



ADDIS ABABA UNIVERSITY

COLLEGE OF DEVELOPMENT STUDIES

CENTER FOR ENVIRONMENT AND DEVELOPMENT STUDIES

APPLE FRUIT PRODUCTION AS CLIMATE CHANGE ADAPTATION OPTION

A CASE STUDY IN SULULTA

A THEIS PRESENTED TO COLLEGE OF DEVELOPMENT STUDIES
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER IN ENVIRONMENTAL AND SUSTAINABLE DEVELOPMENT

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OCTOBER 2020
ADDIS ABABA, ETHIOPIA

DECLARATION

I, the undersigned, declare that this thesis is my original work and has not been presented for any degree in any university and all the sources of materials used for the thesis have been duly acknowledged.

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This thesis has been submitted for examination with my approval as university supervisor.

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Acronyms

ADLI	Agricultural Development Led Industrialization
BC	Black Carbon
CBA	Community-Based Adaptation
CBO	Community-Based Organization
CC	Climate Change
CCD	Climate Compatible Development
CH ₄	Methane
CO ₂	Carbon Dioxide
CRGE	Climate Resilient Green Economy
ESD	Environment and Sustainable Development
FGD	Focus Group Discussion
GDP	Growth Domestic Product
GHGs	Green House Gases
GOC	Government Office
HHs	House Holds
IPCC	International Panel on Climate Change
KP	Koyoto Protocol
MOFED	Ministry of Finance and Economic Development
NAPA	National Adaptation Program Action
NMA	National Metrological Agency

O ₃	Ozone
SLCP	Short-Lived Climate Pollutants
TNA	Technical Need Assessment
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change

Abstract

The agricultural production of Ethiopia is challenged by the current changing climate. This research aims to assess and examine the contribution of farmer's apple fruit production as an option for climate change adaptation and diversification of household income. Data were collected from sampled individual apple producers, non - apple producer farmers, from focus group discussions and secondary data were thoroughly looked and analyzed. Data obtained from physical observations were also processed and analyzed. The findings of the processed data indicated that apple production in the sululta area had a wider contribution in strengthening the adaptation capacity of the urban and rural poor community against the current climate change effects happening in the area. The growth of apple trees provides additional income to the household beyond fresh and organic apple fruit supply to improve household nutrition. Apple tree largely contributing to conserving the soil and gives tremendous nutritional benefits to the urban dwellers and rural communities beyond its contribution to moderate the microenvironment. Even though tree growing in the area have shown tremendous benefits and contribution, however, apple promotion is not supported by new research findings and technical expertise. Apple production needs technical backstopping and well-organized extension services for encouraging tree growth and good production for a household. Studies confirmed that collaboration efforts bring remarkable change at the community level through resource contribution and knowledge sharing. From the analysis of the study result, we can conclude that both the government, private companies and industries working in the area jointly with the grass-root communities need to give due consideration and attention to the promotion of apple production to bring paradigm shift from less productive crop production to diversified fruit production in the area. A deeper understanding of the interdependence between changing climatic conditions and apple production together with adaptation options are very crucial.

Key Words: Agricultural transformation, Apple tree, Climate change, Climate change effects adaptation, Income diversification.

1. INTRODUCTION

1.1. Background

Ethiopia is a country with having an altitude range of 110m to 4620m with a wide range of land topography and vegetation diversity. Because of its topographic variation and location in the tropics, the country has a diverse climate condition that favours the growing diversity of crops and plants. However, due to poor land and resource management practiced coupled with limited knowledge about cash crops growing and management in the country for centuries resulted in sharp resource degradation that highly contributed to low climate change adaptation.

The country's economy is heavily dependent on rain-fed agriculture; its geographical location and topography in combination with low adaptive capacity imply a high vulnerability to adverse impacts of climate change. Historically, land degradation in the form of soil erosion has negatively affected agricultural production and economic development in Ethiopia. An easement and examination of farmers' Apple Fruit Production as a climate change adaptation and income diversification option was conducted in the Sululta area. The study area Sululta Town Administration is located in Oromia Regional State on the North side of Special Zone surrounding finfinne. The center of Sululta town is suited at 23Km distance from Addis Ababa on the Main Road leading to North Shoa Oromia Gohastion.

Climate change is everywhere and its impacts are wide and large, the study area Suluta has also exposed to a wide range of climate change effects that resulted in poor agricultural productivity and Low income at the household level. Flooding, Erratic rainfall, Crop failure, Reduced Grass/ Straw production, and Lose of some bird species are among the major climate change effects that happed in sululta. This study has been also dedicated and commissioned to examine farmers' apple fruit production as an option to climate change adaptation and income diversification.

Nowadays the effect of climate change is becoming a major development challenge to Developing countries including Ethiopia. The study result conducted in the Sululta area has also shown that the area is becoming one of the most vulnerable to the effects of climate change. Well studied and panned adaptation measures have to be implemented.

It can be easily recognized that less attention has been given to to the environmental issues and depending only on a certain adaptations strategy coupled with late actions will cost the

community and can set back development efforts and achievements by years. The majority of the farmers of the area largely depend on the erratic rainfall farming system which is the major cause for loss of productivity in the area. The study result has also shown that various agricultural and natural resource intervention measures have been undertaken to build the farmer's adaptation capacity including apple fruit tree growing at farmer's area. The study conducted by (Lemlem et al, 2018) on apple adoption potential as agroforestry in farmers' area has also revealed that promotion of apple fruit tree as Agroforestry technologies is important because it offers the prospect of increasing production resulted with increased income.

Apple Fruit Production as an option for climate change adaptation and income diversification is being practiced by the farmers and urban dwellers of the Sululta area. The various studies conducted on fruit production indicated that income diversifications and household nutritional improvement can be achieved through the promotion of apple fruit tree growing at farmer's level.

Generally, Apple trees in Sululta have great adaptability, disease-resistant, less damaged by excessive rainfall and frost. Significantly apple fruit production at farmer's level builds the resilience capacity through household nutritional improvement, fresh Fruit intake by the family from own farm, helps in additional income from the sale of fruits to improve the livelihoods, Conserve the soil and water system of the catchment. The contribution of apple fruit tree growing as an option to climate change adaptation is also paramount important and it needs further studies and investigation.

Thus, a deeper understanding of the interdependence between the changing climatic Conditions and apple production together with adaptation options are the very crucial points to bring changes in the life of communities. Information about farmers' perception regarding climate change effects and adaptation approaches would assist policymakers to decrease the farmer's vulnerability to the adverse impacts of climate change

1.2. Problem Statement

Climate change affects poor people in particular, because of their weak adaptive capacities. Development projects of all kinds can strengthen or weaken those capacities. At the same time, they can influence greenhouse gas emissions, the main cause of climate change, positively or negatively.

Our Climate is varied and complex: The biophysical characteristics within Ethiopia are highly varied. The terrain spans from the hot arid desert of the Danakil lowland to the mountains ranges of the simian. Overlaid on this terrain, agriculture and land use- activities are extremely diverse. This reflects the variation in climate, soil type and cultural practices across the country. This variation complicates policy planning, particularly since responses to build resilience must be grounded in local contexts.

There are evidences of climate change in Ethiopia over the last 50 years. At the National level, temperatures have increased by an average of around 1⁰C since the 1960s. This increase has been felt across all regions. Rainfall nationally is subjected to high variability between years, seasons and regions. Yearly variation around mean rainfall levels is 25% and can increase to 50% in some regions. Despite this complexity, there is evidence of a 20% decrease in rainfall in the south central region of the country.

Weather variability leads to extreme events and hazards: Within Ethiopia extreme weather events are common, especially droughts and floods. Alongside the evidence of changing climate . There is a suggestion that the incidence of drought and floods may have increased in the last 10 years relative to the decade before. Soil erosion is a key hazard for agriculture with up to 6% of the country at risk.

Historic weather variability, extreme events and hazards have resulted in a substantial negative impact on economic growth in agriculture: Floods and droughts have resulted in severe loss to agricultural crops and livestock resulting in food security implications. The economic impacts depends on the extent of the variability and extreme events but droughts alone can reduce total GDP by 1% to 4%. Soil erosion has been estimated to reduce agricultural GDP by 2% to 3% (around 1% of total GDP). Even excluding these major extremes, the sensitivity of agricultural output to weather variability means we must aggressively address the costs of current vulnerability.

In addition to economic impacts, agricultural livelihoods are also vulnerable to weather variability and stresses. By mapping Ethiopian agricultural livelihoods we assessed how the different types of livelihood are vulnerable to ongoing weather variability and extreme events. The impacts to agricultural livelihoods depend on the livelihood type and region of

Ethiopia, underscoring the needs for responses appropriate to the local context. Consecutive droughts are the most prominent of these hazards, as they impact all livelihood types.

Future climate change in Ethiopia is uncertain, although scenarios of change show the range of possible outcomes. There is a high degree of uncertainty in projections of how global climate change will affect temperature and rainfall patterns in Ethiopia. While projections clearly show temperatures increasing there is disagreement on the exact level, with a range of projections indicating between 0.5⁰C to 2^oc by the 2050s relative to today. Due to the complexity of our climate, the projections of future rainfall are uncertain. However, the models project that current rainfall variability will continue (projections of the change in future annual rainfall range from -25% to +30% by the 2050s). Given the outputs of the climate models, the scenario to a much hotter and drier scenario, along with potential changes in the intensity and frequency of extreme events.

The future impacts and costs of climate change on agriculture and forestry are potentially very significant, which could put our ambition of reaching middle-income status by 2025 at risk. In a hotter drier scenario, with increased incidences of droughts, the negative impact on GDP could be 10% or more by 2050. This is particularly worrying not only for our middle – income ambition but also because the impacts will fall on the most vulnerable in society. The analysis made on the impacts of climate change has highlighted that climate change poses a particular threat to one of our key exports, Arabica coffee (worth around 2% of GDP to our economy today but the total income is set to double under the worst phase of the Growth and Transformation Plan (GTP)), as it can only be grown within tight temperature thresholds. We must therefore prepare for these specific effects of climate change. The Federal Democratic Republic of Ethiopia Climate Resilient Green Economy, Climate Resilience Strategy Agriculture and Forestry (2012: 5-6)

Results of the Preliminary assessment conducted at study area indicated that the communities are suffering and challenged by droughts, crops failure, crop pests, water-shortage, flooding and higher variability of rainfall are a consequence of climate change in the area. The local population has many functioning coping strategies, but they cannot reduce their vulnerability sufficiently, particularly with a view to ongoing climate change.

In fact various attempts are undergoing to build the communities adaptation to the climate change. However, Apple fruit production as option to climate change adaptation and income diversification is not well promoted in sululta area. The fact that sululta is sited in the average

altitude of 2500mas to 2800 mas with average temperature of 12^oc which is suitable for apple fruit tree growing and fruit production. Growing apple in the high land areas of the town have not given due attention. Nevertheless the contribution of apple tree growing to ecological balance and stress coping potential is significant that needs the attention and efforts of multidisciplinary sectors. The contribution of the apple tree growing in the area is not well studied and documented that might have some positive or negative contribution on those livelihood resources impacts. Yet more actions need to be taken, and more people in the area should benefit from planting apple trees to render the population resilient.

Apple tree growing at farmers are have largely expected to contribute positively to reducing greenhouse gases in the atmosphere, contribute for afforestation, Enhanced agroforestry practices, soil improvement, enhance the practice and usage of manure or organic fertilizer. This study will also focus on assessing the level on which apple tree growing in sululta area have contributing to climate change adaptation as one of the many options and the tree contribution to household income diversification

1.3. Objective of the study

1.3.1. General objective

The main objective this study is to assess the contribution of apple fruit tree growing by the farmers for climate change adaptation and its contribution to income diversification.

1.3.2. The specific objectives

The specific objective of this study is to:

- To explore and understand farmers climate change adaptation options practiced in the study area
- To assess and examine the contribution of apple tree growing by the farmers for climate change adaptation option
- To measure and know the income contribution of apple fruit production for household income diversification and livelihood resource improvement
- To assess the knowledge and practice of the farmers on apple tree growing and management as well as on climate change adaptation.

1.4. Research Questions

The Research questions answered by this study were the following,

- What was the major climate change impacts in the study area
- Types of climate change adaptation options being undertaken by the farmers in the study area
- What does farmers benefiting from apple tree growing in their locality
- How does apple fruit tree growing contribute as a climate change adaptation option
- What was the major problems of apple tree growing by the farmers
- What are the favourable micro climatic conditions for apple fruit production
- What does apple fruit production contributed for livelihood resource improvement

1.5. Significance of the study

The Study conducted on apple production for climate change effects adaptation in sululta area has significance to community development, policy formulation and evaluation and as well as it has great significant importance to academic and research. The details of the study significance are discussed as follows.

a) Significance to Community Development

- ✓ Due consideration and attention to incorporate apple tree planting and growing as one option of climate change adaptation
- ✓ Contribute in income diversification options
- ✓ Contribute in improving Household food security
- ✓ Improve micro climate, soil nutrient, and apple production helps to recycle household solid wastes.

b) Significance to Policy

- ✓ Provide first hand information to the local stakeholders and government intuitions regarding to climate change impacts and its adaptation strategies.
- ✓ The study will contribute to analyse and assess the local strategies and options of climate changes adaptation in depth
- ✓ The result will be important in designing effective and applicable policy intervention on Climate Resilient Green Economy

c) Significance to Academic and Research

The study result will create further understanding and interest for the researchers to look the relationship of apple fruit production and climate change adaptation and household livelihood improvement. Limited studies have been conducted on apple production in the country. Apple tree physiological characteristics, productivity, nutrient requirements, growing and management techniques needs to be studied further.

1.6. Scope of the study

This Study was conducted to assess the contribution of apple fruit production for climate change adaptation in Sululta area.

1.7. Limitation of the study

This study was subjected to the following limitations.

- ✓ Time series information is difficult to collect from the farmers since they are not recording and remember only the most recent ones. It was not possible to take more than one-year data.
- ✓ Change in soil fertility, environmental amelioration which are very important to see the contribution of apple tree to the environment was not conducted due to fund and time shortage
- ✓ Analysis of adaptation options being exercised by non apple growing farmers were not deeply undertaken due to movement restriction as a result of COVID-19 Pandemic
- ✓ Apple tree mitigation co benefit in particularly the tree carbon sequestration capacity was not well studied and very limited research findings and literatures are available on this point.

2. LITERATURE REVIEW

2.1. Concepts and Definition of Apple fruit production and climate change adaptation options

Apple fruit production

Apple tree is the deciduous fruit tree that potentially grows and bears fruits in wet – dry, mid, and highland areas of the country (Agriculture and Environment Journal Vol.15 : 2014).

In Ethiopia the majority of the high land areas are much suitable for the growing and production of Apple fruit, however, it was not a common agricultural practice in these areas for a century. Apple fruit production in Ethiopia is a new agricultural practice. Even though it's not evidenced by the literature, this agricultural practice has been started before sixty years ago during the missionary's movement to the Southern parts of the country.

The Gamo area is the first area where apple and different high land fruit trees have been introduced to Ethiopia. later on, it was expended to the central high land of the country particularly to North Shoa Oromia regions through the Government and International development partners' support. Apple is a deciduous fruit tree that drops its leave and flowers during the rainy time and starts bud brake after the long rainy time is completed. The seeding of apple is prepared from Apple rootstock and Apple scion which is propagated through the propagation techniques of Grafting and Budding.

According to the chilling requirement apple fruit tree varieties are classified as Low chill, Medium Chill, and High Chill. Low Chill Apple varieties need a short period of chilling or cold weather to obtain dormancy or rest time. This time is the time at which the tree becomes dormant and no vegetation growth is seen. The tree dormancy condition will continue until the cold weather or the rainy time is over or passed. Depending on the management undertaken by the farmers low chill apple varieties can provide fruits twice in a year. From the so far experience of the study area, apple trees are growing and producing fruit in sululta under the erratic and fluctuating weather conditions in the area. In the area, erratic rainfall and fluctuating weather conditions are mostly observed during the dormancy or rest period of the tree that might not be the problem on tree growth and fruit production.

According to the analysis of information gathered from Sululta Town Urban Agriculture office Apple fruit tree planting has been started in sululta area some fifteen years back. The promotion was started by Non-governmental organizations working in the area later on the government started distribution of medium chill apple seedlings brought from Chenchha area.

The community's attitude towards to the management of these trees was very minimal that resulted with less productivity. Very recently as a result of urbanization households that have good knowledge and information about apple tree management showing tremendous results of apple fruit tree growing in the area. The nearby farmers are also enjoying high quality apple fruit produced in their locality that strongly supporting them to adapt the changing climate conditions in the area. .

Apple tree growing in Sululta and the Chilling Requirement

Chilling is the most important climatic condition for apple productivity. As the varieties of apple trees are different the chilling requirements also vary from variety to variety. Based on the chilling Requirements Apple trees are categorized as Low Chilling, Medium Chilling, and High chilling. Low chill apple cultivars require a short Dormancy period and while High Chilling Apple cultivars require a Long dormancy period. Apple Dormancy period is the time at which the trees are at rest or on brake time through defoliate its leaf, no bud development, and no vegetative growth at all. Apple fruit tree has two main parts that include the Rootstock and Scion. Rootstock is the root part of the Tree mostly helps to anchor the tree with soil and roots supply nutrients and water to the upper part of the tree. In the upper part of the apple tree, we call it the scion which is the fruiting part of the tree. The scion contains the desired genes to be duplicated in future production by the stock/scion plant

Climate change is a change in global or regional climate patterns, in particular a change apparent from the mid to late 20th century onwards and attributed largely to the increased levels of atmospheric carbon dioxide produced by the use of fossil fuels.

Climate change and the situation in Sululta

Climate change (CC) has occurred across much of Ethiopia, particularly since the 1970s, at a rate that is variable but broadly consistent with wider African and global trends. Mean annual temperature increased by 1.3°C between 1960 and 2006, an average rate of 0.28 °C per decade. Models suggest that Ethiopia will see further warming in all seasons of between 0.7 °C and 2.3°C by the 2020s and of between 1.4 °C and 2.9 °C by the 2050s and that the timing, intensity, and volume of rainfall will change over much of the country. Climate

change is predicted to affect the GDP growth of the country by between 0.5 and 2.5 percent each year unless effective steps are taken to build resilience. Climate change, therefore, has the potential to hold back economic progress or to reverse the gains made in Ethiopia's development and could exacerbate social and economic problems.

