Influencing Households Adoption Level of CSAPTs in the Study Area

Albeit for different CSAPs, various factors have been indicated in previous studies to affect adoption level of households among smallholders. In this study thus, eleven socioeconomic factors assumed to influence adoption level of CSA at household level were identified, and then tested through Ordered Probit Regression Model. The ordered Probit model on module of STATA version 13 was used to perform the regression since the dependent variable (CSA Adoption level) was assumed to have a natural ordering as Low (Y=0), Medium (Y=1) and High (Y=2) adoption groups. Log likelihood of -96.2285 with a *p*-value of 0.0000 revealed that the model as a whole was statistically significant. Estimated cut-off points (μ) showed that the categories were ranked in an ordered way of $\mu_2 > \mu_1 > \mu_0$.

Marginal effect estimates indicated that years of education, livestock and membership in SACCOs were significant explanatory variables influencing adoption level of CSAPTs among households in low and high adoption categories at 10%, 5% and 1% level of significance, respectively. On the other hand, none of the explanatory variables significantly influenced adoption level of CSAPTs among households in the medium adoption category. Results of the Ordered Probit Model were presented in Table 5.

As can be seen in Table 5, the marginal effects in the LAG for all variables have negative signs, while the signs in HAG were positive indicating that the higher the values for this variable means the less likely they were in the LAG and the more likely they were in the HAG. The negative sign in the LAG and MAG implied an increase in all the explanatory variables will cause the farm households therein to increase their adoption level of CSAPTs, although marginal impacts were not significant, except for those mentioned above. In the HAG, on the other hand, all the explanatory variables were positively related, as the value of these variables increase, there will be a boost in adoption level of existing CSAPTs in the HAG.

Table 5. Distribution of Households' Calorie Consumption by adoption level of CSAPTs

Variables	Coefficients	Low adopter group			Medium adopter group			High adopter group		
		SE	*P*-Value	ME	SE	*P*-Value	ME	SE	*P*-Value	ME
AGE	.0003895	.005990	.98300	-.000125	.000470	.98300	-9.68e-06	.006450	.98300	.0001340
GENDER	.150110	.36620	.89300	-.04950	.018290	.96900	-.00070	.349310	.88600	.050160
EDUCATION	.0553309	.010560	.09500*	-.017660	.002740	.61600	-.001380	.011410	.09500*	.0190350
HH SIZE (AE)	.04984	.01141	.16300	-.0159	.00252	.62300	-.0012	.01233	.16400	.01715
FARM INCOME	6.04e-07	.00000	.69400	-1.93e-07	.00000	.75300	-1.50e-08	.00000	.69400	2.08e-07
OFF-FARM INCOME	1.02e-06	.00000	.82400	-3.25e-07	.00000	.84500	-2.53e-08	.00000	.82500	3.50e-07
FARM IMPLEMENTS	3.04e-076	.00000	.54900	-2.23e-07	.00000	.79500	-4.35e-08	.00000	.75200	2.68e-07
MEMBERSHIP	.7728677	.08350	.00300***	-.2466735	.036790	.60200	-.019210	.089050	.00300***	.2658835
CREDIT ACCESS	.52498	.08503	.0740*	-.1521	.04492	.39600	-.0381	.12216	.12000	.19016
EXTENSION	-.132690	.040820	.30000	.0423491	.006820	.62900	.0032980	.04360	.29500	-.045647
LIVESTOCK	.5798643	.115610	.05000**	-.149310	.122820	.56700	-.070381	.234460	.05000**	.2196904
LAND SIZE	.01588	.00440	.25100	-.0051	.00079	.61700	-.0004	.00468	.24300	.00546
Cut 1 -.631523										
Cut 2 1.003240										

4 Conclusion and Recommendation

4.1 Conclusions

The following conclusions emerged from the main research findings. Smallholder farmers in the study area adopt a wide variety of CSAPTs at different level, composition and for variety of reasons. Based on the findings, Crop and Livestock Management and Soil and Water Conservation Practices were most widely adopted CSAPTs, whereas Agroecological Practices and Integrated Food Energy Systems were least adopted CSAPTs in the study area, with slight variations in average number of adopters on both cases. Some of these identified CSAPTs were recently introduced, while others have long been part of the traditional subsistence mixed farming system of the study area.

