

Forecasting the Fruit Belt Development Using Rainwater Harvesting and Wastewater Recycling System In Case of Bishoftu Town, Ethiopia.

Dereje Girma Zewudie



A Thesis submitted to the Department of Architecture, in the School of Civil Engineering and Architecture.

Presented in Partial Fulfillment of the Requirement for the Degree of Masters of Science in Environmental Architecture.

**Office of Graduate Studies
Adama Science and Technology University**

Adama, Ethiopia

July, 2019

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ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY
SCHOOL OF GRADUATE STUDIES

DECLARATION

I, Dereje Girma Zewudie, hereby declare that this thesis entitled: “**Forecasting the Fruit Belt Development Using Rainwater Harvesting and Partially Wastewater Recycling System in Bishoftu Sub City, Ethiopia**” Submitted by me or the award of the degree of master of science in Environmental Architecture, Adama science and technology university at Adama, Ethiopia, is my own original work and that it has not been presented and will not be presented to any other University, and all sources of material used for this thesis have been duly acknowledged.

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5. ACRONOMY AND ABBREVIATION

C°	Degree Centigrade
CAD	Computer Aided Design
DEM	Digital Elevation Model
EIA	Environmental Impact Assessment
EPA	Environmental Protection Authority
EWRMP	Ethiopian Water Resource Management Policy
°F	Degree Fahrenheit
FAO	Food And Agricultural Organization (Of UN)
FBD	Fruit Belt Development
FBN	Fruit Belt Neighborhood
GB	Green Belt
GBD	Green Belt Development
GI	Green Infrastructure
GIS	Geographic Information System
GoE	Government Of Ethiopia
GND	Green Network Development
GS	Green Space
Ha	Hectare
In	Inch
Km	Kilometer
LDP	Local Development Plan
M	Meter
m/s	Meter Per Second
MARC	Ministry Of Agricultural Research Center
mm	Millimeter
MoE	Ministry of Education
MoFED	Ministry Of Finance And Economic Development
MoWIE	Ministry of water, irrigation and energy

NMA	National Metrology Agency
NPHOSS	Ntional Protocol For Hygine And “On-Site” Sanitation
ORAAMP	Office For Revision Of Addis Ababa Master Plan
OUPi	Oromia Urban Planning Institute
OWNP	One Wash National Program
RWH	Rainwater Harvesting
RWHS	Rainwater Harvesting System
SP	Structural Plan
TIF	Tax Incremental Finacing District
UGI	Urban Green Infrastructure
US	Urban Sustinablity
WH	Water Harvesting
WM	Watershed Managment

6. Abstract

Fruit belt development in Ethiopia, Bishoftu sub-city would solve different problems with respect to environmental, social, and economic values. The research has multi-dimensional purposes and objectives with multi-dimensional planning approach of environmental development and comprehensives landscape system for producing food products and creating of comfortable Town environment. This study encourages the development of Towns and urban environment by improving traditional green space into more functional ways. The study can play an effective role in revealing Town dwellers to nature improvement and productive environment with the enhancement of habitats for flora and fauna, which is a great opportunity for other development such as apiculture, aquaculture, and biodiversity. In order to the study results, buffer zones are the first and most effective and suitable places to develop a fruit tree and vegetation's and enhance the comprehensive urban landscape. Fruit belt development is a conspicuous way to struggle with poverty. A setback along roadside also the second suitable and potential places to plant fruit trees. The land availability and water access and supply were the least challenges, which shows that an opportunity to develop a fruit belt in Bishoftu sub-city. Its aim is to plant fruit trees and vegetation using rainwater harvesting in the urban environment. This study has high values in an urban environment to address dwellers food consumption and other multi-benefits in the urban environment and social life improvement. The fruit belt development in the city helps to minimize flooding impacts, urban heat island, and air quality and rise water cycling system. The planner and designers of urban green space should rethink creatively to find innovative thoughts and provide opportunities to develop and enhance fruit belt development in Bishoftu sub-city.