Climate change is everywhere and its impacts are wide and large. The study area sululta has also exposed to a wide range of climate change effects. CC effects are flooding , erratic rainfall , change in morning and night temperature, pollution and frost are the major one .

The climate change effects seen in Sululta area have resulted with a Consequences of vicious circle problems that includes

- Land degradation
- Loss of crop and animal husbandry productivity
- Loss of income and disrupted Community Livelihood that finally resulted in weak community adapting capacity.

This study has been also dedicated and commissioned to examine farmers' apple fruit production as an option to climate change adaptation and income diversification.

Dedicated adaptation is required to reduce vulnerability and strengthen resilience to unavoidable climate change. In recent years, the international community has increasingly emphasized the need for adaptation, and more funding has been made available, but most efforts to help countries adapt have centred on top-down approaches and policy solutions . However, given that climate change impacts. appropriate responses, and, to some extent, adaptive capacity, are location-specific, community level implementations are the key solution to adapt the current climate changes occurring in sululta area.

Apple fruit tree seedling and propagation techniques

Apple Seedlings are propagated by the techniques of Grafting and Budding.

Grafting is a method of asexual plant propagation widely used in agriculture and horticulture where the tissues of one plant are encouraged to fuse with those of another. It is most commonly used for the propagation of trees and shrubs grown commercially. There are different techniques of grafting and the whole technique of grafting is all about fixing the selected Stick (Graft Wood) on the Rootstock through any convenient and experience grafting techniques. Some of the Grafting techniques are Wedge, Whip, Side ...etc).

Budding is another way of propagation techniques mostly used to propagate apples. The budding techniques are all about fixing the Bud of the selected Stick on the Rootstock. It is the easiest way of propagation technique that commonly used in Sululta area for the multiplication of Apple seedlings by a private nursery. T Budding, Inverted T, and Cheep Budding are the common techniques mostly used in Ethiopia to propagate apples. For successful grafting to take place, the vascular cambium tissues of the stock and scion plants must be placed in contact with each other. Both tissues must be kept alive until the graft has taken, usually a period of a few weeks. Successful propagation only requires that a vascular connection takes place between the two tissues. A physical weak point often still occurs at the graft, because the structural tissue of the two distinct plants, such as wood, may not fuse. (Source own experience and observation)

Apple grafting onto rootstocks enables the grower to determine the tree's eventual size. Apple tree size ranges between one to ten in increasing height and breadth. A "1" is a dwarf that can be productive and as short as three feet with proper pruning. A "10" is the standard sized tree with no dwarfing and will grow to twenty or more feet tall and wide, dependent upon the variety chosen.

Dwarf apples trees are propagated by using one special rootstock & grafting the desired apple to the rootstock. When you plant a seed it is the result of pollinating the ovum & results in a plant that is genetically close but not the same as the parent. This may result in a larger or smaller apple, sweeter or more bitter taste, colour change, etc.

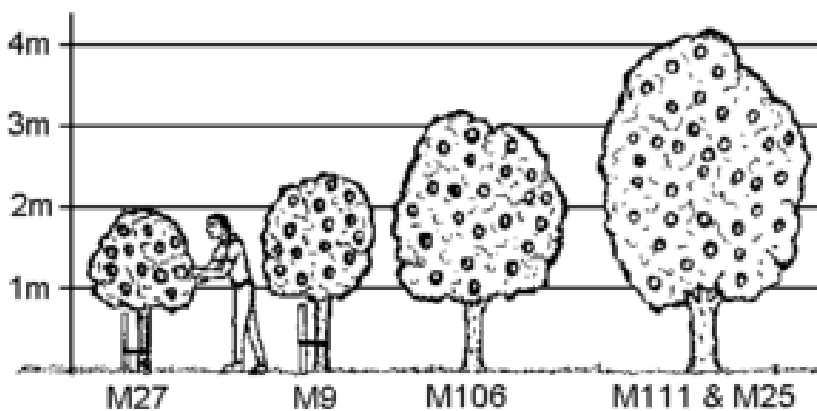


Figure 1 Comparative size of Apple Trees depending on rootstock grafting

Source : (<http://en.Wikipedia.org/wiki/file.applerootstock.png>)

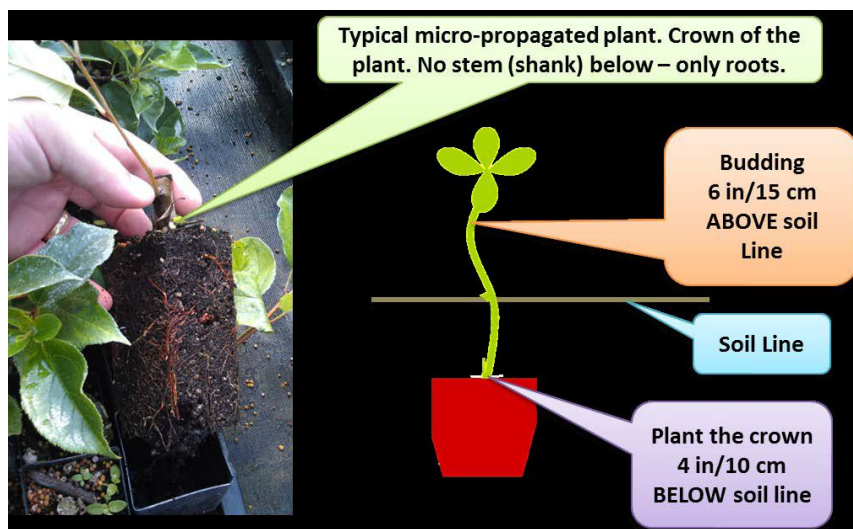


Figure 2 Apple Fruit Tree Parts and propagation techniques

Source: Cornell University Apple rootstock Comparison (2019:ChartV4)

Impacts of climate change and adaption options in sululta area

Adaptation is an adjustment to the natural and human system to climate change effect. It is a process of protecting nations and communities from disruption and damage to climate change effects. Adaptation is classified as autonomous and planned. Autonomous adaptation is a spontaneous action taken during the effects of climate change and while planned adaptation is a strategy based on available information, research, and future for the caste of the effects. Adaptation and vulnerability are interlinked. Vulnerability to climate change effects depends on potential impacts and adaptive capacity. Potential impacts are characterized by exposure and sensitivity, while adaptive capacity depends on livelihood assets and capacity and willingness.

Normally the community adaptations measures are classified as the technological solution (grey Measure), Ecosystem-based measure (Green measure), and Behavioral Measure (soft) adaptation. Green and soft adaptation measures are less cost and while grey measure needs research and high technological solution and therefore it is costly. Adaptation capacity and coping strategy are somewhat similar and adaptation is beyond the coping strategy. Copping is actions talked during the effects time and while adaptation is information and research-based and it looks to future and forested effects.

Adaptation strategies enhance and implement measures to reduce, moderate, and take advantage of climate impacts at all scales. Such strategies may aim to: create high levels of economic and livelihood diversity; promote skills, learning, and innovation; reduce dependence on ecosystem services; reduce inequality, and ensure decision-making processes at multiple levels are well-connected and involve participation from all stakeholder groups.

Design is critical to the adaptation process. Community organizing for adaptation to climate change in itself also increases resilience to climate risks by strengthening and expanding social networks and links with donors and supporting institutions and by having communities take responsibility for environmental and social problems rather than creating a reliance on external actors to assume these responsibilities on behalf of the communities. Community-Based Adaptation (CBA) is used to refer to adaptation activities based on the principles of participatory, community-driven planning and community responsibility for project implementation. As such, the CBA process is based on communities' identified priority needs, knowledge, and capabilities. It empowers community members to plan and adapt to the impacts of climate change that are most relevant to their well-being. Implicit in CBA is the principle that meaningful measures to reduce vulnerability and minimize socioeconomic consequences of climate change can be achieved through an understanding of how people cope with and adapt to climate variability consistent with predicted CC effects. The study by (Belay Simane et al, 2013) revealed that the ultimate goal of CBA is to increase the resilience of communities by enhancing their capacity to cope with CC impacts. This kind of CBA depends on the ability of a community to work collectively through social networks to manage the risks of climate change. Collective work, in turn, frequently requires the presence of a sustainable community based organization (CBO) that can coordinate community efforts.

The sustainability of a CBO is in large part a function of the empowerment of organizations, such that members are capable of planning and implementing their development initiatives independently. Community driven developments are part of a broader paradigm shift responding to critiques of sustainability. The local institutions do not replace national and international development actors, but they serve as an essential complement that ensures a bottom-up component emerges from participating communities. Building sustainable

communities requires a proactive, localized, and highly participatory approach that depends upon the unique role and capabilities of local government and the engagement of a wide range of stakeholders. It also requires the establishment and maintenance of considerable community autonomy and participatory management within the community. The establishment of CBOs does, however, require technical and financial capacity that is often beyond the reach of climate vulnerable communities. (Simane et al, : 2018).

Practical adaptation options in Suulta

Communities of sululta area have practicing a variety of climate change adaptation options to overcome the problems they phased as a result of the current climate change impacts. Among the adaptation strategies used to adopt from harmful impacts are

- ✓ Tree planting
- ✓ Undertaking Intensive urban Agriculture (Home garden vegetable production, poultry, Beekeeping, Mushroom production and others)
- ✓ Soil and water conservation activities on the upper hillside of the catchment
- ✓ Apple fruit production around the residential area both for house consumption and marketing
- ✓ Grass/ hay production and marketing during off season to get additional income for household commodity procurement
- ✓ Fuel wood collection and marketing to the near by Addis Ababa market
- ✓ Milk and milk products production and marketing as a major income source for household
- ✓ Working in Industry and construction areas and petty trade are among the adaptation options being practicing by the majority of the sululta community. Different studies conducted with this regards have also witnessed that communities are searching options to get income to overcome the problems of climate change impacts in their locality.

2.2.Theoretical Review of Apple fruit production and climate change adaptation option

Apple production and climate change adaptation

A deeper understanding of the interdependence between the changing climatic conditions and apple production together with adaptation options are the very crucial points. Information about farmers' perceptions regarding climate change and adaptation strategies would assist policymakers to decrease the farmer's vulnerability to the adverse impacts of climate change. (Uttan Khanal,2014:13)

Apple is one of the high-value fruit trees that can grow and provide fruit in the high and midlands of the sululta area. Proper variety selection suitable to the locality determines the adaptability and productivity of the tree. Low chilling apple cultivars best perform in sululta area that requires a cumulative chilling of 200 to 300 hours below 8^{0C}. These low chill apple varieties need a short period of dormancy as compared to medium chill apple varieties and it needs a small amount of water supply and bear fruits twice in the year depending on the management of the grower.

Table 1 Apple (Maults domestic) Variety With Chilling Requirement

Apple Variety	Chilling Requirement	
	Low Chill	Medium Chill
Anna	✓	
Dorset golden	✓	
Princesa	✓	
CP- 92	✓	
Bond Red		✓
Grany smith		✓
Fuji		✓
Red Delicious		✓

Source: Analysis of Secondary data from sululta apple seedling production nursery

Ecological Benefits of Apple Fruit Production

The growing of apple fruit in the farmer's area provides a wide range of ecological and economic benefits that greatly interlinked with adaptation options to climate change. The nature of the apple fruit tree root growth system is shallow that contributes to fix and protect the upper soil part from wind and water erosion. The shallow root growth system also helps to enhanced soil structure and improves soil nutrients.

Normally Apple trees will take some rest after fruit production time when the cold-weather season comes to the growing area. The rest period of apple trees knows to be the dormancy. Apple fruit tree dormancy refers to a state of temporary metabolic inactivity or minimal activity. But at this dormancy time, the tree biology does not include the mechanism for going dormant. During Apple tree dormancy, the tree stops growing and conserve energy until better cultural conditions present themselves.

Table 2 Ecological Requirement for Low Chilling Apple Variety

Ecological Requirements	The ideal condition in Sululta area
Chilling requirement	From 200 – 300hr less than 8 ° c
Agroecological zone	Suitable in Wet and Moist Dega and WoyenaDega
Altitude:	1900- 2800 masl.
Soil:	Fertile, deep, and well-structured soils with good aeration, no waterlogging. black cotton soil is not recommended
Slope	Gentle slope assists drainage during the rainy season
Aeration	Open field, avoid neighboring trees
Water	Gravity or pumped irrigation water
Planting Space	3meter between plants and 4-meter b/n row
Planting pit size	80cm – 1m depth and width
Planting and grafting Point	Keep always grafting point 10-15cm above the ground level

Source: Secondary Data and Own Observation

In the study area during the long rainy time in most of the time from June to End of August Apple Trees will be in the Dormancy period and at this time trees do not show any vegetative growth. In the study area during the dormancy period apple trees drop the leaves and have no flower and vegetative growth.

The vegetative growth of the tree will temporarily stop and just it looks a dry and dead tree without any leaves. The filed observations made to the study area revealed that the length of the dormancy period is depending on the intensity of the rainfall. If the rainfall extends up to September sometimes the tree dormancy will prolong until the rain stops and warm conditions come to favour bud sprout. This condition helps the farmers to save the trees from excessive rainfall and snow damage.

The result of focus group discussion and analysis of secondary data also show there is not damaged on the tree during the heavy and prolonged rainy in the area and while other vegetables and cereal crops growing in the area are heavily damaged and leads farmers to poverty.



Figure 3 Fruiting Apple Tree In the High Land of Sululta

Apple trees are the only fruit tree in the area that do not damage by heavy rain, cold weather conditions, sun stock, and frost due to its dormancy characteristics at a time of harsh weather conditions in Sululta. The farmers are happy by planting apple fruit trees because the trees are always saved and new bud development and blossoming start after the rainy season hoping to get high fruit production from January to March.

Economic benefits of apple fruit production

In Ethiopia apple fruit production is at its infant stage, the promotion is very low and analysis of secondary data shows that the country has very small annual apple fruit production. This is not because of the climate problem and the availability of suitable areas for apple production rather it is due to lack of technical knowledge on apple fruit growing and management and shortage of adaptive, healthy, and quality apple seedlings supply.

In Ethiopia the annual apple fruit production is not more than 1000ton. 90% of apple fruit demand of the country is covered by imports from China, USA, France, South Africa, Chill, and other Arab countries with hard currency. 1kg (five fruits) of imported fresh and high quality apple fruit is currently sold at 240 ETB in Addis Ababa supermarkets. Further studies and analysis required in this area. Source: (Own Survey 2020)

In the study area, apple fruit tree production is a means to get additional income for the family. It is common in the area to see apple trees in the compounds of farmers and urban dwellers. The study result indicated that farmers plant 10 to 15 seedlings of an apple tree in their compound and generating annually 20,000 to 25,000 Birr from 25% product sale to the market.



Figure 4 Improved Versus Local Products of Apple

2.3. Apple production and its significance for Climate change adaptation option

The impact of climate change on food security in Sub-Saharan Africa has largely been explored by a plethora of authors using either the agronomic model or Ricardian analysis (Simane et al, 2018). Empirical literature shows that Ethiopia is the most vulnerable country owing to its least adaptive capacity and low diversified economies (Stige et al.2006). This becomes even more complicated where Ethiopia's agricultural systems have largely relied on rain-fed that have been closely associated with climate (World Bank:2006). It has been noted that extreme climate events such as drought and floods reduced one-third of Ethiopia's economic growth (World Bank: 2006). A large body of literature has recognized adaptation as one of the policy options in response to climate change impact (Smit et al. 1999, Smith and Lenhart : 1996 and UNFCCC : 1992).

Growing of apple tree both for fruit production as well as any tree to conserve the environment has significant contribution to adapt the changing climate events in the study area sululta. The elevation and moderate chilling condition of Sululta area encourages farmers and town residents to grow a number of apple trees in the very pocket area.. Remarkable changes in terms of harvest and nutritional supply for households are the observable benefits enjoyed from the tree.

Adaptation strategies

Adaptation strategies enhance and implement measures to reduce, moderate, and take advantage of climate impacts at all scales. Such strategies may aim to: create high levels of economic and livelihood diversity; promote skills, learning, and innovation; reduce dependence on ecosystem services; reduce inequality, and ensure decision-making processes at multiple levels are well-connected and involve participation from all stakeholder groups.

Some practical examples include investing in disaster risk reduction, creating measures to protect food security when droughts increase food prices, or developing additional water storage capacity to deal with changing rainfall patterns (Mitchell:2019).

The Result of a feasibility study conducted during area scanning shows that the farmers of the sululta area were affected by the current climate change impacts as other area farmers too.

Small scale and subsistent agriculture is the common farming system exercised by the majority in the study area.

Small scale agriculture includes two to three dairy cow management for milk and milk product marketing, Hay production and marketing, Cereal crop barley and wheat production for family consumption, apple fruit, and vegetable production for additional income are among the farming systems of sululta area. Some dwellers of the area have also involved in petty trade activities that include fuel wood and cow dung marketing to get income for their livelihood.

The above mentioned agricultural operations have exposed to the climate change impacts due to it is dependent on the erratic rainfall and unpredictable weather condition commonly observed in the area. However, the diversified small scale agricultural operation practiced by the farmers in the area might have some contribution to building the adaptation capacity of the farmers to the existing climate change. In this study, attempts have been made to assess whether apple fruit production by the farmers have some contribution to the existing climate change or not. Some authors and literature have also recommended small scale agriculture including agroforestry taken as an option of climate change adaptation. (Bruno,2014: 63-79)

In this study, the significance of farmers' apple production to climate change effects adaptation and contribution to additional income has been analyzed against other current adaptation strategies being practiced by the farmers. The study result indicates that Soil and water conservation, Tree planting, and diversified agriculture are among the climate change effects adaptation strategies practiced in Sululta. To examine and assess the level at which apple production is contributing to climate change effects adaptation compared with other climate change effects adaptation strategies have been discussed very well.