More specifically, results also indicated that crop management practices (such as use of improved crop varieties, alley cropping of cereals and application of mechanical weed control methods, change planting dates), livestock management practices (such as applying fodder conservation, diversify livestock species and use cut and carry feeding) and soil and water conservation practices (such as conservation tillage, crop rotation and use in situ water conservation practices) were widely adopted CSAPTs in the study area, whereas agroecological practices (such as integrating trees in croplands and practicing beekeeping) and integrated food energy systems (biogas production and use of efficient biomass stoves) were least adopted CSAPTs.

Further results indicated the overwhelming majority ($\sim 4/5^{th}$) of the households were medium or low CSA adopters, whereas only a fifth ($1/5^{th}$) of them were happened to be in the high adopters group, which is the empirically identified best adoption level in this study. Finding in this study was that CSAPTs contributed to food security status of households in the study area, especially when they were adopted by households with increased variety and degree of frequency. Besides, the food security contribution of CSAPTs increase substantially when households were shifted from low to high adoption groups than when they were shifted from low to medium or from medium to high adoption groups.

Results further indicated that age of household head, gender of household head, years of education of household head, household size, group membership, access to credit, farm size and farm income, off-farm income and value of productive farm implements were all negatively related, implying that an increase in all these explanatory variables will cause farm households in low and medium adoption groups to increase their level of adoption of CSAPTs, thereby improve their food security status. On the other hand, all explanatory variables mentioned above were positively related implying that as these variables increase, there would be a boost in adoption level of CSAPTs in high adoption group, which is perhaps likely to boost their food security status and improve overall livelihoods via surplus food production (availability) and increasing supply to local food markets (accessibility).

4.2 Recommendations

This particular sub-section is devoted to pertinent recommendations drawn from major findings of the study. Findings showed unlike crop and livestock management, and soil and water conservation practices, agroecological practices (integrating trees in croplands and practicing bee-keeping) and integrated food energy systems (biogas production and use of efficient biomass stoves) were the least adopted CSAPTs in the study area. Therefore, local government and their development partners such as NGOs and donors should collaborate to roll out programs intended to increase the demand for agroecological practices (mainly integrate trees in croplands and practice bee-keeping) and integrated food energy systems (mainly biogas production and use of efficient biomass stoves) with the efforts to boost crop and livestock management, and soil and water conservation practices.

One of the key findings of the study was that CSAPTs contributed significantly to food security status of farm households, especially when the level of adoption was higher both in terms of number (diversity) and frequency of use. As to the findings of the study, it is important to diversify farm households' income sources and their access to extension and credit services enhance adoption level of existing CSAPTs among smallholder farm households, and thereby improve their food security status.

In addition, smallholder farmers should be sensitized about the needs to invest in productive assets to enable them absorb more risks associated with climate change. The sensitization can be carried out in groups by extension workers or other local development agents. Smallholders should also be encouraged to participate in such farmers' association as RSACCOs so that they will be able to share information on benefits of increased adoption level of CSAPTs to improve households' food security status. To this end, the present study calls for increased participation and collaboration of local and international development agencies in the efforts to deal with interlinked challenges of climate change, smallholder agriculture and food security.

Future studies in the study area should focus on the contribution of adoption level of individual CSAPTs on food security status of farm households in order to come up with more refined entry points for future intervention. Further studies should also focus on how to enhance synergies and reduce tradeoffs between the triple goals of CSA, namely improving food security via increased agricultural production and income, enhancing resilience through increased adaptation to climatic change and enhancing climate change mitigation through reducing agricultural GHG emissions.

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Conflict of Interest:

The author would like to declare that there is no conflict of interest.

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