Keywords: *fruit belt, productive environment, rainwater, urban environment, green space*

CHAPTER ONE

1. Introduction

This thesis project is entitled “Forecasting the fruit belt development using rainwater harvesting and wastewater recycling system in case of Bishoftu Town, Ethiopia”. This project is highlighted on fruit belt development (FBD), it needs an attention and planning system to generate food products and will create comfortable fruit belt Town in Bishoftu, Ethiopia. Until recently this issue has not been taken up in Ethiopia, hence it’s an interesting event in the city to acquire a safe city and livable environment. The FBD has been different purposes in the worlds and it’s a key to struggle with poverty. The objective of this research is to develop a fruit belt city with the planning of the natural rainwater harvesting and partially wastewater recycling system in Bishoftu sub city for fruit belt development and other multi-dimensional benefits that give to city dwellers. The ultimate objective of production, handling, and distribution of fresh fruits is to satisfy consumers (Thakur, 2016).

The aim of this study is to produce a multi-dimensional planning approach of environmental operation and comprehensive landscape system for bringing about and comfortable city development with the keeping of economic, environmental and social benefit. Its goal is to inspire hope and optimism throughout the residential district, create projects for local residents, bring beauty and quality life in the urban center, generate positive attention for the city and the community often highlighted for resolve negative reasons and inspire long term investment and additional resources for city dwellers. And to design a city development that is become a hybrid-class multi-functional purpose for the fruit belt development in the future. Adopt a circular economy development, the concept of the circular economy has regained attention, especially related to achieve a more sustainable society (Denise Reike, Walter J.V. Vermeulen, and Sjors Witjes, 2018).

It is focused on fruit belt sub city development with the harvesting of rainwater in the form of creating a water reservoir at the sunken place for fruit trees and partially wastewater recycling for some other woods and bamboo trees in Bishoftu sub city, Ethiopia within the specific action area of the city. The subject area of fruit belt city development in Bishoftu, Ethiopia and it is a very important event as a local environment in addition to regional and global context because

it's conducted in the whole global environment. Consequently, the study would have several benefits in Bishoftu Town development, according to multi-directions benefits as follows: it will conduce to their surroundings by providing oxygen, improving air quality, conserving water, preserving soil, and supporting wildlife in addition to addressing of food ingestion. Making a broad umbrella city environment by developing of vertical and horizontal planes with fruit production and other green development.

1.1 Background of the study

Fruit belt city development is the development of food products in the city, which caves, various benefits for social, economic, and environmental quality to produce oxygen and absorbing of carbon discharge in the urban center. The major global environmental challenges are an accumulation of carbon emission which raises the global temperature regime and environmental pollutions. The cause to inspire on this topic in our country is an expansion of Town developments that consumed a lot of agricultural lands, so at once running out of agricultural lands due to city expansion and it requires an enhancement of agricultural products in the urban center with the keeping of urban characters. The FBD is part of the green infrastructure in the Town with an urban self-healing environment and to reconcile between economy and environment. FBD is a core of economic development and it has its own value for social development. And the city is hardly like the human body, the human body needs some foods, water, cloths or coverage, breath, infrastructure and so on Green infrastructure (GI): maximizing the delivery of multiple benefits (Jenny Claridge, Carl Foster, and Tony Hutchings, 2010). Urban policy today can be classified as hitting three main targets (Jenny Claridge, Carl Foster, and Tony Hutchings, 2010):

- Economic development, including local economic activity, income generation, and employment insurance;
- Social evolution, including housing and neighborhood events, relations within and between communities, and social inclusion;
- Environmental issues, concerned with spatial relationships in the urban center, planning, transport, and the urban infrastructure.

At the start of the 21st century, humanity is becoming a predominantly urban species and this historic development represents a fundamental, systemic change in the relationship between

humans and nature (Lawrence, 2010). Cities as ecological and economic organizations. Towns and cities need sustenance for their people and this requires elaborate ecological and economic systems (Lawrence, 2010). The challenge today is to assure that the major challenge upward to the environmental impacts of urban living before they start to hit some problems in the kind of health problems, higher food or energy prices, storms, and sea level rise. Creating a circular urban metabolism can create resilient cities and create many new local businesses and jobs (Lawrence, 2010). The aim is to enhance green space (GS) and FBD with pairs on pair's dimensions. Because green place can be called the lungs of the urban centers. Therefore, to alter the green place by planting fruit trees within urban planning and design principles consideration.

Urban agriculture (UA) has the potential to considerably contribute to food and income security, pollution prevention, waste reduction, and the improvement of living conditions in urban environments (Devuyst, 2011). UA has multiple aspects, including arable farming (food grains and vegetables), fruit growing, aquaculture, and livestock rearing from a micro scale up to co-operatives with a considerable overall total production. The regenerative development of cities is a comprehensive approach that goes beyond established concepts of sustainable development (Lawrence, 2010). The charge is two key factors; first, environmental conservation must go hand in hand with poverty eradication. Secondly, people must be helped to understand their status and that of their surroundings and then empowered to take responsibility for their own destiny-rather than wait for others to make the determination (Maathai and Wangari, 2007).