2.4. Empirical Review of Apple fruit production and climate change adaptation option

Climate change is a fundamental threat to sustainable economic development, with devastating impacts on agriculture, water resources, ecosystems, and human health. Immediate, substantial reductions in CO₂ and other long-lived GHGs are needed to avoid a 4°C warmer world (UNEP : 2011). While every region will be affected, those least able to

adapt. The poor and most vulnerable will be hit hardest. The large and dominant role of CO₂ emissions in rising global average temperature remains unchanged; understanding of the effects of greenhouse gases and other pollutants on the climate system, however, is improving.

Other pollutants namely methane (CH₄), ozone (O₃), black carbon (BC), and some hydro fluorocarbons (HFCs), collectively referred to as short-lived climate pollutants (SLCPs) are now recognized for their potency and as a significant cause of global warming.

The global climate is changing due to the carbon-intensive path of development that has been pursued by rich countries since the beginning of the industrial revolution. The concentration of CO₂ in the atmosphere has increased from a pre-industrial value of about 280 ppm to 379 ppm in 2005. Developing countries, especially the least developed countries like Ethiopia, are disproportionately affected by the harmful effects of the global warming on agricultural production and food security, water resources, health, physical infrastructure and ecosystems due to the combination of already fragile environments, the dominance of climate-sensitive sectors in economic activity, and low adaptive capacity.

Recurrent droughts and floods have resulted in the loss of life and property as well as the migration of people. Drought frequency is predicted to increase, placing stress on already vulnerable production systems. The number of people affected due to drought has increased from 1.5 million in 1974 to 12.6 million in 2005. The international community has responded to the problem of climate change by adopting the United Nations Framework Convention on Climate Change (UNFCCC:2015) and the Kyoto Protocol (KP) to stabilize the concentration of greenhouse gases in the atmosphere.

Ethiopia is also highly vulnerable to climate change and weather variability. It is heavily dependent on rain-fed agriculture, and its geographical location and topography in combination with low adaptive capacity entail a high vulnerability to adverse impacts of climate change. The Country's natural resources base, its land, water, the biodiversity that are the foundation of its economic development and food security are highly vulnerable to both anthropogenic and natural induced climate changes. The intense pressure on the natural resources base from population growth and inappropriate traditional farming and management practices (extensive cultivation, overgrazing and deforestation, and soil erosion) are additional stresses of climate change in the country (Alemneh et al, 2017:82-115)

Climate change (CC) has occurred across much of Ethiopia, particularly since the 1970s, at a rate that is variable but broadly consistent with wider African and global trends. The mean annual temperature increased by 1.3 °C between 1960 and 2006, an average rate of 0.28 °C per decade Climate. Belay Simane, (2013).

Models suggest that Ethiopia will see further warming in all seasons of between 0.7 °C and 2.3 °C by the 2020s and of between 1.4 °C and 2.9 °C by the 2050s and that the timing, intensity, and volume of rainfall will change over much of the country. Climate change is predicted to affect the GDP growth of the country by between 0.5 and 2.5 percent each year unless effective steps are taken to build resilience. Climate change, therefore, has the potential to hold back economic progress or to reverse the gains made in Ethiopia's development and could exacerbate social and economic problems.

Dedicated adaptation is required to reduce vulnerability and strengthen resilience to unavoidable climate change. In recent years, the international community has increasingly emphasized the need for adaptation, and more funding has been made available, but most efforts to help countries adapt have centred on top-down approaches and policy solutions. However, given that climate change impacts appropriate responses, and, to some extent, adaptive capacity, are location-specific, the community-level design is critical to the adaptation process (Simane, 2013).

Community organizing for adaptation to climate change in it-self also increases resilience to climate risks by strengthening and expanding social networks and links with donors and supporting institutions and by having communities take responsibility for environmental and social problems rather than creating a reliance on external actors to assume these responsibilities on behalf of the communities. Community-Based Adaptation (CBA) is used to refer to adaptation activities based on the principles of participatory, community-driven planning, and community responsibility for project implementation. As such, the CBA process is based on communities' identified priority needs, knowledge, and capabilities. It empowers the community. Members plan and adapt to the impacts of climate change that are most relevant to their well-being. Implicit in CBA is the principle that meaningful measures to reduce vulnerability and minimize socioeconomic consequences of climate change can be

achieved through an understanding of how people cope with and adapt to climate variability consistent with predicted CC effects.

The study by (Belay Simane, 2013) revealed that the ultimate goal of CBA is to increase the resilience of communities by enhancing their capacity to cope with CC impacts. This kind of CBA depends on the ability of a community to work collectively through social networks to manage the risks of climate change. Collective work, in turn, frequently requires the presence of a sustainable community-based organization (CBO) that can coordinate community efforts. The sustainability of a CBO is in large part a function of the empowerment of organizations, such that members are capable of planning and implementing their development initiatives independently. Community driven developments are part of a broader paradigm shift responding to critiques of Sustainability.

The local institutions do not replace national and international development actors, but they serve as an essential complement that ensures a bottom-up component emerges from participating communities. Building sustainable communities require a proactive, localized, and highly participatory approach that depends upon the unique role and capabilities of local government and the engagement of a wide range of stakeholders. It also requires the establishment and maintenance of considerable community autonomy and participatory management within the community. The establishment of CBOs does, however, require technical and financial capacity that is often beyond the reach of climate-vulnerable communities. (Simane et al, 2018)

Different authors and literature define the word adaptation in different ways. Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploit beneficial opportunities (IPCC). Practical steps to protect countries and communities from the likely disruption and damage that will result from the effects of climate change UNFCCC (2015).

Some literature also defined the term adaptation as a process by which strategies to moderate, cope with, and take advantage of the consequences of climatic events are enhanced, developed, and implemented. (UNDP). The type of adaptation is mostly categorized as Autonomous (reactive) adaptations: often those that are undertaken spontaneously as routine

adjustments to conditions and Planned (anticipatory or proactive) adaptations: explicitly strategic and tends to involve planning in anticipation of future states and structural or transformational changes in operations. The impact of climate change on food security has largely been explored by a plethora of authors Using either agronomic model or Ricardian analysis (Thornton and Herrero :2014).

Literature shows that Ethiopia is the most vulnerable country owing to the least adaptive capacity and low diversified economies (Stage, et, 2016). The Ethiopian Climate change adaptation becomes even more complicated as the country's agriculture systems have largely depended on erratic rainfall that has been closely associated with climate.

Given the serious problem posed by climate change, many potential adaptation options have been suggested for developing countries including Ethiopia. Soil and water conservation practices, application of drip irrigation, crop rotation, intensive urban agriculture are among the ones Simane (2018). Apple fruit production by the farmers as the option of climate change adaptation could be seen as another possibility that can contribute to farmers' resilience building.

To build resilience against the risks from current weather variability and future climate change, 350 unique options were filtered down to 41 promising options using several criteria. These criteria were feasibility; contribution to economic growth; contribution to equity and distributional issues; and the extent to which they address the current weather variability and future impacts of climate change. Analysis of the 41 options showed that 38 were currently covered to some extent by the Ministry of Agriculture's federal programs. This demonstrates deep commitment at the federal level to deliver activities to build resilience. (FDRE, Climate Resilience Strategy, Agriculture and Forestry, 2012: 41)

Agriculture is the backbone of the Ethiopian economy. It employs over 80% of the population and still dominates GDP contribution. Its growth, like the country's economic growth, was stagnant for decades. The Ethiopian Government began taking different policy measures and development interventions since the 1990s. (MoFED, 2006). The country has

trained tens of thousands of extension workers and assigned a minimum of three extension agents (crop, livestock, and natural resources management) to each Kebele. Studies indicate that the agricultural sector has less performed over the last 10 years. However, there is a high potential to improve productivity, production, and market linkages. The government has made a strong commitment to the sector through the allocation of more than 15% of the total budget (MoFED, 2006).

Ethiopia has made important decisions and taken various measures to minimize the effects of climate change. It is a party to both the UNFCCC (ratified in 1994) and the Kyoto Protocol (ratified in 2005). The Environmental Protection Authority (EPA) and the National Meteorological Agency (NMA) have been designated as DNA and Focal Points, respectively.

Ethiopia has submitted the First National Communication in 2001, and the National Adaptation Program of Action (NAPA) to UNFCCC in 2007, which identified 11 priority areas. The government has also conducted a Technological Needs Assessment (TNA) in 2008, prioritizing the technology needed for mitigation and adaptation. Ethiopia has also submitted its Nationally Appropriate Mitigation Action (NAMA) plan to the UNFCCC in 2010.

The country has completed the preparation of the “Ethiopian Program of Adaptation to Climate Change” (EPACC), which replaces the NAPA. It has also completed developing an overarching framework and national strategy, the “Climate Resilient Green Economy Strategy” (CRGE). The Green Economy Strategy has been completed for seven sectors that offer the highest greenhouse gas abatement potential: Power Supply; Buildings and Green Cities; Forestry (REDD+); Agricultural/Soil-based Emissions; Livestock; Transport; and Industry. (The Green Economy Strategy Rio+20, National Assessment Report 2012, :40 - 73)

A study conducted on Promotions of on-farm tree/shrub plantings has greatly relieved that reduced pressure on the remnant natural forest by providing a variety of forest products (Sisay and Mekonnen, 2013).

To minimize farmers' pressure to the forest and improve the livelihood of the people the Homestead agroforestry that consists apple fruit tree as one component is highly recommended. Different international agencies and Government sectors have introduced and provided low chill apple varieties namely, Anna, Crispin, Dorset-golden, and Princesa, to the dwellers of North and West Shoa Zones of Ethiopia. (Lemlem and Asfaw, 2018)

The study indicated that farmers in land-scarce situations can directly benefit by incorporating fruit trees into an agricultural landscape with few other trees and this also relieve the people's pressure to the natural forest. Since, fruit trees enjoy great popularity among subsistence farmers and provide tangible benefits in short time frames (Rankoana, 2017). Despite the provision of such variety of apple tree seedlings to the farmers in the area, knowledge of critical factors that can lead to the adoption of these systems as a land management alternative is yet to be identified (Lemelem and Asfaw 2018)

2.5. Conceptual framework

Micro-farming systems that include growing of apple trees in farmers and urban dwellers compound cannot compete with conventional agriculture in terms of yields and potential of market distribution for the sale of their products and services. However, on top of Apple production to adapt the current climate change impacts in the community, its potential for ensuring a reliable supply of quality fruit in the urban and suburban environments is not negligible. Apple trees are easily adaptable to climate and environmental changes because they are more biologically diverse and reliant on local resources, knowledge, and appropriate technologies.

Homestead plantation, small gardens, and micro-farms can become very productive, and its efficiency has been amply demonstrated by the success of urban agriculture in Cuba since the fall of the former Soviet Union and loss of support for its former food system (Bruno ,2014:63-79).

Many other countries in the developing world depend on urban farming to complement food production, thus maintaining local economies and conserving valuable germplasm and resources. These and similar systems cannot compete with the yields and profits that

industrial agriculture can achieve. However, the much lower environmental impact of food production on micro-farms should be appreciated and recognized and inspire macro agriculture to design and manage more bio-diverse farms that can be more self-sustaining.

Farmers in the Midwest states of the U.S. and Mesoamerican countries like Panamá may be able to reduce climate-induced economic losses by adapting their management practices to the changing environment, but adaptations involving typical crops and techniques may only be able to compensate for 50% of yield losses predicted from moderate climate warming. Bruno (2014).

Management adaptations that incorporate apple fruit production as an option to climate change adaptation, home-based agroforestry, increased diversity of crops and livestock and less reliance on annual crops such as wheat and barley in the study area may be necessary agronomic strategies to effectively cope with a changing climate in most agricultural landscapes.

Sustainability in agriculture is possible when farming becomes multifunctional, to enhance benefits for society in terms of production and services Bruno (2014).

The result of the study conducted on apple adoption has shown that Apple adopted agroforestry as a tangible approach to foster sustainability through household income diversification and better adopted by the farmers of the north and west shoa area. Lemalem and Tajebe (2018).

Micro agriculture that includes plantation of 10 to 15 apple trees around the residential area can demonstrate the economic benefits of a local approach to food production, as the much lower input demand for such system and has potential to establish a vibrant, local food system of quality, stability and regional economic prosperity. Large-scale agriculture, whether or not it is founded on the science of agro ecology, causes more drastic disturbances to natural ecosystems than micro-agriculture. Minimizing these and similar effects becomes imperative to lessen the consequences of a changing climate upon the pests, diseases, and their toll on cultivated crops.

Apple Production is a climate smart technology

As it is illustrated in the above conceptual framework apple production is being practicing by the farmers and urban dwellers as one option to adapt and the harmful impacts of the climate change being seen in the area. In this study, the significance of farmer apple production to climate change effects adaptation and contribution to additional income has been analyzed and studied very well. The available chilling and soil type in sululta area encourages farmers and urban dwellers to grow apple trees. The availability of knowledge and extension service in the area makes apple production one of the known agricultural activity being practiced by the community.

In fact, Apple production is not the only agricultural activity undertaking in sululta area. Communities are engaged in a both agriculture and non-agriculture activities to get income to sustain the livelihood. The level of farmers income depends on the type of the activity they are performing. In this study detail analysis have been made to compare and contrast the income level of apple producer farmers with non apple producers. The significance of the income level is discussed in result section of this paper.

Detail conceptual analysis was made to observe and examine the significance of apple production to climate change.

Apple production to Productivity:

This is all about the potential, income, agronomic practices and perception exist in the study area. Suluta area is suitable to grow apples. Apple trees require chilling to bear its fruits. The average chilling available in suluta that ranges from 200 to 300hours is quite very good for low chill apple cultivars mostly growing in the area. The trees are much productive and provides high yield in the area. on average from a single tree we can harvest 22Kg and generate around 2200 Birr. The average number of trees farmers grow at the moment is 10 trees and so that one can obtain 22000 bir form the management of apple trees. Apple production have the potential to generate measurable income for the farmers that ultimately improves the livelihood of the community.

Apple Production to Resilience:

Growing of apple trees enhance sustainable land management practices. The nature of apple root (Root stock) is tolerant to harsh climatic condition and water stress. The root of apple le

can grow and stay dormant for about six months until the favorable conditions come. This helps to maintain the tree alive even under changed climate. Four apple varieties namely Anna, Dorsset golde, Princesa and CP-92 can perform very well in sululta area. Apple trees can be planted at spacing of 4 meters, this spacing allows to intercrop other vegetables like garlic that could help farmers to get additional income from apple farm. As long as the water is available it is possible to plant an apple tree at any time. Organic fertilizer can be used for apple production. Apple production helps farmers to use cow dung to minimize CH₄ the cost for chemical fertilizer is very low and farmers rarely apply chemical fertilizers. Zero tillage can be used to manage the soil and improve the drainage. Soil management under an apple tree helps to reduce soil erosion. Apple fruit can be cultivated using improved existing irrigation systems like drip irrigation to use scarce water in the area.

Apple Production - Mitigation Co Benefits

Carbon Sequestration Capacity of Apple Tree : Due to time and resource limitations in this study I did not measure and investigate apple tree carbon sequestration capacity in sululta area. However, the different studies conducted earlier in different countries have outlined that apple trees growing in the locality have a contribution in carbon sequestration. A study conducted in China clearly shows that apple trees are very important to sequester carbon. In apple the results of C sequestration capability matrix suggested that the net C sink is 0.7, 1.9, and 1.7 kg C m⁻² for the 5, 18 and 22-year-old orchards, respectively. The apple trees older than 8 years could be considered as a C sink. When the trees are 18 years old, they reach the peak of C sequestration capability which then begins to decline with their ages. Only when apple trees grow till a certain age in an orchard, the orchard could start to sequester C. Carbon emission derived from management practices would not be compensated through C storage in apple trees before reaching the mature stage. The findings of the study conducted in China with this regard is discussed in this research report just as an example and to show the capacity of apple growing and its contribution to mitigation.

A Study conducted on Carbon Sequestration by Fruit Trees – the case of Chinese Apple Orchards Apple production systems are an important component in the Chinese agricultural sector with 1.99 million ha plantation. The orchards in China could play an important role in the carbon (C) cycle of terrestrial ecosystems and contribute to C sequestration. The carbon sequestration capability in apple orchards was analyzed through identifying a set of potential

assessment factors and their weighting factors determined by a field model study and literature. The dynamics of the net C sink in apple orchards in China was estimated based on the apple orchard inventory data from 1990s and the capability analysis. The field study showed that the trees reached the peak of C sequestration capability when they were 18 years old, and then the capability began to decline with age. Carbon emission derived from management practices would not be compensated through C storage in apple trees before reaching the mature stage. The net C sink in apple orchards in China ranged from 14 to 32 Tg C, and C storage in biomass from 230 to 475 Tg C between 1990 and 2010. The estimated net C sequestration in Chinese apple orchards from 1990 to 2010 was equal to 4.5% of the total net C sink in the terrestrial ecosystems in China. Therefore, apple production systems can be potentially considered as C sinks excluding the energy associated with fruit production in addition to provide fruits.

From the study conducted in china we conclude ethat apple trees have contribution in carbn sequestration. However, in order to estimate C sequestration potential from apple orchards in Ethiopia accurately, more long-term field monitoring experiments at different ages are necessary. (Wu T Wang, et al, 2012)

Apple production to Livelihood Improvement

Growing of apple fruit tree in the high land area of suluta provides a diverse benefits to improve the livelihood of the community. The tree helps the farmers to get additional income from the sale of fruits. Apple tree growing helps to improve the natural resource in protecting the soil from depletion. Existence of apple tree in the farmers compound builds the physical asset of the owner that can be used as a collateral for local loan and it enhances farmers wealth status. Branches from the tree during the pruning time provide energy and reduce womens burden to search for fire wood and saves natural tree cutting for fire wood purpose. The income obtained from sale of surplus apple fruit builds the financial resource of the farmers , so that farmers engaged on apple production are finically strong as compared to non apple producer farmers. Socially farmers that grow apple in their locality would have good reputation and social status.