1.2 Statement of the problem

The major problems in urban environment is environmental pollutions and income constraints to live in Town. The study has different substantial points in the Town such as income growth, addressing food consumption, minimizing urban heat island, improving environmental quality, enhancing ecological systems and minimizing pollutions in the Town. Hence, the study is focused on responding to the problems of those issues in Bishoftu Town and would claim it as the whole Ethiopian Town grows. The other problems are water systems in Bishoftu Town based on rainwater management to reduce flooding impact and wastewater that generated from buildings in the city have an impact on city development because the land is gone over by asphalt and buildings due to this reason flooding effect and other environmental pollutions happened.

1.3 The Overall goal of the research

The goal of FBD in Bishoftu, Ethiopia is to create a multi-dimensional and cross-benefit, retaining the existing population demand and promoting other new residential districts. Hence, the benefits are income/economic development, environmental benefit and social benefits are the most abundant issues in this study. The residential district would determine this potential benefit, substantial public, and private investments are needed to make up the physical, optical, environmental and societal conditions of the urban core. To design a city development that will become a hybrid-class multi-functional purpose in the fruit belt city development for features:

- To make the internal, local environment as pleasant, beautiful and healthy as possible.
- To make wise use of a natural resource that sustains the urban life-support system.
- To minimize the negative environmental effects of the city on the countryside and addressing food consumption with environmental benefits in the neighborhood area.

1.4 Objective

1.4.1 General objective:

- To develop a multi-dimensional planning approach of fruit belt development in designing of the action area for producing food products and comfortable Town development at Bishoftu Town.

1.4.2 Specific objective:

- ◆ To suggest the possible fruit trees for improving urban food consumption and other fruit types.
- ◆ To assessed water system approach for human consumption and production of fruits and related ecosystem service and food product development in Bishoftu Town.
- ◆ To develop a comprehensive Eco-landscape planning system, including Green wedges, Corridors, and inward and outward fruit belt development.

1.5 Research questions

- What kind of fruit trees are available and adaptable around Bishoftu Town for food use of commodities and services?
- How to harvest rainwater, when the weather is rainy and how to recycle wastewater that generated from buildings, surface runoff and again how to use it for fruit belt development?
- Where to plan a water system and how to integrate the resource for eco- Town growth?

1.6 The scope and limitation of the study

The study focused on fruit belt and vegetation developments with the harvesting of rainwater and partially wastewater recycling system in Bishoftu sub-city, Ethiopia within the selected sub city/district. In general, to investigate a data from Bishoftu city and other empirical observation about the water source for fruit belt city development, and to ascertain a solution in designing and planning manners for city development in a multi-dimensional way for creating of a more honest environment and quality life in Bishoftu city. The main limitation to study this reaearch is lack of collaborative experts to be realize it at this time.

1.7 Justification and research significance

The study of fruit belt city development in Bishoftu, Ethiopia is a very important issue as a local environment in addition to the regional and global context, because it's conducted to the whole global environment. And it would give an advantage for a community through multi-dimensional ways such as to produce food production, reduce pollutions in the Town, and reduce other impacts with multi-dimensional planning approach from current land use planning to ecological landscape planning including; underground and aboveground physical space planning and enhancing ecological system with a holistic water system approach for human consumption and natural ecosystem development.

Therefore, the study would have several benefits in Bishoftu sub-city development, according to multi-directions benefits as follows:

- Fruit belt city development contributes to their surroundings by providing oxygen, improving air quality, conserving water, preserving soil, and supporting wildlife in addition to addressing food consumption.
- Making a broad umbrella city environment by developing of vertical and horizontal planes with fruit production and other green development.
- It has economic and environmental benefits for social change in the city environment according to the demand of city dwellers.