Previous study conducted in other area have also confirmed the livelihood importance of apple growing in farmers area. Apple trees can serve farmers and urban growers as a physical resource to take it as a guaranty or collateral to obtain loan service. The tree is a good financial resource in generating additional income for the family. As a result of planting some

seedlings of apple in the homestead area, the idle/jobless labour can be exploited and changed to productive labour that can contribute a lot for tree productivity. Socially farmers who have apple trees in their compound have great value and received good resection from neighbours and the surrounding community. Having apple trees in a compound develops a sense of proudness and confidence to do innovative activities. Different studies conducted on apple production have also confirmed that because of a high market value of their products and the contribution of fruits to household dietary needs, fruit tree-based agroforestry enjoys high popularity among resource-limited producers Lemlem Tajebe (2017)

Existing climate change adaptation options in Suluta area

Soil and water conservation: According to the study conducted by Addis Ababa University water and land resource center, the upper catchment area of sululta is highly exposed to Sevier soil erosion and land degradation. Farmers are executing soil conservation structures that includes soil bund & stone terraces to reduce erosion on the upper hill farm areas, Forest plantation enterprise of Oromia region had also undertaking soil conservation structures on the hillside of plantation area to reduce erosion as well. However, the formed gulley and irregular ponds during quarry excavation had created huge soil damage and erosion in the area (Addis Ababa University 2019)

As a result of low soil and water conservation practice the lower catchment area of sululta particularly, the grass/hay production area had been affected by silt deposition. The production loss due to the absence of proper conservation structure in the upper hill area has also contributed to less community climate change adaptation. (source: own observation and secondary data)

Tree planting: The upper catchment of the sululta area is dominated by eucalyptus plantation that mostly serving in the town and Addis Ababa for fuelwood and construction purposes. Farmers of the area plant Eucalyptus tree mainly to sell and generate income for household consumption. The individual farmer who has planted the Eucalyptus tree is generating income ranging from 20,000 - 30,000 ETB.

In the study area, the Eucalyptus tree is matured and ready for harvesting every 4 - 5 years. The study result indicates that farmers are not planting other tree species except Eucalyptus and this tree is the dominant species in the area serving farmers to get fuel wood and generate income from the sale of products every 4-5 years. The practice of multipurpose tree planting is not common in the area. Only a few farmers have started apple tree planting in their residential area for fruit production and conservation.

Agricultural Diversification: Crop production is the major occupation and income source for the farmers of the study area. The activity is challenged by the current changing climate effects. Erratic rainfall distribution and temperature change in the morning and night coupled with frost-damaged are the major climate change effects that altering the normal agricultural operation, particularly crop production. Results of focused group discussion indicate that frost damage to crops mostly occurred between September to October. Study result indicated that the rural communities that encountered income loss due to crop production decline have exposed and vulnerable to climate change effects and their shock and stress adapting capacity is gradually coming lower and lower.

On top of the climate change effects, agriculture is not yet backed by technologies and new research findings. In the study area still, agriculture is being practiced as usual and it is common to see farmers while they are manually digging the hill farm plots and using oxen to plow the land. No mechanization agriculture is being seen and introduced to the area to increase and boost productivity. Furthermore, mono -cropping is the dominant agricultural practice that largely involves the production of barley and wheat.

Apple Production: In the study area, Apple Production is considered a diversified agricultural activity that is practiced in the rural and urban areas. The study result shows apple is the new fruit tree that has been introduced to the area very recently. Apple trees are planted both in the farmers and urban dwellers' area.

Literature evidenced that, growing of apple trees in the presentational area does not require wide and large production areas like that of other plantation and cereal crop production. The average number of trees in each grower is ranging from 10 o 15 trees. In the study area, apple tree starts to yield fruits after three years of plantation and then after every year the trees

provides yields, whereas other trees planted for fuel wood and construction material purpose are expected to be harvested every four to five years.

Results of secondary data obtained from the sululta Apple seedling production center indicate that Low chilling apple cultivars can give fruit twice in the year which is, fact depends on the management techniques and of the growers. Apple tree growing does not need to much labor, effort, and technology like that of other agricultural activity. Limited manpower available around the residential area can manage at least 10 trees and able to produce 220kg of Apple fruits every year. Farmers and urban growers have planted apple trees for fresh fruit consumption at home, surplus fruit marketing, and as well as the trees are planted to conserve the soil and environment.

Results data analysis shows that farmers and dwellers have also planted the tree as ornamental in their compound. The survey analysis result indicates that out of the total apple fruit production 25 % is sold on the nearby shop and market to get additional income for the household. From the sale of fruits, an individual is generating an annual income of 19188 birrs. Growing of apple fruit trees on 100M² is by many beneficiaries and increases farmers' income when it is compared with crop production its annual income for the household. Due to the increment of farmers' income from the sale of apple fruits the grower's stress and shock absorbing and effects adapting capacity is increased.

3. STUDY AREA AND RESEARCH METHODE

3.1. Description of the study area

The study was done in Sululta town administration located in Oromia Regional State on the North side of Special Zone Surrounding Finfine. The center of Sululta town is suited at 23Km distance from Addis Ababa on the main road leading to North Shoa Oromia's gohastion.

Administratively the study area has Tow Rural and Tow Urban Kebele administration. The Rural Kebeles include Keta Well and Nonomanaabichu and while the Urban Kebels consist of Kaso Weserbi and Sululta 01 Kebels. According to the information collected from Suluta town administration office the total land cover area of the town is about 7597 hectares of land.

The Total population of Sululta was estimated to be 52,126 in 2016 out of this 25,541 are male and 26603 are female. The current sululta Population is expected to exceed 100,000 in the next ten years. This is not surprising since Sululta is one of the fastest-growing towns in the country. (Source: Suluta town Administration office)

The Sululta town is bounded by Entoto Mountain on the east and south side which is largely covered by dense Eucalyptus and Juniperous trees mostly characterized as mixed plantation forests. The average elevation in the town is 2600m above mean sea level. The altitude of the study area generally drops down south-north direction from 2800m to 2500m above mean sea level. The peak altitude of the area is 2800m at Entoto ridges and the lowest is 2500m to the north fringe of the study area. The minute elevation difference within the whole area contributes a lot for waterlogging as most of the area is possibly classified as plain area.

Table 3 Sululta Town land cover detail information

Land Cover	Area (ha)	% age
Built-Up	1183	15.6
Cultivated Land	1763.6	23.2
Degraded Land	131	1.7

Wet and Grassland	1858.2	24.5
Plantation	2504.4	33
Settlement	156.8	2.1
Total	7597.2	100

Source: Sululta town administration

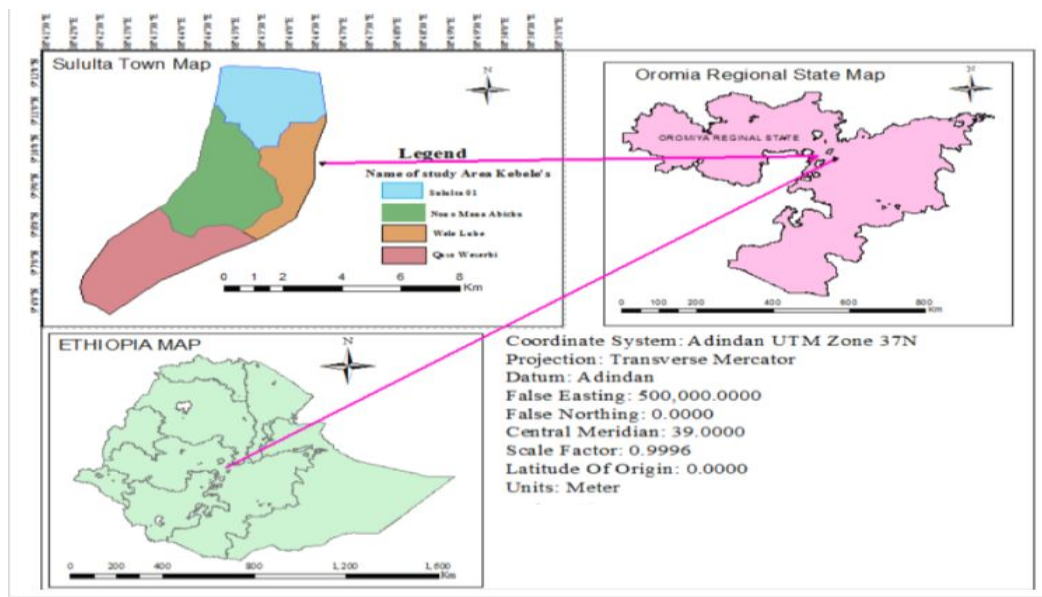


Figure 6 Map of the Study Area

Source: Google Map

Sululta town is an enjoyable and interesting town when one is viewed from the top of entoto mountain down to the escarpments. From the pick of entoto, it is possible to view the five landscape structure of sululta without using any device or binocular. The partial side of Entoto mountain is delineated to the sululta area which served as a pick and divide point of the Blue Nile and awash basins. This interesting and rich forest area is serving as a recreational area for many tourists and residents of the city of Addis Ababa and it is also serving as hillside sport exercising area for many local and internationally known Athletes. High oxygen accumulation in this forest area initiated many athletes to make their exercise every day in this area.

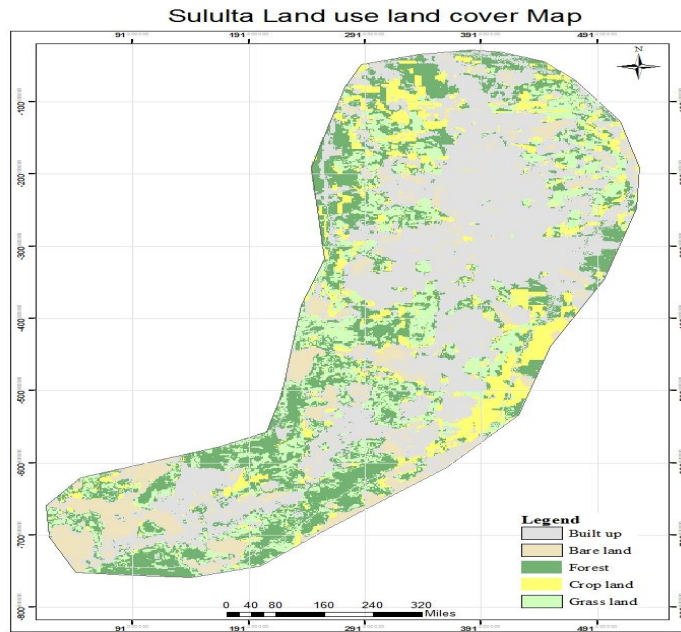


Figure 7 Land use Cover Map of Sululta

Source: Google Map

Agricultural activities in the sululta area

Crop Production

Agriculture land in Sululta is known to produce barley, wheat, and fava beans that are mainly for household consumption. Crop production in sululta accounts for 35% of the main occupation of the residents. However, the productivity of these crops is low due to soil degradation, low fertilizer application, and acidity of the soil. Crop intensification and diversification with new fruits and vegetables can take place.

Livestock Production

Livestock production is the second mainstay of Suulta farming and urban residential communities that accounts for 31% of the livelihood occupations undertaken in the area. Livestock production is known for the production of cattle, sheep, and poultry and products such as Milk, Cheese, Butter, Eggs, and meat. However, recent trends show a decline in dairy products due to the shrinkage of pasture land.

Vegetable and fruits

Mainly vegetables like cabbage , lettuce, beetroot, Carrot, Onion, and Potato are growing in sululta area for local and Addis Ababa Market. . The climate is also favorable for temperate fruits such as Apple ,plum and peach. The vegetable garden managed by the residents and farming community is currently complementing the growers and producers to improve the household nutrition beyond its income contribution for the livelihood through supplying the market in Addis Ababa. The study result shows that Vegetable and fruit farming is not strong or large enough to do either. Addis Ababa university (2019)

3.2. Sampling Design and Sample Size

This Study used mixed research approaches to assess farmer's apple fruit production as climate change adaptation and income diversification options in Sululta area. The study was targeted by apple producer and non-apple producer farmers and urban residents of all four kebel of Sululta town administration. List of farmers and urban residents who have planted apple seedling since 2005 have been given by the Sululta town Urban Agriculture office; from the given List of 1190 farmers, the sample size was determined by using the statistical formula by Yamane (1967). Based on the assumption of 95% confidence level and population 1190.

$$\text{sample size} = \frac{\text{Population size}}{1 + \text{Population size}(e)^2}$$
$$\text{sample size} = \frac{1190}{1 + 1190(0.05)^2}$$
$$\text{sample size} = 299.37 \approx \mathbf{299}$$

Where: e represent margin of error which is 0.05

Therefore, based on the above result, 299 sample was targeted for interview. However from the ground data were collected only from 200 sampled individuals. The remaining 99 individuals targeted for sample were not reached due to reasons of some were changed their residence area, some were changed apple growing area to settlement and some destroyed apple growing due to lack of proper management. Having this fact and personal constraint in mind the researcher has decided to interview and collect data only from available 200 sampled individuals from the given 1190 farmers and urban dwellers involved in apple fruit

production. The collection of data was limited and only focused on the research problem, resources of the researcher in particularly the money and logistic service, degree of accuracy, and personal experience on data collection and analysis. From the given list to Select and decide the farmer and urban dweller that is going to be asked or interviewed was determined using the Systematic Random Sampling techniques. A sampling Interval "K" was calculated by dividing the total number of farmers and urban dwellers given by the office of Agriculture by the desire sample number of the researcher.

Mathematically illustrated as $P / N = K$, $1190 / 299$ which is approximately equals to 4 Where "P" represents the total number of farmers and "N" represent the desired Sample Number of the researcher and: K" represents a Sampling Interval. The literature on research methodology recommends using Systematic Sampling for such a study type. Systematic sampling: In some instances, the most practical way of sampling is to select every item on a list. A sampling of this type is known as systematic sampling.

An element of randomness is introduced into this kind of sampling by using random numbers to pick up the unit with which to start. For instance, if a 4 percent sample is desired, the first item would be selected randomly from the first twenty-five and thereafter every 25th item would automatically be included in the sample. Thus, in systematic sampling, only the first unit is selected randomly and the remaining units of the sample are selected at fixed intervals. Although a systematic sample is not a random sample in the strict sense of the term, it is often considered reasonable to treat a systematic sample as if it were a random sample (Bonett et al, 2014)

Five data collectors that speak the local language Afan Oromo were temporarily employed in this study. Before actual data collected from the respondents, the enumerators were trained on the data collection procedure and assisted to exercise the data collection and filling on the given sheet with non-sampled respondents. Five focused group Discussions were made with key informants selected from the for kebeles, representatives of private companies working in the area, and government representatives.

The relation between Apple fruit production and Climate change adaptation and as well as the contribution of apple fruit production for likelihood resource improvement was the issue of discussion whiles the FGD was conducted. The governing discussion points used during the discussion were prepared by the researcher ahead of the time.

3.3. Source and Method of Data Collection

Qualitative data at farmers and urban dwellers level were collected through Individual Interviews using the employed trained enumerators.

Focus group discussions and field area observations were also conducted by the facilitation and moderator of the researcher to collect additional data and to visualize what is truly existing on the ground and see the actual settings and landform of the study area. Data at the household level were collected through Individual interviews using unstructured and structured questionnaires.

From the locality, five enumerators were recruited and trained on the techniques and procedures of data collection. The prepared questions were initially pretested to check the validity and appropriateness. For pretesting the questionnaire eleven individual respondents from non-sampled farmers list were identified and interviewed before the actual interview of the target sample individuals.

This allowed the restructuring of questions before intensive data collection. Based on the limitations identified in the pretest, the questionnaires were then amended and enriched for the actual interview. Out of the total 200 sampled respondents 78.5% (157) were Male respondents and while 21.5% (43) were Female. The local language Afan Oromo was used for effective communication for the individual interview and focus group discussion.

Five focus group discussions each consists of eight members was Conducted with key informants, representatives of agriculture and natural resource office, private companies, and institutions. The sessions were moderated by the researcher using a discussion point that includes, the major climate change effects in the area, farmers climate change adaptation options being practiced in the study area, the favorable conditions of apple fruit tree growing, benefits of apple fruit production in the area, the major problems in apple fruit production and the relation between Apple fruit production and climate change adaptation and the contribution of apple fruit production for livelihood resource improvement were the main discussion points.

To back up data collected from the individual respondent and enrich the points discussed with focus groups a secondary data were collected from Sululta Town Agriculture and Natural resource office, From Oromia Agriculture and Natural Resource Beau and private farms working in Sululta area.

3.4. Method of data analysis

Farmers' climate change adaptation strategies, socioeconomic, demography, and individuals respondent data were summarized and presented using descriptive statistics such as frequency, percentage, graphs, figures, and tables.

Additionally, some inferential statistics measures such as Independent sample t test was used to support the descriptive statistics as well as the difference between the variables based on the types of respondents (producer and non-producer). The literature document on Research and Metrology recommends using descriptive data analysis techniques that suit to this study.

The analysis were, therefore, be categorized as descriptive analysis and inferential analysis (Inferential analysis is often known as statistical analysis). "Descriptive analysis is largely the study of distributions of one variable. This study provides us with profiles of companies, workgroups, persons, and other subjects on any of a multiple of characteristics such as size composition, efficiency, preferences, etc.

This sort of analysis were in respect of one variable (described as uni-dimensional analysis), or in respect of two variables (described as bivariate analysis) or in respect of more than two variables (described as multivariate analysis). In this context, we work out various measures that show the size and shape of the distribution(s) along with the study of measuring relationships between two or more variables.

For the analysis of all collected primary and secondary data, Microsoft Excel and SPSS version 24 were used. All Information and secondary data are gathered during the transect-walk to the area and physical observations made at farmers' plot or production site were examined and analyzed using semiotic and thematic data analysis methods to understand farmers' apple fruit production and its contribution to climate change adaptation and income diversification options.

4. RESULTS AND DISCUSSION

4.1. Apple grower farmers respondent category by Sex

As illustrated in table 4 below out of the total 200 sampled respondents who have planted apple trees 78.5 % (157) were male and while the rest 21.5% (43) respondents were female.

Table 4 Sex of the apple growing Respondents

Respondent Sex	Number of Respondents	Percent
Male	157	78.5
Female	43	21.5
Total	200	100.0

Source: Own Survey 2020

As it is indicated in table 5 below 35% of the communities are engaged in Crop production and followed by 31% Milk and Milk Products Marketing operation to improve the livelihood of the family. Only 5.5% of the communities are undertaking petty trade in the area.

The descriptive analysis result indicated that 35% of the community is generating income from Crop production followed by Milk and Milk Products operation which accounts for 31%. Petty trade is the lowest operation of income source in the area from which the communities are generated less income 5.5% as compared to other income-generating activities being practiced in the area.

Table 5 Main Occupation of the Respondents

S.N	Type of Main Occupation In the area	Occupation by Respondent Sex (%)		
		Male	Female	Total
1	Crop Production	27.48	7.53	35.00
2	Milk and Milk Products Marketing	24.34	6.67	31.00

3	Grass/ Hay Production and Marketing	7.46	2.04	9.50
4	Fuel Wood Collection and Marketing	10.21	2.80	13.00
5	Petty Trade	4.32	1.18	5.50
6	Employment	4.71	1.29	6.00

Source: Individual Survey 2020

The closeness of Suluta town to Addis Ababa helps the farmers and dwellers to generate income from different activities. In this study, the annual income of the community from the main income source was analyzed using descriptive statics. As the result shown in table 6, 35% (70) respondents were mainly getting income from crop production, 31% (62) were getting annual income from Milk and milk products marketing and 13% (26) had to get their income from Fuel wood collection and marketing.

The result in table 6 had also shown the average income level that the respondents are getting from the main income sources. Accordingly, 32.5% (65) of the respondents earn an annual income ranging from 30,000 to 40,000 birr, and while only 5% (10) of the respondents are getting an annual income of birr above 50,000.

Table 6 Respondents Main Income source and Income amount

Source of income	Number of Respondent Households by Income Range				
	10,000-20,000	20,000-30,000	30,000-40,000	40,000-50,000	Above 50,000
Crop Production	5	14	31	15	5
Milk and Milk Products Marketing	12	14	25	7	4
Grass Marketing	5	7	4	3	-
Fuel collection and marketing	15	9	2	-	-
Petty Trade	4	6	1	-	-
Employment	3	3	2	3	1
Total Number and percentage	44 (22%)	53 (26.5%)	65 (32.5%)	25 (12.5%)	10(5%)

Source : Own survey 2020

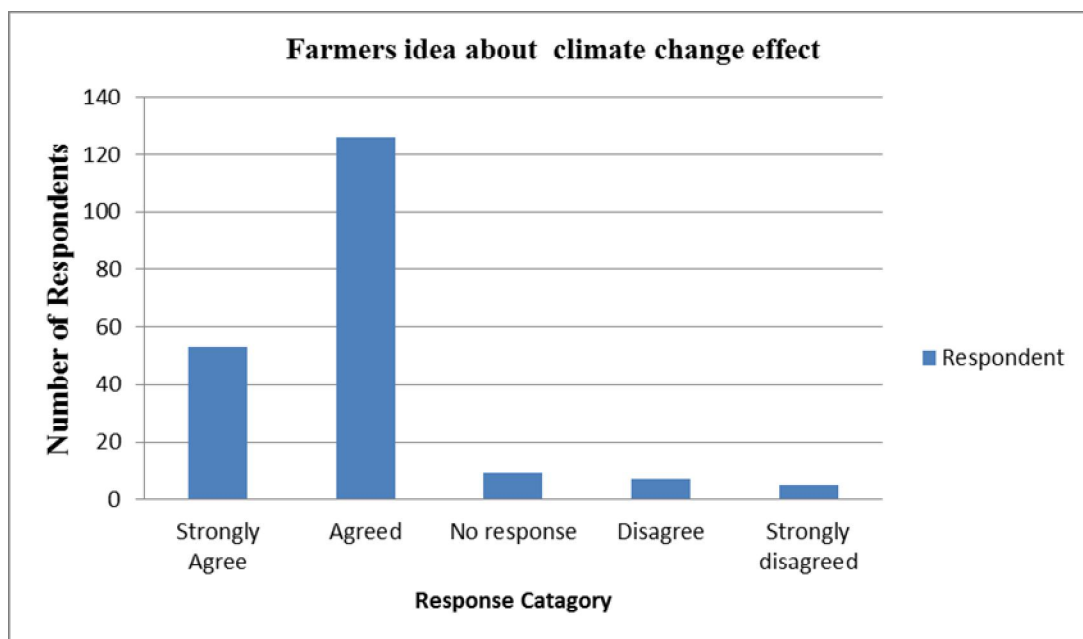


Figure 8 Framer Idea about climate change effect

Source: Own survey 2020

As illustrated in figure 8 above among the surveyed households 63% (126) had an idea about climate change while only 4.5% (9) of the respondents have no idea about climate change and its effects. This finding is also correlated with the qualitative assessment result. The FGD discussion was also revealed that the majority of the communities of the area are well aware of climate change. For those communities who have an idea about climate change and its effects, a further assessment was made to understand the time when they have recognized climate change in the area.

The results of the household survey showed that 48.5% of the community understand climate change very recently, 32% of the respondents understand before 3-5 years and 12.5% of the community were not recognize climate change at all. However, from the total sampled households 7% had not remembered the time when climate change is a common problem to the area.

The issue of climate change is not a new agenda for the majority of farmers and urban dwellers. A study conducted on Smallholder farmers' adaptation to climate change and determinants of their adaptation decisions in the Central Rift Valley of Ethiopia has shown that the majority of the farmers have already perceived climate variability, and some are

made attempts to adapt using practices like crop diversification, planting date adjustment, soil and water conservation and management, increasing the intensity of input use, integrating crop with livestock, and tree planting (Belay et al. Agri. & Food Security (2017) 6:24)

This study attempts to understand and examine how the communities have recognized about Climate change effects in the area. Among the surveyed individuals 41% have known about the climate change effects through observing the change in rainfall and weather conditions to the area. The result of Focus Group Discussion had also revealed that Crop and grass/hay production of the area have heavily affected by erratic rainfall distribution.

Data collected from Ethiopia Metrological Station shows the distribution of Rainfall in the area is not uniform and it affects the agricultural activities. As per the obtained information from key informants, Rainfall shortage is not the problem to the area, rather, the time and intensity of the rain is the problem that does not suit the normal cropping calendar. In fact, in the lower catchment area excessive rainfall amount damage grass/ Hay production. In the area, Grass/ hay production is the main business of stay for the majority of the farmers. Grass serves the community as a cash crop in the area...

Climate change is everywhere and it affects all of us. In the study area, these all climate change effects are affecting negatively the livelihood of the community both in terms of land degradation which leads to loss of productivity that in turn resulted in the loss of income for household consumption and life-sustaining. In this area, as a result of climate change effects, 42% of the respondents have encountered a loss of income due to productivity loss.

Table 7 Community Initiative against to the effect of climate change

Initiatives by the community	Number of Respondent Farmers	Percent
Enhancing Community Knowhow	30	15
Soil and Water Conservation Works	37	18.5
Tree Planting	49	24.5
Crop Diversification	54	27
Fruits and Vegetable Production	30	15

Source: Own Survey 2020

Findings articulated in table 7 show a list of community initiatives being undertaken in the area to overcome the effects of climate change. The result of assessments conducted with focus group discussion and outcomes of an individual survey also confirmed that conservation and awareness activities contributing to combat the climate change impacts are being practiced in the area. Among the community initiatives include, enhancing community awareness, soil, and water conservation work, tree planting, crop diversification, and fruit and vegetable production is the major one that was listed out during the Focus group discussion and of the individual survey.

Following a discussion on the initiatives by the community, the researcher made attempts to figure out the responsibility share among the community and other stakeholders to ensure the sustainability of the initiatives. Accordingly, Communities have categorized responsibility share among Individuals, Government, Community itself, and Private Sectors.

The majority of the individual respondents reported that all including Community, Government, private sectors have to involve in the initiatives. 23% of the Respondents have reported that only the Private sector has to take the greatest initiative to protect the environment particularly not to pollute the river and the air and while 21 % of the respondents react that the government has to take the responsibility in controlling and protecting the environment. 18% of the respondent replied that Individuals or only community have also a share of the initiatives

Table 7 Know-how about Apple Production and its Contribution to climate change effects

Do apple production contribute to climate change effects adaptation	Number of Respondent Farmers	Percent
Yes	134	67.0
No, I don't think	36	18.0
I don't have any Information about It	23	11.5
Not Applicable	6	3.0

Source: Own Survey 2020

Direct observations made during the data collection in individual respondent homes show that it is common to see Apple Fruit Trees in the compound of the respondents. 67% of the respondent confirmed that farmers had known to about Apple fruit production and its contribution to Climate change effects. While 18% of the respondents reported that, the tree has no contribution to the effects of climate change. 11.5% of the respondent had no information about the relation between apple production and climate change effects.

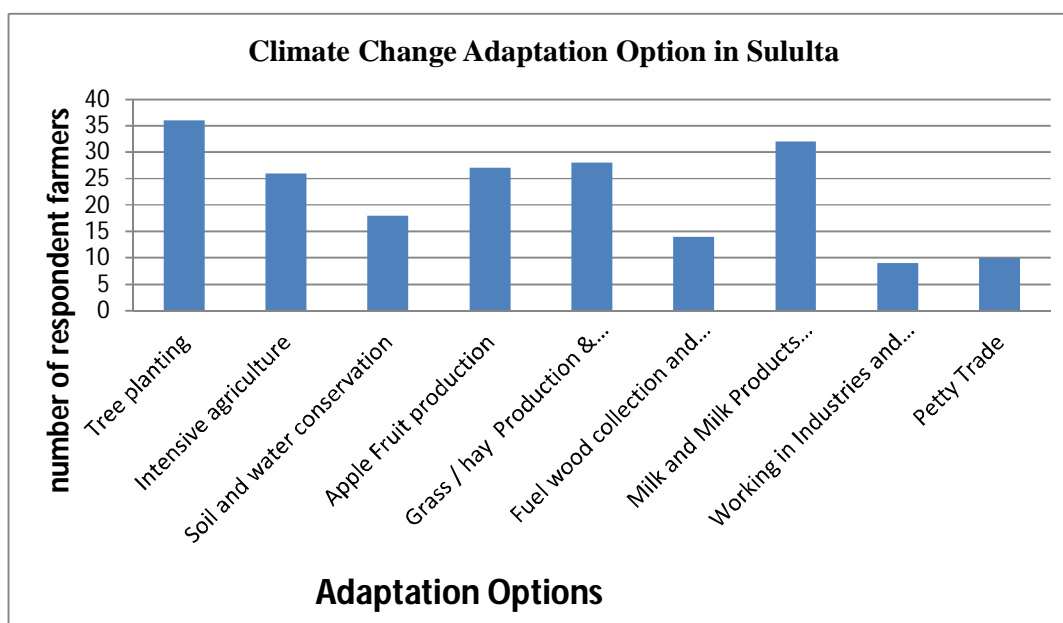


Figure 9 Climate Change Adaption Options In Sululta

Source: Own Survey

Results in Figure 9 indicated the major operations practiced both by the farmers and urban dwellers to adapt to the current climate change effects in the study area. Eucalyptus tree planting and marketing, Milk and Milk products marketing, and Grass/ hay production and Marketing are the major operations being practiced in the area. 18% of the respondents have reported that Tree planting is practiced in the area as a climate change adaptation option. 16% of the respondents show milk and milk products marketing are the other alternative option to adapt the climate change in the area.

The result of field observation also showed that communities are practicing Grass / Hay production and marketing as a major livelihood activity. The Individual survey result has also witnessed that 14% of the respondents have reported that grass production and marketing is the major climate change adaptation option in sululta area. The result of the individual survey and focus group discussion has indicated that the current agricultural activity particularly the crop production being practiced in the area has less contributing to adapt the climate change effects. 49.5% of the respondents have also confirmed this.

The contribution of Apple fruit production in the area have also paramount great and important. The result of individual survey indicated in figure 10 show 13.5% of the respondents have confirmed that apple fruit production in the Sululta area was being practiced as one option of climate change adaptation. The physical field observation made to farmers' area during data collection time has also shown that the majority of the farmers have started apple fruit production in their compound and even some of the farmers are have given more attention to apple fruit production as compared to cereal crop production activity.

Figure 10 illustrated below indicate percentage of farmers perception How apple production contribute for climate change adaptation. The fact how much apple production contributes for climate change adaptation needs to be investigated and studied.

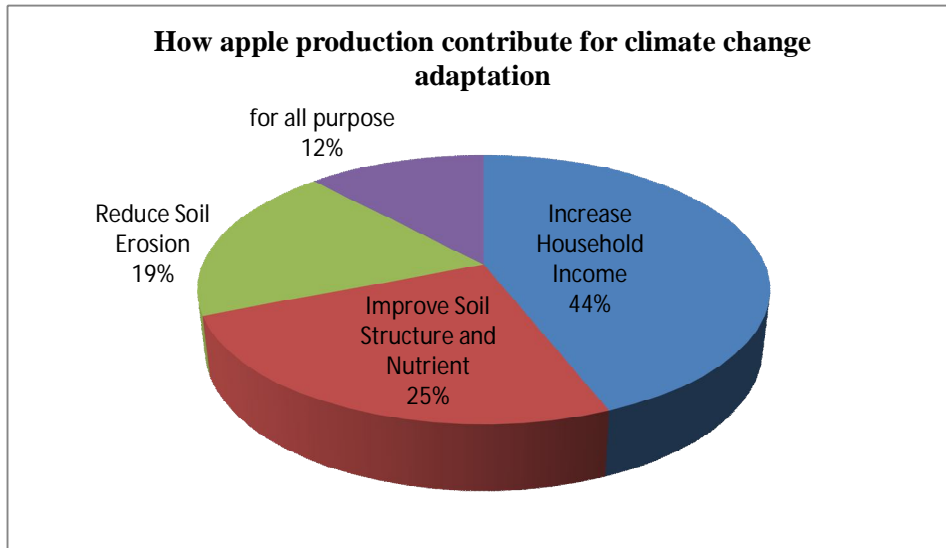


Figure 10 Apple Production contribution for Climate Change Adaption

Source: Own survey 2020

The researcher has made an in-depth assessment and investigation to understand and examine how Apple fruit Production Contributes for farmers and urban dwellers to adapt the existing climate change effects in comparison to agricultural activities and other adaptation strategies being practiced in Sululta area.

Analysis of data indicated that, 44% of the target community have planted apple fruit in their vicinity to increase household income from the sale of fruits. Whereas, 25% of the respondents have reported that apple trees are being planted in the area to improve soil structure and nutrients.

Moreover, 12% of the Respondent replied that Apple fruit Trees are planted in Suluta area for a Multi-purpose that includes increasing household Income, to improve soil structure and nutrient, to contribute for soil erosion reduction, and for household nutritional improvement.

The analysis of secondary data and focus group discussions have also witnessed that growing of apple trees in the compound of farmers and urban dwellers provides diversified benefits and importance that strengthen the resilience capacity of the growers to the current climate change effects.

4.2. The need to scale-up apple fruit tree as an option to resilience building

The analysis of Secondary data obtained from Sululta Apple Seedling Production Center showed that Apple seedlings planted in the area have great adaptability, disease-resistant, less damaged by excessive rainfall and frost. The reviewed documents and physical observations results have also indicated that significantly apple fruit production at farmer's level builds the resilience capacity through

- a) Household Nutritional improvement through fresh Fruit intake by the family from own farm.
- b) Additional income from the sale of fruits to improve the livelihoods
- c) Apple fruit tree growing in the area contribute to environmental protection.
- d) Apple fruit tree growing in the degraded area helps to conserve the soil and water system of the catchment
- e) Growing of apple fruit tree in farmers and residents compound gives mental satisfaction due to its various growing cycle and nature and further,

The practical assessment and experiences of smallholder farmers engaged in apple production have shown satisfactory results with high production increment of apple fruit and vegetables. The use of organic seedlings coupled with practical training on plant growing and management needs to be promoted and scaled up as the technology has great importance to build the communities' resilience to the current Climate change effects.

The researcher has also made a further investigation to understand and examine farmers' views and perceptions on adaptation measures not yet commonly practiced in the study area. Results of focus group discussion and field observation show that labor work in construction areas and everyday travel to Addis Ababa for any daily works are the other climate change adaptation options being exercised in the area by a certain community group.

4.3. The favorable conditions for apple fruit production in Sululta area

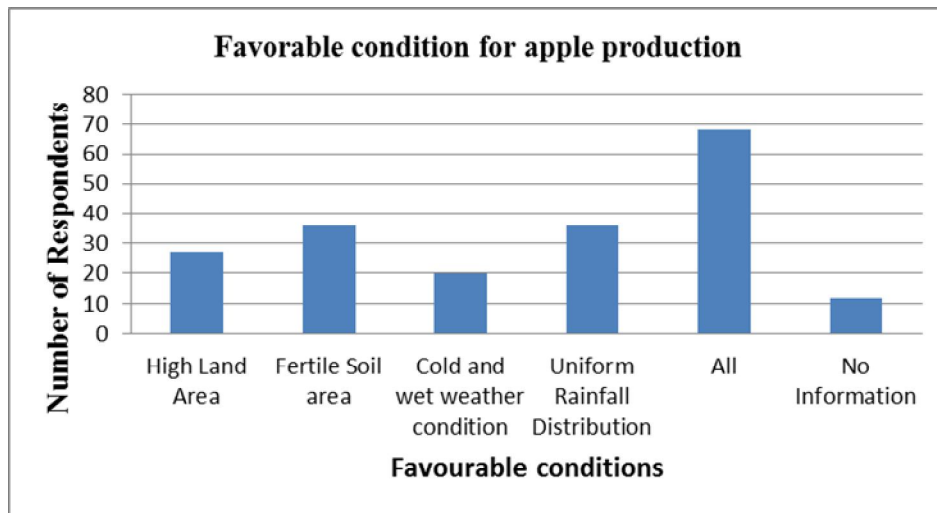


Figure 11 Favorable Conditions for Apple Production

Source: Own compilation

The analysis of the baseline survey has revealed that only 26% have responded to have the necessary knowledge about apple fruit trees growing and management.