Table 1: The potential benefit of fruit belt development in sub-city or city

Urban issue	Potential benefits of urban forests
Food security	Provide food, clean water, and woodland
Urban poverty	Create jobs and increase income
Soil and landscape degradation	Improve soil conditions and prevent erosion
Reduced biodiversity	Preserve and increase biodiversity
Air and noise pollution	Remove air pollutants and buffer noise
Greenhouse gas emissions	Sequester carbon and mitigate climate change, improve local climate and build resilience
Extreme weather events	Mitigate the local climate and build resilience
Energy shortage	Save energy through shading/cooling, and grow wood fuel
Heat island effect	Cool the built environment through shade and evapotranspiration
Flooding	Mitigate stormwater runoff and reduce flooding
Limited recreational opportunities	Provide opportunities for recreation and environmental education
Exposure	Provide shelter
Limited water resources	Enable infiltration and the reuse of wastewater
Lack of community and social cohesion	Provide distinctive places for formal and informal outdoor interaction

2. CHAPTER TWO

2 Literature review

2.1 What is the fruit belt

The Fruit Belt is an important region because it has the potential to increase the number of fruits that a country produces significantly. Increasing the number of fruits a region produces would significantly raise the living standards of the residents. The Fruit Belt Strategic Plan is built on the city's Green Code and helps guide and support the redevelopment of the Fruit Belt neighborhood (plan39, 2018). The concept of fruit belt is highly related to green belt development (GBD), the difference is to add an effective and efficient purpose as usual of GBD by planting of adaptive fruit trees. The Fruit Belt was originally developed by German settlers in the 1850s, with the residential streets named for various trees that were planted. The neighborhood has undergone many changes since its inception and now faces potential development pressure spilling over from the Buffalo Niagara Medical Campus immediately to its west (Hon Darius G. Pridgen, 2018). The green belt (GB) is the area around a city where development is restricted so that town and cities do not merge.

Fruit trees are ectothermic which means that the metabolism of the tree is driven by the accumulation of ambient heat (i.e. they do not regulate internally). As the coast fails to accumulate large amounts of heat for prolonged periods of time throughout the summer, fruit trees grown in coastal areas exhibit different growth patterns than those in interior areas (Beynon, 2012). Greenbelts have been widely applied to contain urban growth, provide recreational opportunities, and improve the quality of life (Ali, 2008). FBD is a part of green infrastructure for sustainable urbanism.

Urban sustainability (US) is defined as a multi-layered concept and aesthetics is equally important as economic viability or ecological value, not more or less important (Roggema, 2016). Sustainability is not similar to environmental quality. High environmental quality only does not guarantee high sustainability. Similarly, an urban environment with high environmental quality or a high economic value, but without beauty is also not sustainable (Roggema, 2016).

The concept of fruit belt is adopting ecological and GBD in the city environment with understanding of the water system, the soil and nature became important as the directing force of these concepts.

Greenbelts are networks of managed land adapted to meet a wide array of ecological and other goals (Felix Fung and Tenley Conway, 2008). The fruit belts are most often created to hold an additional purpose rather than green belts by adding the value of economic, recreational, and social developments with planning and patterns have sought to support multi-parts.

The Fruit Belt has a very distinctive character with the exception of new suburban-style homes constructed over the last decade, the properties were built in the late 19th and early 20th centuries (Henry L. Taylor, 2004). Similarly, in our country, Ethiopia also has distinctive characters to develop a fruit belt city. In the existing city has great challenges to developing fruit based city structures because of the entire city structure, while in the new sub-city development is not much difficult to when to compare the existing city.

Efforts to increase fruit and vegetable consumption are a significant aspect of national approaches to preventive health. However, policy frameworks for increasing fruit and vegetable consumption rarely take an integrated food-systems approach that includes a focus on production (Rachel Carey, 2011). In this policy analysis and commentary, they examine fruit and vegetable production in peri-urban areas of Melbourne in Victoria, Australia, and highlight the significance of emerging environmental and economic pressures on fruit and vegetable production. Peri-urban agriculture includes all agricultural activities within mutual respects like fisheries, horticulture, apiculture and some other ecosystem services. Therefore, fruit belt development is opening up diverse development and it's a process of economic growth and positive opportunities. In the context of increasing the high-value production of agricultural commodities, fruit tree and perennial crops play an important role. This commodity group includes tropical nuts, fruit trees, grapes, bananas, mango, pineapple, papaya, passion fruits, apples and others (Honja, 2014).

2.2 Fruit Belt States

The Fruit Belt is a region in the northern United States near the Great Lakes ideal for growing fruit. And develop around any place that has suitable soil to plant it in areas around the industrial establishment, residential areas, roadside, and some other suitable place should be the ones targeted for fruit belts and enhancing of urban ecology. Urban ecology is an interdisciplinary field that aims to understand how human beings and ecological processes can coexist in human-dominated systems and helps societies with their efforts to become more sustainably (Arnaud Diemer, Manuel Eduardo, and Patricia Ingrid , 2017).

2.3 The guiding principle of the fruit belt

The Strategic Plan contains goals and policies to guide redevelopment and activities within the Fruit Belt neighborhood. These are driven by a series of principles that the community would like to see implemented (Hon Darius G. Pridgen, 2018).

A. The Fruit Belt relies on the concept of community development to guide our policies

The community is committed to meeting existing needs without compromising future generations. Long-term impacts of policy development will be consistent to ensure the neighborhood's social, cultural and environmental systems are well-integrated.

B. The fruit belt values equity

The community will actively work to eliminate barriers to collaboration and participation in community development. Residents will ensure that their resources and opportunities are fairly distributed and that every person has the capacity and a fair say in their community's progress.

C. The Fruit Belt is committed to investments that support long-term sustainability

Residents will ensure that strategic investments maximizing long-term returns are supported. The community recognizes that investments in infrastructure, public facilities, housing and the use of green space and green development will maximize property values, strengthen blocks, and foster a strong business corridor to make the Fruit Belt a great place to live, work and play.

D. Partnerships are essential

Because the community is a series of interconnected systems that function together, partnerships among businesses, professionals, organizations, residents, the city, and all community stakeholders are necessary to achieve community development.

2.3 Sources of water

Our main sources of water for drinking, washing, agriculture, and industry are surface water, groundwater and collected rainwater, all of which are dependent on rain and snow falling on the Earth's surface. Rainfall is the primary source of water in the countries providing flow in the streams as surface water, direct recharge to the limestone and alluvium aquifers and indirect recharge to the aquifers through the streams, depending on the geology of the country (FAO, 2014).

Water is continually moving around the Earth and continuously changing its form. The hydrological cycle maintains a balance between evaporation, precipitation, the transport of water vapor in the atmosphere from the sea to the land and run-off from land to sea. Managing water resources in a way that responds to multiple natural and socioeconomic changes and pressures is fundamental for the economic growth and development of Ethiopia (Beatrice Mosello, et al., 2015). This requires investments in a minimum platform of water infrastructure to buffer variability, as well as investments in the institutional platform that is required to define who gets what, when and how.

a) Rainwater

Rainwater is also an important source of water, although on a relatively small scale. Rain is the embodiment of life. It infuses water into our spring, rivers, and aquifers. Collecting rain from roofs or other hard-surfaced areas and storing it until it is needed can provide a valuable source of water for many purposes.

b) Surface water

Rivers, streams, lakes, and ponds are widely used as water sources in Ethiopia, especially in rural areas. The amount of available surface water depends largely on rainfall. When rainfall is limited, the supply of surface water will vary considerably between wet and dry seasons and also between years. One way to overcome this problem is to construct a dam across a river to create a reservoir that provides water storage. Large surface water reservoirs may be used for

hydroelectric power generation, regulating water releases to control river flows, for recreational purposes and to provide water for agricultural, municipal and industrial uses. Smaller dams are also used to enable irrigation. The water collects behind the dam and flows under gravity into irrigation channels leading to the fields.

2.4 Rainwater harvesting

Rainwater harvesting (RWH) is the technique of collection and storage of rainwater at the surface or in subsurface aquifers before it is lost as surface runoff. The rain-water harvesting techniques most commonly practiced in Ethiopia today are run-off irrigation (run-off Farming), flood spreading (spate irrigation), in-situ water harvesting (ridges, micro-basins, etc.) and roof water harvesting (Alem, 1999). Hence, to harvest rainwater from building into under each building beneath in each house ownership for vegetable development on the vegetable bed with different bed layer, which is free from pathogens, because rainwater is not conducted by waste pollutants. The integration of treated wastewater into water resources management is of paramount importance to meet future demands. Despite this need, only a few projects of effluent reuse have been implemented, most of them being pilot projects of crop or landscape irrigation (Andreas Ilias, Athanasios Panoras, and Andreas Angelakis, 2014).