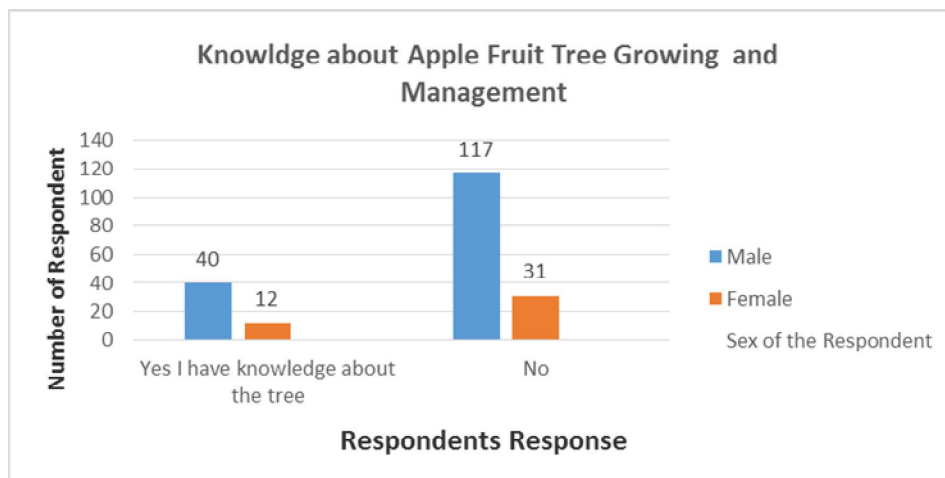


Figure 12 Respondents knowledge regarding apple production and management

Respondents' Knowledge towards the overall operation of Apple production is also found below. The subsequent inquiries which were intended to examine about what important operations they did to grow the tree and produce the fruit, about 13% have reported to have undertaken all operations that include Site selection, Variety selection, Proper planting, Watering, Fertilization, Pruning, Branch training, and Protection.

Table 8 The common apple tree growing and management Operations

Operations to Apple production	Farmers Practice	
	Number of Respondents	Percent
Site Selection	22	11.1
Variety Selection	13	6.5
Proper Planting	47	23.6
Watering	30	15.1
Fertilization	29	14.6
Pruning	12	6.0
Branch Training	6	3.0
Protection	14	7.0
All operations	26	13.1
Total	199	100.0

Source: Own Survey

This study attempts to examine the major operations that had been performed by apple fruit producers. The results individual respondents have indicated that 11% of the farmers know the tree variety, 23.5% of the respondents know the techniques of tree planting and only 14.5% of the respondents have knowledge about the proper watering and compost application. Few individuals that do not more than, 3% know apple fruit tree pruning techniques and its benefit to fruit quality and quantity increment.

Sufficient water application for apple trees is the very curtail and important to have good tree growth and production. A study conducted by Uttam (2014) on apple production and climate change adaptation indicated that the application of water for apple trees particularly, during flowering time is very important. 24% of the individual survey result confirmed that water application is a very necessary operation for high and quality apple production.

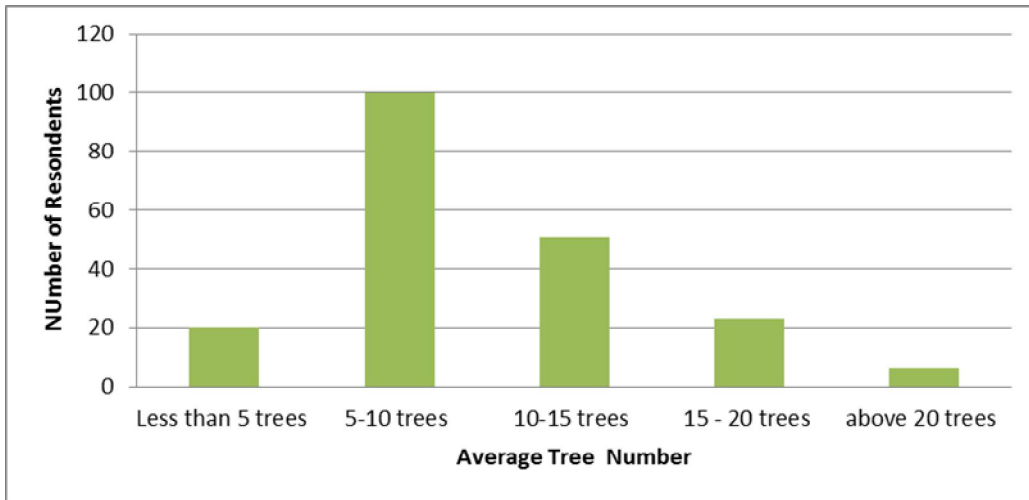


Figure 13 Number of Trees Growing by Individual Growers

Source: Own Survey 2020

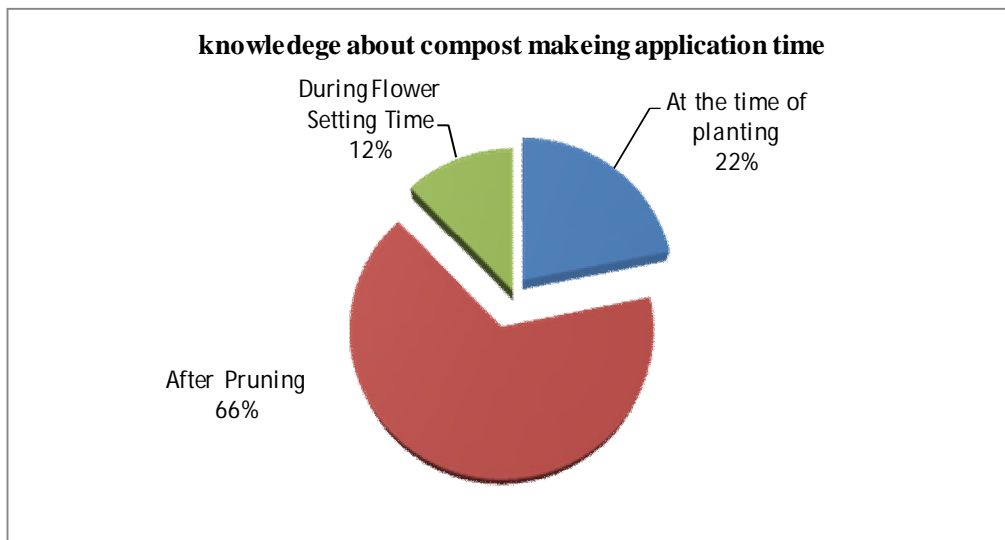


Figure 14 Knowledge about compost making and application time

Source: Own Survey 2020

Results in fig.14 illustrate individual responses on the farmer's concept on Compost making and its application time for apple trees. Apple trees demanded organic fertilizer in a defined period and time for its growth and yield increment. (Souse: Own experience).

To confirm these situations 200 respondents were asked to reply about compost and its application to apple trees. 65% of the respondents have replied that they have knowledge and techniques of compost making and application to apple trees after pruning is conducted, 21.5% of having reported that, compost is applied at the time of planting and while 12% of the respondents confirmed compost or fertilizer is applied during flower setting time.

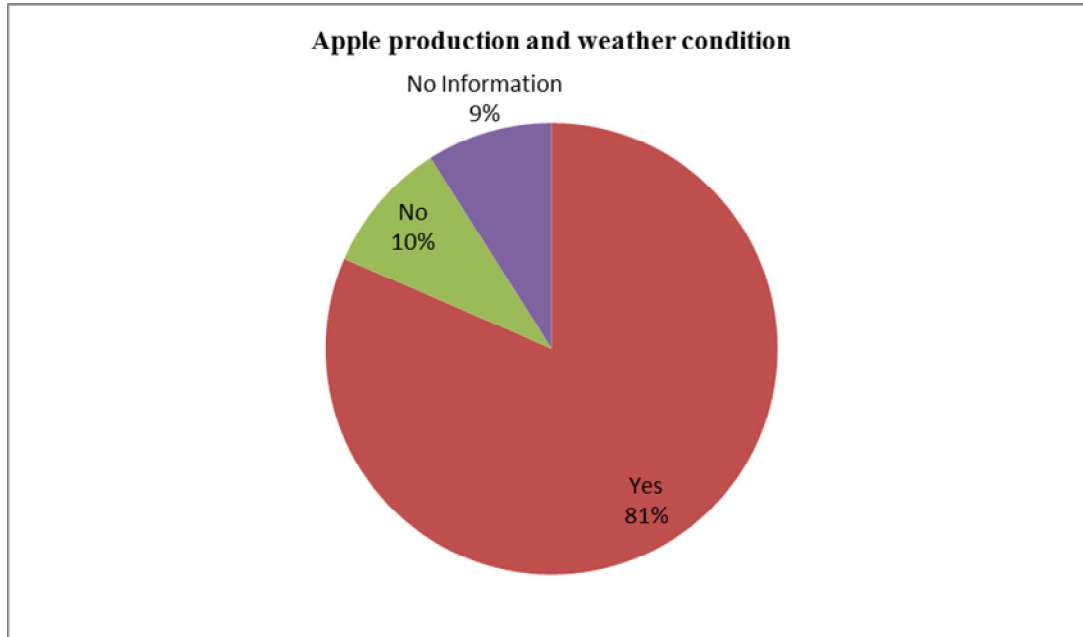


Figure 15 Apple Production and Weather Condition

Source: Own Survey Result 2020

Results in fig. 15 show farmers' perception of apple production and cold weather condition in Sululta. This study found that the predominant cold weather, low temperature during the tree dormancy period, moderate humidity, and relatively good rainfall distribution in sululta is a favorable situation and a preferred condition for apple production. The results of Focus Group discussion and Physical observation coupled with secondary data analysis had witnessed that apple trees are growing well and good in the area and producing fruit. In fact, as per the information obtained from experts high yield production of apple is subjected to farmer knowledge about the tree and proper management operations undertaken by the growers.

The researcher has also asked the farmers to dig out the relationship between apple and the cold weather of the area. Accordingly, 81.5% of the respondents were confirmed that the trees are growing good and it loves to have apple trees in the area. 9.5% of the respondents replied the cold weather condition is not good for apples and while the other 9.5% of the

respondent have no idea about the situation of apple tree growing and cold weather conditions.

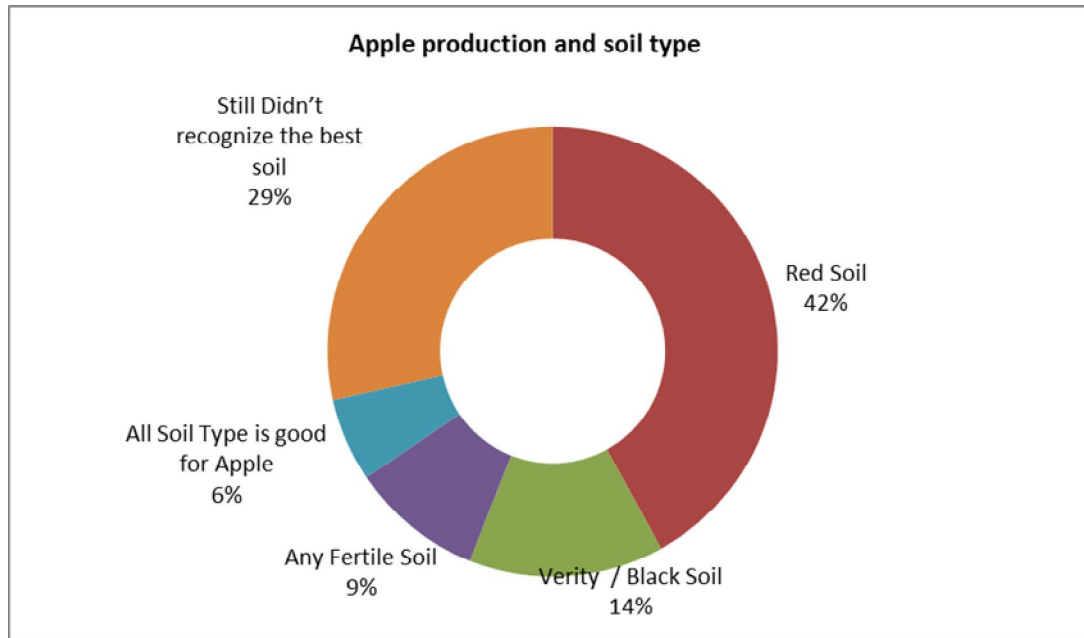


Figure 16 Apple Production and Soil Type

Source: Own Survey 2020

Figure 16 illustrated above show the different soil type for apple production and farmers reaction. The baseline survey of this study indicated that apple production largely depends on soil structure and nutrients available in the soil. The researcher made efforts to know and understand the best soil type mostly preferred by the farmers for apple production in the study area. 200 sampled individuals were requested to reply to the questions outline the best soil type for Apple fruit production. 42% (84 Individuals) were reported that red soil is the best soil type for apple production in the sululta area. 28.5% of the respondents were answered still they didn't recognize the best soil type in their area for apple production and while 14.5% were reported Verity Black soil is good for apple production.

The physical observation and focus-grouped discussion results coupled with secondary data analysis outlined that all soil type with good aeration and fertility was used in the area for apple production.

Table 9 Reason why Apple trees are preferred than other crops growing in Sululta by farmers

The reason why apple is preferred than other agricultural activities	Number of Households	Percent of Households
Not damaged by the effects of climate change	18	9.0
Fresh fruit for the family	84	42.2
Generate Income for the family	64	32.2
Conserve the soil structure	10	5.0
It is a good ornamental tree in the compound	23	11.6

Source: Own Survey

As shown in table 9 above the researcher has made attempts to understand and examine why farmers are growing apple fruit than any other plant in their compound. The major reasons why farmers are growing the plant includes to get fresh fruit for the family 42.2% (84), to generate income from the sale of fresh fruits 32.2% (64). In the study are apple growing also contribute to conserve soil and enhance soil nutrient. Some individuals have also planted apple trees for leisure and just to have a beautiful tree in the compound. The contribution of apple tree growing to soil nutrient improvement needs to be further studied and investigated very well.

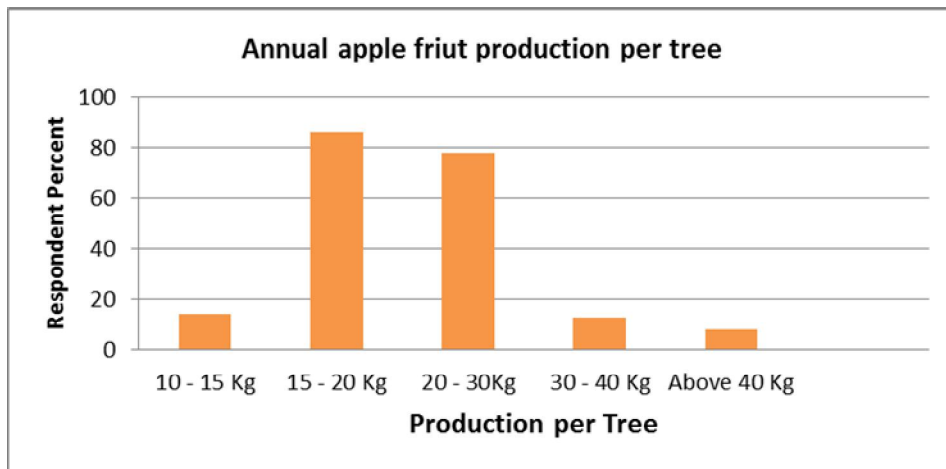


Figure 17 Apple Production per tree

Source: Own Survey

The physical observation made during data collection we have observed that the planted apple trees were producing fruits and we have got a chance to test the fresh from farmer plot farmers were asked to tell us how much fruit product they are getting or harvesting from a single tree the result of the discussion may be with sampled individual shows that 39% have confirmed from a single tree farmer are harvesting 20-30kg of fruits. 43% of the respondent reported that is annually a single apple tree is providing 15-20kg of fruit and while 7% of the respondent farmers are getting 10-15kg per tree. Only 4% of tree respondents are harvesting above 40kg fruit from a single apple tree in the study area.

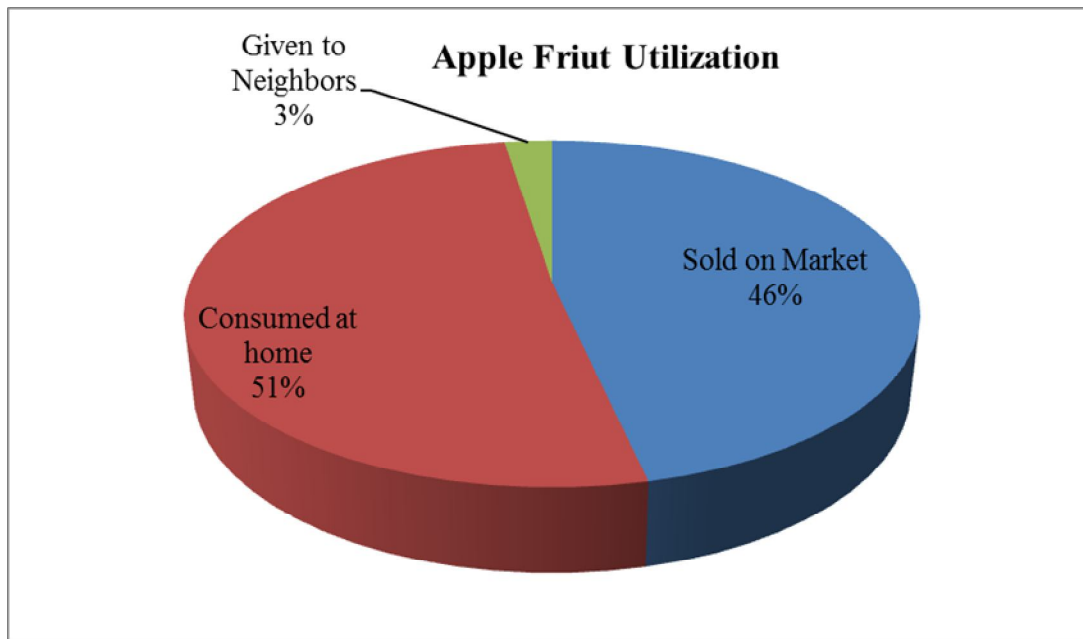


Figure 18 Apple Friut Utilization

Source: Own survey

Farmers and urban dwellers are utilizing the produced fruit for various purpose figure 18 illustrated farmers' apple fruit utilization. The result of a survey undertaken with apple producer indicated that 46.5% are selling the produced product on the nearby market 51% and 2.5% farmers have consumed the fresh apple at home and given some part to the neighbors respectively.