All in all, Africa as a region has diverse urban green spaces with much attention given to the growth of urban trees. Agriculture plays an essential role in every culture throughout the world. Everyone has to eat. The global food systems are complex but they rely on agriculture, i.e. the production of crops and animals from the land, and aquaculture and fisheries. Most of the GS in Africa is concentrated in Sub-Saharan Africa than North Africa because of unfavorable vegetation and soil conditions (Didanna, 2015).

The overall development of urban green spaces in Africa was found to be hindered by many challenges (Collins Adjei , 2014). The agricultural land-use in the peri-urban contributes to the quality of life in urban regions, as it fulfills broad ranges of functions and services to the nearby urban areas (Zasada, 2012). This includes food production as well as the provision of recreational services and other services related to the management of the cultural landscape, which in turn contribute to the ecological capacity of the landscape.

a. Designing rainwater harvesting systems for agriculture

The goal of the rainwater harvesting system is to ensure there is adequate water in storage for irrigation during periods of water scarcity caused by normal or extended periods of drought (FAO, 2014). Water can be collected from catchments, rooftops, courtyard, and similar compacted or treated surfaces. Depending on site natural flow and properties of surface structure is mandatory to calculate and designing of rainwater harvesting. The major requirements to calculate rainwater harvesting are to know average annual rainfall data of the site, identification of permeable and impermeable areas within the area. Coefficient of surface runoff and surface types in the rainwater harvesting system is most important to calculate annual rainwater.

Table 2: Coefficient of surface runoff and surface types

Description of area	Runoff coefficient	Character of surface	Runoff coefficient	Type of ground surface	Runoff coefficient
Business		Pavement		Road	
Downtown	0.70-0.95	Asphaltic	0.7-0.95	Pavement (P)	0.7-0.9
Neighborhood	0.5-0.7	Brick	0.7-0.85	Permeable P	0.3-0.4
Residential		Roof	0.75-0.95	Gravel road	0.3-0.7
Single-family	0.30-0.50	Lawns, sandy soil		Shoulder or top of the soil	
Multiunit, detached	0.4-0.6	Flat, 2%	0.05-0.10	Fine soil	0.4-0.65
Multiunit, attached	0.6-0.75	Average 2-7	0.10-0.15	Coarse soil	0.1-0.3
Residential	0.25-0.40	Steep, 7%	0.15-0.20	Hard rock	0.7-0.85
Apartment	0.50-0.7	Lawns, heavy soil		Soft rock	0.5-0.75
Industrial		Flat, 2%	0.13-0.17	Unused bare	0.2-0.4
Light	0.5-0.8	Average 2-7	0.18-0.22	Athletic field	0.4-0.8
Heavy	0.6-0.9	Steep, 7%	0.25-0.35	Park vegetation	0.1-0.25
Parks, cemeteries	0.1-0.25	Grass plot of clay		Gentle mountain	0.3
Playgrounds	0.2-0.35	Flat, 2%	0.13-0.17	Steep mountain	0.5
Railroad yard	0.2-0.35	Average 2-7	0.18-0.22	Water/paddy field	0.7-0.8
Unimproved	0.1-0.30	Steep, 7%	0.25-0.35	Farmland	0.1-0.3

Source: (Design, 2010)

b. Components and benefits of rainwater harvesting

The important components of the physical design elements to harvest water are precipitation, soil type, soil characteristics, runoff area ratio, runoff efficiency, and vegetation type (Wubetu, 2016). All water harvesting (WH) systems must have the following components:-

1. Catchment area/run-off area, varying from a few square meters (micro-catchment) to as large as several square kilometers (macro-catchment): the part of the land where a portion or all of the precipitation which falls on it runs off its boundaries. It can be agricultural, fruit tree development, rocky or marginal land, or even a rooftop or a paved road.
2. Storage facility: The place where the run-off water is held from the time it occurs until it is utilized by crops, animals, human beings and/or other uses. Storage can be: (I) above the soil surface as in surface reservoirs or ponds; (II) in the soil profile as soil moisture using permeable pavement; and/or (III) underground in cisterns or as groundwater in aquifers.
3. Target or use: the beneficiary of the stored water. In agricultural production, the target is the plant or the animal, whereas, in domestic use, it refers to human beings and their needs.

Improved rainwater harvesting may result in improved crop yields, food security and better livelihood among households (Wubetu, 2016). The implementation of RWH increases the irrigation area, which changes more “blue” water into “green” water.