Table 10 Annual Income From the sale of Apple Fruit(ETB)

The response of apple sales income	Number of Respondents	Percent of Respondent
10 000 - 15 000	20	10.0
15 000 - 20 000	100	50.0
20 000 - 25 000	51	25.5
above 25 000	23	11.5
I don't know the amount	6	3.0

Source: Own Survey 2020

Table 10 illustrate the annual income range of apple producer farmers. Out of the total sampled 200 individuals, 25.5% were confirmed that the annual income of the farmer is about 20,000-25,000. 50% of the respondent reported that the average annual income of farmers engaged in 11.5 % and 10% of the respondent were replied that the annual income is above 25,000 and 10,000 to 15,000 respectively

4.4.Fruit Sales Income and Utilization

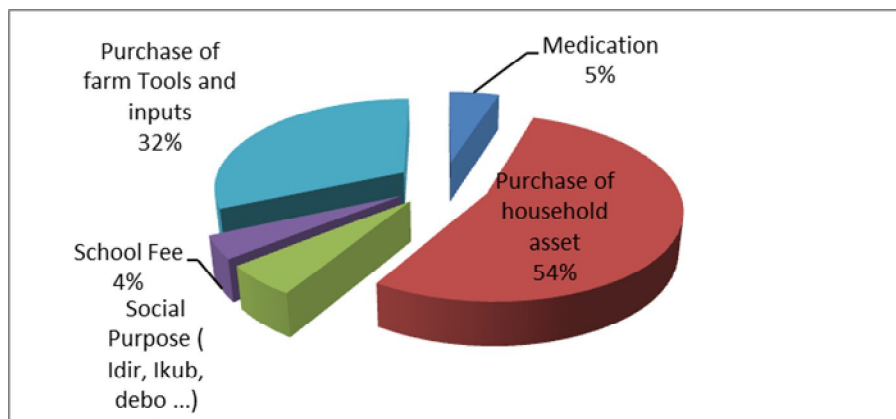


Figure 19 Apple Fruit Sales Income and Its Utilization Purpose

Figure 19: illustrated above show the purpose on which the income earned from the sale of apple fruit was invested. The result of the individual survey indicates that 53.5% of the respondent were utilizing the income from the sale of Apple fruit was used for the purchase of household assets. 31.5% had replied that the income used for the purchase farm tool and

equipment while 15.5% and 5% of the respondent reported that the income generated from the sale of fresh apple fruit were utilized for household medication and social purpose such as Iddir, ikub, saving (locally named tekemach) and for debo purposes respectively.

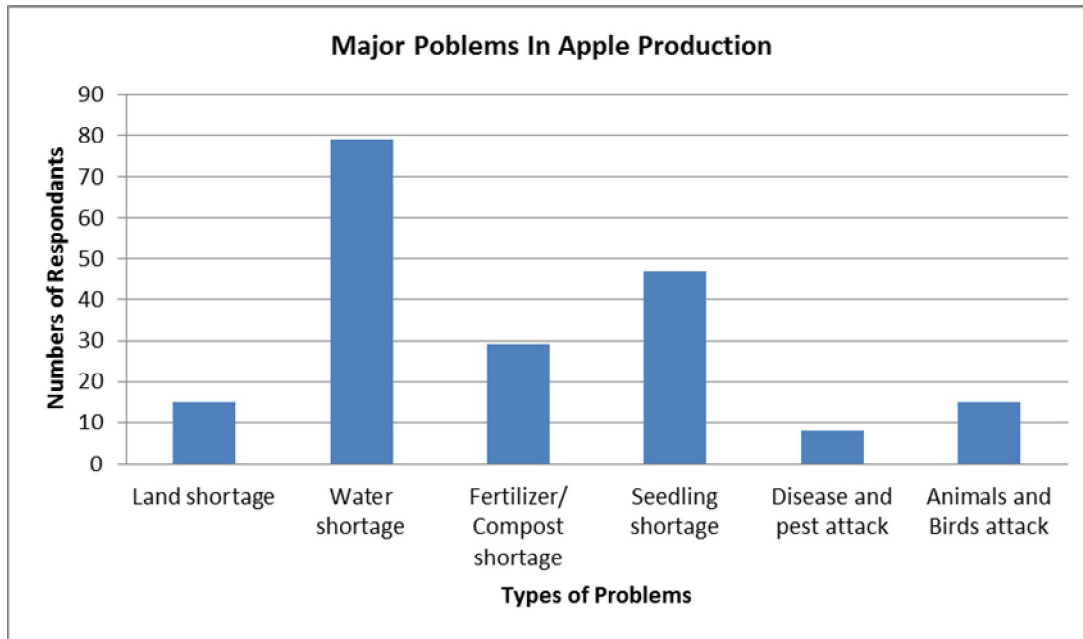


Figure 20 Major Problems in Apple Production

Source: Own Survey 2020

Apple fruit production is not an easy job. The operation needs to be undertaken are very technical and depends on the knowledge of the grower. Fig. 20 above indicates the major challenges and problems encountered during apple in the study area. The result of focus group discussion and individual survey coupled with secondary data analysis show that 39.5% farmers have a water a shortage problem, 23.5% and 14.5% of the respondent reported that seedling shortage and compost/fertilizer shortage are the problems in apple production respectively. Land shortage, animal attack, disease, and pest problems are also some of the challenges farmers phased in the area.

This study found that apple production is the new agricultural activity to the area and it needs growers to follow up and extension service by the expert. Analyses of focus group discussion and secondary data show the office of agriculture and natural resources is under staff and has no expertise in the field of apple promotion. As a result, the extension service to the farmers is below the exception which determined by the knowledge and experts know-how on apple tree growing and management the result of the individual survey had shown that 57% of the respondent reported that is the provided extension service was very small. 7.5% and 35%

interviewed farmers had reported the service given by extension workers good and enough and no service at all.

4.5. Technical Problems on Apple fruit Production

The Ethiopian Agriculture Sector in general and fruit promotion in particular had a very complex problem that hinders productivity. The major cause includes; increased population in the high land area, policy, and technological limitations are among the many causes. The researchers correlate the problems in agriculture with apple production and the technology gap. This Study finds that the technical gaps in apple production are the major problems that need the intervention of professionals and researchers to boost the sector. Among the technical gaps are;

- Insufficient knowledge and know-how on adaptive and productive apple Variety selection much suitable to the area
- Apple growers limitation on proper planting site preparation and seedling planting
- Farmers and urban growers had very limited knowledge and know-how about water fertilizer application time and amount of application per tree
- In the area, there was a wide gap and limitation the concept of tree pruning and techniques farmers knowledge apple fruit pruning benefits was very minimal
- There was limitation identification of matured and ripen fruit and time of harvesting

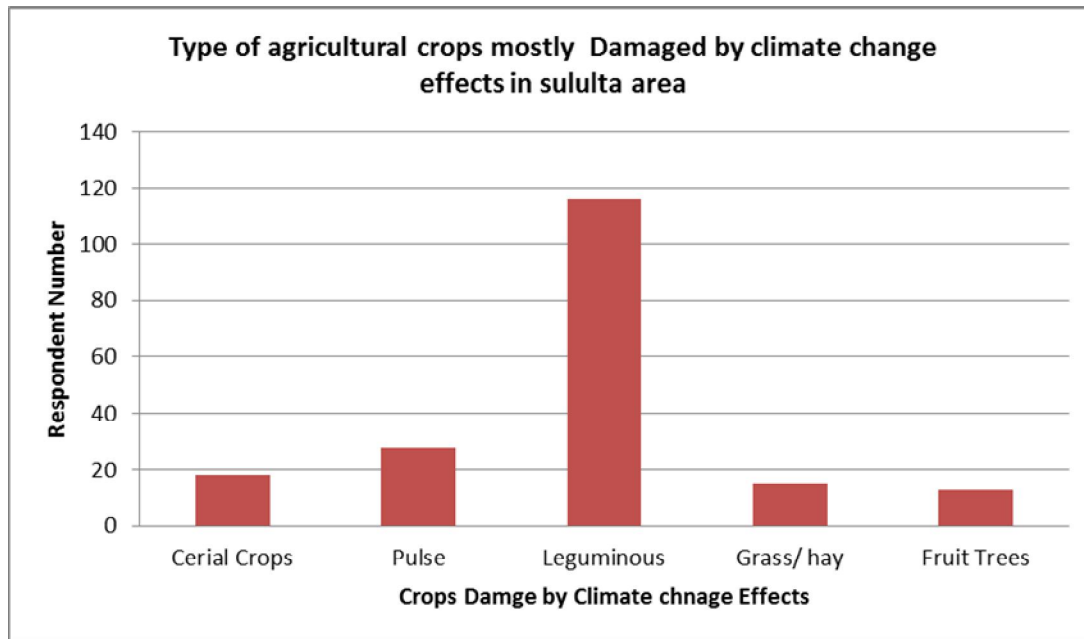


Figure 21 crops and Climate change effects

Source: Own survey 2020

This study found that climate change is exerting effects on the life of the study area community. Farmers and down catchment area communities are exposed to flooding and extreme grass production loss. Fig.21 shows the major agricultural crop/activities harnessed/damaged by the effect of climate change. A thorough discussion was made with focus group discussion members to outline the major crops and agricultural activities that were largely damaged in the area. The result of the study indicates that 58% of the farmers confirmed that leguminous crops are largely affected and while 6.5% were reported climate change affecting fruit trees.

The outlined reasons by farmers why apple tree are preferred than others includes, but not limited to generate income for the family fresh fruits for the family, the tree is a good ornamental tree as well, and farmers prefer apple due to less damage by the effects of climate change as compared to other agricultural activities performed in the area. The tree contribution in soil conservation and carbon sequestration is also permanent important and makes the tree more selective.

Results of the various studies conducted on apple fruit and its contribution to nutritional benefits Indicated that the Apple fruit tree has tremendous benefits through consisting of nutrition intake. Apple fruit consists of Minerals, Energy, Vitamins, Protein, and Fat as a nutritional improvement. The survey result of this study also revealed that 78% of the respondents had expressed that growing apple trees have some contribution to improving their nutritional status. 19.5% of the respondents have no idea about apple tree fruit wither it has nutritional improvement advantage or not. The physical observation made in the study area and results of the secondary data analysis showed that most of the farmers and urban dwellers have apple trees in their compound.

Those sampled households haven been interview using the structure and unstructured questioners wither apple fruit production has some contribution to household asset development. Almost out of the total 200 sampled individuals to respond to the question about 78% has confirmed that Apple fruit production has a contribution to household asset development and while 19.5% of interviewers were replied that the tree growing has no contribution to building the household asset. The same result has been also obtained from the discussion made with focus group members.

Table 11 Apple Production to Household asset development

Respondent Response category	Number of Respondents	Percent of Respondent
Yes	157	78.5
No	39	19.5

The physical observation made in the study area and results of the secondary data analysis showed that most of the farmers and urban dwellers have apple trees in their compound. Those sampled households haven been interview using the structure and unstructured questioners wither apple fruit production has some contribution to household asset development. Almost out of the total 200 sampled individuals to respond to the question about 78% has confirmed that Apple fruit production has a contribution to household asset development and while 19.5% of interviewers were replied that the tree growing has no contribution to building the household asset. The same result has been also obtained from the discussion made with focus group members.

4.6. Comparison of farmer income source with the generated income amount

Table 12 Respondents main income source and generated income

S.N	Main Income source by Respondents	Number of Respondents interviewed	Production area	Quantity produced	Generated Income (Birr)
1	Crop Production	70	5000 M ²	10000kg Wheat and 6000kg of Barley	35000
2	Milk and Milk Product Marketing	62	Two milk cow	5040 litter of milk	30967
3	Apple fruit production	200	150M ²	220kg	19188

Source: Own survey 2020

Table 12 illustrated above shows a comparison of respondents' income generated from different income sources. The researcher made attempts to compare and contrast these average income

amounts generated by the respondents from different income sources with an annual income of apple fruit sales.

Table 13 Apple Productivity Summary Index

Category of Index	Number in reality
Average land allocated for apple growing	150 M ²
The average number of trees per individual	10 apple trees
Average labor allocated to manage planted apple trees	1 person
Average fruit production per tree	22kg
Average fruit production per respondent/individual	220kg
Average annual income from sales of fruits	19,188 birr

Source: own survey

The result shows the income generated from growing of 10 apple trees on 150 M² of land using only one person with limited extension service and technology is generating an annual income of 19188 birrs for individual, whereas table 15 above shows the whole family was engaged on the cultivation of 5000 M² Land for crop production to generate an annual income of 35 000 Birr. From the above analysis we conclude that growing apple tree is more economical and profitable to the farmers than field crop production.

A study conducted in North shoa oromia by Lemlem and Tajebe have also revealed the same finding results. According to information obtained from the focus group, discussion farmers bought one heifer of improved milk cow by a cost of 70,000 birrs and the initial purchasing cost for two milk cows is about 140,000 ETB.

The monthly expenses for feed, labor, and supplement and medication are escalating and it is becoming beyond the farmer's capacity as a result of that managing 10 apple trees in the nearby area is much more profitable than managing two milk cows. The result of this study is similar to the previous study. The study conducted on apple profitability in west and north shoa area of Oromia was revealed that mean annual gross income from vegetable + apple fruit was 24,337.22 ETB and mean annual gross income of non-adopters from vegetables was 7480.53ETB.

The income obtained from apple contributes 16.84% to the income of the agri-horticultural system. The agri-horticulture system contributed three-fold higher gross revenue for adopters in addition to its nutritional value (Lemlem et al ,2018).

4.7. Comparison of apple production with Crop, Milk and Grass production

Table 14 Comparison of the top three main income sources with apple production

Comparison points	Source of Income			
	Crop production	Milk & Milk products Marketing	Grass/ Hay Production & Marketing	Apple Production
Average land size used for production by individual	5000M ²	100M ²	1500 M ²	150M ²
Manpower involved	5 person	1 person	2 person	1 person
Annual production	10000kg of Wheat and 6000kg of Barley	5040 litter of milk	200 Bundle	220kg
Annual income	35000	30967	27631	19188

Source: own survey 2020

Table 14 show growing of 10 apple trees on 150M² of land with one person labor required to generate an annual income of 19188 Birr is much more beneficiary and economical beyond its nutritional and ecological benefits as compared to the production of crops on 5000M² with all family involvement to generate total income if 35000 birr. Likewise, the study found that apple production was more benefiting farmers and urban dwellers than practicing milk and milk products marketing.

Analysis of the study indicated that the investment cost for having two milk cows and its related expense for feed and medication is by far large as compared to expenses incurred to establish 10 trees. Once apple trees are planted its management cost is very low. With minimum input supply and technical assistance, the grower is benefiting, and while nowadays, in the study area managing milk cows is becoming more expensive and challenging work due to the annual increment of feed cost.

4.8. Independent sample T test results

The following section presents the independent sample t test conducted to find out the presence or absence of significant mean difference among producer and non-producers of apple in the study area.

4.8.1. Income level and apple producing status

The following analysis was made to compare the income level of both apple producers and non apple producers using independent t test.

Table 15 Independent sample T test

	Status	No of sample	Mean	Std. Deviation	df	t	Sig.
Annual Income of the Respondent	Non Producer	171	1.91	1.042	368.984	-6.571	.000
	Producer	200	2.68	1.211			

Based on the above table, based on income range of producers and non-producers with a mean value of 1.91 and 2.68 respectively, there was a statistically significant difference between the two groups with a significance value .000 (<0.05). This result implies that producers of apple in the study area were significantly better than non-producers in terms of their income level.

4.8.2. Perception of Climate Change and Producing Status

The perception of climate change plays a vital role to use climate change adaptation mechanism to mitigate the change so as to produce sufficient income for the household. Accordingly, this study has conducted the following t test analysis to compare the perception of the two groups.

Table 16 Perception of Climate Change and Producing Status

	Status	No of Sample	Mean	Std. Deviation	d.f.	t	Sig
Farmers Perception of Climate Change Effect	Non Producer	171	1.98	.822	369	-.608	.544
	Producer	200	2.04	.976			

According to the independent sample t test conducted and depicted in the above table, mean of farmers perception of climate change effect were found to be 1.98 for non-producers and 2.04 for producers. Even though, there is a slight mean difference between the two groupings in favor of the producing group, the significance result 0.544 (p value >0.05) which indicate the absence of significant mean difference between the two groups. This result implies that there was no statistically meaningful difference between producers and non-producers based on their perception of climate change.

4.8.3. Climate Change Adaptation and Producing Status

Lastly, regarding the climate change adaptation of apple producing and non-producing groups of the sample, the following comparison was made using t test.

Table 17 Climate Change Adaptation and Producing Status

	Status	No of sample	Mean	Std. Deviation	df	t	Sig
Climate Change Adaptation	Non Producer	171	1.5906	.81654	356.200	-4.121	.000
	Producer	198	2.0101	1.13097			

The above table showed that apple producers and non-producers have a climate change adaptation man value of 2.0101 and 1.5906 respectively. The significant result also showed the presence of statistically significant mean difference with a p value of .000 (<0.05). This result implies that producers of apple were found to better adapt climate change than non-producers.

5. CONCLUSIONS & RECOMMENDATIONS

5.1. Conclusions

The study result shows Sululta is circumstanced with inter-woven climate change problems that include; flooding, erratic rainfall, change in temperature and frost are among the major climate change effects that exerting pressure on the day to day operations of urban and rural communities.

As a result of frequent climate change effects in the area of crop failure and household, income reduction leads the rural and urban communities to low adaptation. A study on farmers' apple production practice in the sululta area was conducted to assess and examine the level of its importance to climate change effects adaptation and income diversification option.

The data analysis of this study indicates that as a result of visible Climate change effects in the area communities are experiencing loss of production, reduction in household income, and shortage of water for household consumption is the critical one. The results of FGD made with key informants and different institutions indicated that some households are engaged in more than one activity to generate additional income for the family. Subsequently, the qualitative data analysis indicated that the main income source of the community is directly related to the main occupation being practiced by the community.

The result of focus group discussions, individual interviews, secondary data analysis, and physical observation made to the area indicated that both the rural and urban communities of the study area are implementing and executing different adaptation strategies. Among the adaptation strategies being practicing in the area including tree planting, soil and water conservation, intensification of agriculture activities that includes apple production.

The closeness of sululta town to Addis Ababa helps the farmers and dwellers to generate income from different activities. Through the income generated from different operations are differ and vary from person to person and it depends on the person's activeness and communication ability too. In this study, the annual Income of the community from the main income source was analyzed using descriptive statics. The result shows that majority of the

sululta community is generating income from crop production followed by Milk and milk products marketing. A large number of households have also engaged in fuel wood collection and marketing to sustain their family life. The issue of climate change is not a new agenda for the majority of farmers and urban dwellers. This study result have showed that almost 41% of the community have known about the climate change effects through observing the change in rainfall and weather condition to the area.

Analysis of secondary data showed that the distribution of rainfall in the area is not uniform and it affects the agricultural activities. Rainfall shortage is not the problem to the area, rather, the time and intensity of the rain is the problem that does not suit to the normal cropping calendar. In fact, in the lower catchment area, excessive rainfall amounts have damaged grass/ hay production and created siltation problems. In the area, Grass/ hay production is the main business of stay for the majority of the farmers. Grass serves the community as a cash crop in the area next to crop production.

The findings of the study articulated that community initiatives are being undertaken in the area to overcome the effects of climate change. Among the major ones includes enhancing community awareness, soil and water conservation works, tree planting, crop diversification, and fruit and vegetable production are the major one that was listed out during the Focus group discussion and at the time of individual survey.

During the field visit we have observed that it is common to see apple fruit trees in the compound of the respondents. The assessment result had also shown that almost the majority farmer knows apple fruit production and its wider benefits. Supporting Household income is among the benefits of apple production in the area.

From the results of data analysis, it is possible to conclude that, communities are practicing grass/hay production and marketing as a major livelihood activity. Crop production being practiced in the area has less contributing to adapt the climate change effects. The contribution of Apple fruit production in the area has also paramount great and important and it was being practiced as one option of climate change adaptation. The farmers have started apple fruit production in their compound and even some of the farmers are have given more attention to apple fruit production as compared to other cereal crop production activities.

Findings indicated that, climate change is the most puzzling and complicated can of worms which humanity is facing. In the past, many of these climatic disruptions had occurred by natural phenomena but from scientific studies, it is evident that most climatic changes, which mankind is witnessing, are likely to result from anthropogenic activities.

From the findings of the study, we have concluded that the majority of a farmer that engaged on apple production has 15 – 20 trees in their compound whereas the average number of trees per individual was 10 apple trees and the average land allocated for the growing of 10 apple trees was also 150M² of land. From the growing of trees on average 22 kg, apple fruit is harvested per tree in the area. The collected data analysis has also shown that farmers are annually generating birr 19,188.00 from home managed 10 apple trees.

Apple production is being used as one option of climate change adaptation in the area by generating additional income for the household from the sale of fruits. The t test results conducted showed that apple producers were found to be more adaptive to the climate change and able to generate significantly higher income than non-producing farmers in the Sululta area. The contribution of apple production in soil & water conservation and carbon sequestration is also paramount important that needs further study and investigation in the future.

5.2. Recommendations

- ✓ Effects of climate change are everywhere, and it needs the involvement of all stakeholders and Development Partners. The government should have to developer comprehensive and bottom up oriented natural resource management plans that strictly implemented on the ground with the involvement of stakeholders and community. The stakeholder that includes the financial institutions, research center and universities should actively involve in supporting and guiding the designed Sustainable Land management practices by the grass root community.
- ✓ The hill areas of sululta particularly the Entoto Mountain is still plowed for crop production which results in very low production. Individuals witnessed that the yield obtained from the farm of hill areas of sululta is not alone to cover the house

consumption, it is not sufficient enough to cover the labor and seed cost. So this backyard and un-productive agriculture have to be transform into less labor demand and high productivity from narrow areas.

- ✓ Apple fruit production is one of the recommended adaptation strategies being undertaking both by the rural and urban communities. The study result analysis showed that, apple production in the area improve the lives of the community through generating additional income from the sale of fruits, provides fresh fruit to the family from own farm, contribute as shade and ornamental tree in the compound. As a results of such positive advantages promotion of apple tree growing in the area needs to be strengthened and supported by the government..
- ✓ Results of the various studies conducted indicate that, Apple fruit tree growing in the degraded area helps to conserve the soil and water system of the catchment. from this perspectives apple tree planting in the degraded land of the upper catchment of Entoto mountain is much recommended to conserve the soil. Growing of apple fruit tree in farmers and residents compound gives mental satisfaction due to its various growing cycle and nature and further and apple fruit tree growing to contribute to local climate change adaptation and carbon sequestration. In this study apple carbon sequestration capacity were not studied . I recommend that further study and investigation has to be carried out in the future to know apple tree carbon sequestration capacity in sululta area.
- ✓ Apple productions increases the productivity of the community, builds the resiliency capacity and provide mitigation co benefits to the society and to the environment. Household income increased , sustainable land managenet practice sthat include sorganic compost preparation and application, Zero tillage are practice very well. Apple capacity of carbon sequestration would have also great. This all builds and improve the livelihood of the community. By doing so the communities pressure on tree cutting and nature disturbing would be minimized, therefore apple production has to be strengthened supported at the locality level.

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ANNEXES

Questioner

Part I: Introduction to Survey Objective, Data collection procedure and General Information of the Study area

Section One:

1.1 Introduction to Survey Objective and Data Collection Procedure

This Questioner is designed and used to collect data on Farmer's Apple fruit tree growing and fruit production to examine its contribution to Climate Change Adaptation and Income Diversification option. The information provided by the respondent is only utilized for the analysis of the study conducted to examine apple fruit production contribution to climate and income diversification by the student of Addis Ababa University as a fulfillment of Master Study. All information collected from respondents is used only for the aforementioned purpose and managed confidentially.

1.2 Methodology of Data collection

Enumerators or data collectors should gather and fill all information and data's from the individual respondent to reflect on farmers' apple fruit tree growing and trees contributions as general. Researchers collect and gather all information and data relevant to the study from FGD, Government sectors, and institutions. This Questioner is structured in the following ways. It is organized into four parts that consist of nine sections.

The first section deals with introducing the objective and procedure to follow while this survey is conducting and it covers a survey to map the study area.

Sections 2 and 3 are meant to collect data on major climate change impacts and their adaptation options practiced in the sululta area.

Section 4, 5, and 6 used to collect data about the Climate change adaptation options, the favorable conditions for apple fruit tree growing and fruit production, and its benefits to farmers' livelihood.

Sections 7, 8, and 9 are used to collect data on the major problems in growing apple, the contribution of apple fruit production for climate change adaptation, and livelihood resource

improvement. In each section, the enumerators might receive and get responses out of the scope of the survey. In such a condition guiding the respondents to switch back to the main agenda is important to manage the interview time.

1.3 Guiding Questions for Self - Reflection

A set of questions is provided in each section to guide enumerators through the process, and to describe their operation in the section. Such questions should not be addressed all but used as guiding for critical self – reflection and better strategy setting.

Infobox

Infoboxes provide researchers and data collectors with a short overview of major approaches used in the literature.

Replies can take different structures; anyhow, they must be understandable, clearly written, and narrowed with specificity. Descriptions may not take the form of a one-word reply or that of a list of concepts without any logical link or explanation. For instance, descriptions can have the form of a short statement or that of a structured, or semi-structured list.

1.4 Recommendation to data collectors or respondents

1. Before the start of the questioner and discussion Enumerators or the researcher must introduce his/her self and the purpose/objective of the data collection.
2. The time needed to fill up all questions should not be higher than 60 minutes
3. Enumerators have to fill all sections of the survey within the given time, at one time
4. Enumerators and researcher recommended to fill the questioner using honesty and objectively
5. Once the data is collected the enumerators immediately shared or submitted to the researchers.
6. All respondents should have to be acknowledged for their time and participation in the discussion, data provision, and for their valuable recommendations.

Section Two: General Information about the Study Area

1. Study area addressee and location
 - 1.1 Name of the Area -----
 - 1.2 Region -----
 - 1.3 Zone -----
 - 1.4 Distance from Addis Ababa-----
 - 1.5 Altitude -----
 - 1.6 Direction from the North Pole -----

2. Climate and Weather condition
 - 2.1 Annual Rainfall-----
 - 2.2 Average Annual Temperature Max-Min-----

3. What is the existing Government Structure

4. Demography

4.1 Population

Total Population Size		
Male	Female	Total

5. Land Use

- 5.1 Crop Land -----
- 5.2 Forest Land -----
- 5.3 Wet & grazing land -----

6. Major Institutions exist in the study area

- 6.1 Government -----
- 6.2 Public -----
- 6.3 Private -----

7. The major occupation in the area

8. Existing Infrastructures and its condition in the Study area

S.N	Type of Infrastructure	Size	Existing Condition	Managed by

9. Settlement and Urbanization

9.1 What was the Past (10 Years Back) History of Sululta town settlement and urbanization

9.2 Current Settlement and Urbanization situation in sululta area -----

10. In and out Migration

10.1 Is there peoples are frequently coming to sululta area for permanent stay or work

10.2 Do peoples are Migrate out of Sululta town to other places for long stay or work

11. Unique Features of the study area

12. List out the unique features of sululta area as compared to other places in the country

13. What are the major Environmental issues of Sululta

14. List out the common Indigenous Knowledge and practices in the area

15. Climate change and adaptation practices

15.1 Is there any Climate Change effects in the area

15.2 What are the Commonly observed Climate change effects in the area

16. List out the Major farmer's source of income (livelihood Options) in the area

S.N	Major Source of Income	Rank from Highest to Low-income option

17. What are the Major agriculture activities practiced in Suluta area

18. Do you think that Apple fruit production in sululta area contribute to climate change adaptation and farmers income diversification

19. List out the common Climate Change effect adaptation measures in sululta area

20. Forest management and Deforestation

19.1 Type of forest exist in the area

S.N	by Type	Size(ha)	By ownership		
			Community (Household)	Government	Private (greater than 0.5ha)
1	Plantation				
2	Natural				
3	Mixed				
	Total				

21. Forest Management in the area

22. Waste Management

22.1 Mention the major waste items generated in the town

22.2 Discuss the Solid Waste management practice of the Town

A)Waste Management Practice of the Municipality

A)Waste Management Practice by Individual households

B)Waste management and recycling practice by the flourished Industries in Sululta town

23. Investment and Employment

23.1 How is the Investment Trend in Sululta

23.2 How is the Employment condition in Suluta area as compared to the past ten years

Part II. Questioner for Individual Survey

Section Three: Assess the Respondents know-how and understanding about the major Climate Change effects in Sululta area

1. Respondent Background Information

a. Full Name

b. Age

c. Sex

d. Education level

e. Addressee

f. Family Size

g. Main Occupation

h. Main Income Source

i. Annual Income (ETB)

2. Respondents have been asked about the Idea about Climate Change

3. Presence of climate change effects in the

4. When do you Recognize about Climate change effects in your area

5. How do you know about Climate Change Effects

6. Which one is the Major Climate change effects in this area

7. What Problems do you phase because of Climate change

8. Do you think that Climate Change effects are reversible
9. What measures you are taking on to tackle the climate change effects in your area
10. Do you think that Apple fruit production in your area have a contribution to overcoming the effects of Climate change
11. Who is responsible for taking measures to the effects of climate change?

Section Four: Climate Change Adaptation Options practiced in Sululta area

Under this specific interview Question part farmers, Climate change adaptation options will be assessed.

- 4.1 Which one is a climate change adaptation option in sululta area
- 4.2 Do you think that the current agricultural operations you are doing are helping you to adapt the Climate Change
- 4.3 Do you think that Apple Fruit production in your area have some contribution to climate change adaptation
- 4.4 How does apple fruit production and Marketing, helps you to adapt the current climate change effects
- 4.5 What other measures you recommend to adapt the climate change in your locality than the activity you did now

Section Five: The Favorable Conditions for Apple fruit Production in Sululta area

Under this assessment part please try to understand and document the favorable conditions for apple fruit production from farmers' knowledge and practices on the growth of apple fruit trees in their locality.

- 5.1 Do you have an Apple tree in your compound?
- 5.2 How many Trees do you have?
- 5.3 Which apple variety is growing well in this area
- 5.4 When did you plant Apple trees in your area?
- 5.5 What are the favorable climate conditions for apple fruit production
- 5.6 Where did you plant your apple trees?
- 5.7 What are the important operations you did to grow the tree and produce the fruit? When did you irrigate your apple trees
- 5.8 When did you give or add compost / organic fertilizer for your Apple trees
- 5.9 Is that possible to plant apple seedling in every place or area?

- 5.10 Do excessive rainfall and sunstroke damage apple trees
- 5.11 Do Apple trees need cold weather conditions and why?
- 5.12 Are you observing good climate conditions (Rainfall, Temperature, Humidity) in your locality for apple fruit tree growing?
- 5.13 In your locality which soil type is favorable for apple fruit tree growing and fruit production

Section Six: Farmers Benefits of Apple fruit Production

Under this part of the interview fruit tree growers, in particular, farmers benefit from apple fruit tree planting and fruit production is assessed and documented.

- 6.1 Do you know about apple fruit trees growing and management
- 6.2 From where did you get apple tree seedlings
- 6.3 How did you get the plants
- 6.4 Are you producing fruit from planted apple trees
- 6.5 Which one is the benefit of apple fruit trees planted in your compound
- 6.6 Can you tell me the annual fruit production per tree
- 6.7 What do you do with the product of your apple tree (fruit)
- 6.8 For what purpose do you use the income you get from the sale of apple fruit
- 6.9 On Average how much money you are generating from the sale of apple fruits each year? In ETB

Section Seven: The major problems in Apple fruit Production in sululta area

Under this part of the interview the Major Problems that phased by the farmers while Apple Fruit Tree Growing and Fruit Production are assessed and discussed in detail.

- 7.1 How is the tree growing condition as compared to other trees growing in your area
- 7.2 Did you get Training on apple fruit tree growing and management?
- 7.3 How is the extension services you are getting to fully exploit your true potential
- 7.4 Do you know apple fruit tree pruning benefits and its techniques
- 7.5 Do you think that fruit tree pruning activity increases fruit production?
- 7.6 Do you have any pruning tools or equipment?
- 7.7 Technically what problems do you mention on Apple fruit tree growing and Management?
- 7.8 Do you think that the current climate change is particularly the fluctuation of Rainfall in this area disturb the apple fruit production
- 7.9 Do you think that absence of reliable apple seedling suppliers has impacts on fruit tree promotion in the area.
- 7.10 Which one is the problem you phased in apple fruit production

Section Eight: How does Apple Fruit Tree Growing Contribute for Climate change adaptation

Under this part of the assessment, the contribution of apple fruit tree growing by the farmers to adopt the climate change effect is thoroughly investigated

- 8.1 Does apple fruit tree properly growing and bearing fruits in this area
- 8.2 Do you think that growing of apple fruit trees contribute to soil erosion reduction
- 8.3 Are you harvesting apple fruits every year
- 8.4 In your locality which Agricultural products or crops are largely damaged by climate change effects
- 8.5 Do you recommend other farmers to plant apple fruit trees
- 8.6 Why you prefer Apple Fruit tree planting in your compound than any other crops and trees
- 8.7 Is apple fruit production an easy job in your area?
- 8.8 Do you think that apple fruit tree growing contribute for soil carbon sequestration

Section Nine: How does Apple Fruit Production Contribute to Livelihood Resource Improvement

This part of the study helps to understand and assess the contribution of apple fruit production at the household level for household assist development and other livelihood options.

- 9.1 Why you plant an apple fruit tree in your area
- 9.2 Does apple fruit contribute to household nutritional improvement?
- 9.3 As compared to other Agricultural activities does apple fruit production and marketing helps to develop assets
- 9.4 What types of assets improved/developed in your home from the sale of fruits
- 9.5 Do you recommend other farmers to grow apple for asset building

Thank you very much for your time

Time is taken -----

Focus Group Discussion Points

Part III. Discussion Points for Focus Group Discussion

During the focus Group Discussion with key informants, representatives of institutions, and government representatives the following key points are used as discussion points.

- Discuss the major climate change effects in the area
- Farmers climate change adaptation options practice of the area
- The favorable conditions of apple fruit growing in the area
- Benefits of apple fruit production in the area
- The major problems in apple fruit production
- The relation between Apple fruit production and climate change adaptation
- The contribution of apple fruit production for livelihood resource improvement

Check List for Study area observation

Part IV. Check List for Field Observation

During travel to the study area, at the time of transect walk and data gathering time the following key points are used to visualize and observe the physical set up of the area, community movements and operations, landscape arrangements and other features of the area,

- ✓ Road, Buildings, Vegetation cover
- ✓ Settlements, Urbanization, Farm activities
- ✓ Waste Management, Pollution, Rivers, and tributaries
- ✓ Water flow system and directions, Sediments and its effects
- ✓ Major crops grew in the area, Business operations
- ✓ Transport systems
- ✓ Forest land management and wood harvesting
- ✓ Industries and employment
- ✓ Municipal services
- ✓ Training institutions
- ✓ Fruit and vegetable operations
- ✓ Nurseries and propagation techniques
- ✓ Market and agricultural products
- ✓ Schools and other institutions
- ✓ Wildlife and birds
- ✓Wetland situation