2.5 Methods to harvest rainwater for fruit and wastewater for shrubs development

There are different methods to harvest rainwater and recycling of partial wastewater for green development and the required fruit belt development using harvesting and conserving methods of water resource. It is the application of all methods necessary to harvest the whole water resources. The first thing is to adopt watershed development from a different surface according to the condition of land planning for fruit belt structures. A watershed is an area from which all water drains to a common point, making it an attractive unit for technical efforts to manage water and soil resources for production and conservation (Kerr John, et al., 2002).

The task can be achieved through four major aims (Verma, 2013):

- Prevention and reduction of damages by soil erosion.
- Reduction of pollution in the water and soil.
- Improvement of Water Quality
- Protection of Wildlife and Bio-diversity

The sustainable growth of Watershed Management (WM) aims at (Verma, 2013). Protection and enrichment of Ground Water Table, Improvement of Productivity of Degraded Land, Prevention of Land through reduction of Land Degradation, Conservation of Eco-Fragile Lands, Increment of Fuel, Food and Fodder, Improvement of cattle and milk production and Improvement of Rural Economy through entrepreneurship.

2.6 Approaches to watershed management

A watershed is defined as any surface area from which runoff resulting from rainfall is collected and drained through a common confluence point. The term is synonymous with a drainage basin or catchment area (Lakew D, et al., 2005). Participatory watershed development is also intended to generate greater cohesion within the society and enable its poorest members to benefit from the various assets created and eventually to overcome their food insecurity.

Watershed planning is a binding element for community planning. Topographic contour map, sometimes called topo maps can be very helpful in determining watershed boundaries since they illustrate changing the elevation of a landscape.

There are different approaches to WM and harvesting methods:

- A. Grassed waterways: These are channels laid out preferably on natural drainage lines in the watershed. As far as possible, natural courses should be used without much disturbances for draining out the excess water. At appropriate locations, stilling basin (water pools) should be created with land use of earthen and boulder pitched bunds for the temporary detention of run-off water. This structure will also serve the purpose of energy dissipation of flowing run-off water (R.K. Yadav, et al., 2008)
- B. Water harvesting ponds: Dug out cum embankment type of water harvesting structure can be used for creating seasonal and perennial ponds at the foot of the micro-watershed for irrigation and fish farming purposes. The above soil and water conservation measures can be created with the use of local resources (R.K. Yadav, et al., 2008).
- C. Urban areas should be able to not only change function but also change shape, acting as a breathing organism. For instance, the FBD could give multiple benefits as a city or town planning such as producing food, reduce pollution, minimize urban heat island and improve environmental quality. Sometimes the city inhales people when the population

grows, and sometimes it exhausts them, in times of shrinkage. Similarly, the city sometimes inhales water, in periods of heavy rain or a sudden flood, before slowly exhausting the water again. Therefore, it's possible to minimize that kind of problems by providing of space development for fruit belt town environment. For many functions the city operates as a sponge, taking up and getting rid of materials, flows, and organisms. In urban design, this requires the creation of spaces that are adjustable (Roggema, 2016). The following principles for urban design can be formulated:

- Invent and design spaces that make the city stronger in case of a disaster;
- Create enough space for green, water, regeneration, both for people as the ecosystem;
- Allow for spaces where human and ecological demands for clean air, soil, water, sufficient food and places to stay and live are integrated;
- Arrange the spaces and places such that cycles of wastewater, food, and mobility can be closed.

2.7 Systemic way of fruit belt development in the city/sub city

Starting from the premise of the city as a system, sustainable urbanism aims to close the loop by eliminating the environmental impact of urban development by providing all resources locally (Roggema, 2016). Sustainable urbanism also brings things like electricity and food production into the city. The fruit belt development is one way of food production system with the keeping of environmental quality and pollution reduction in city or town. This means that literally everything that the town or city needs is right there making it truly self-sufficient and sustainable (Roggema, 2016).

To get a grip on developments the design of cities leans on the understanding of networks and flows. The design of the city is then based on ways in which depletion of resources and production of waste are reduced and in which resources can be reused and recycled within the city.

2.8 Case study of fruit belt development

Case Study 1: Fruit Belt/Buffalo Niagara Medical Campus Tax Increment Financing District

The Project designates a Tax Increment Financing District (TIF) that encompasses a Residential Redevelopment Area. Improving the image of the Fruit Belt neighborhood by transforming the Fruit Belt resident neighborhood into a visually attractive community is an important aspect of the developmental strategy (Henry L. Taylor, 2004).

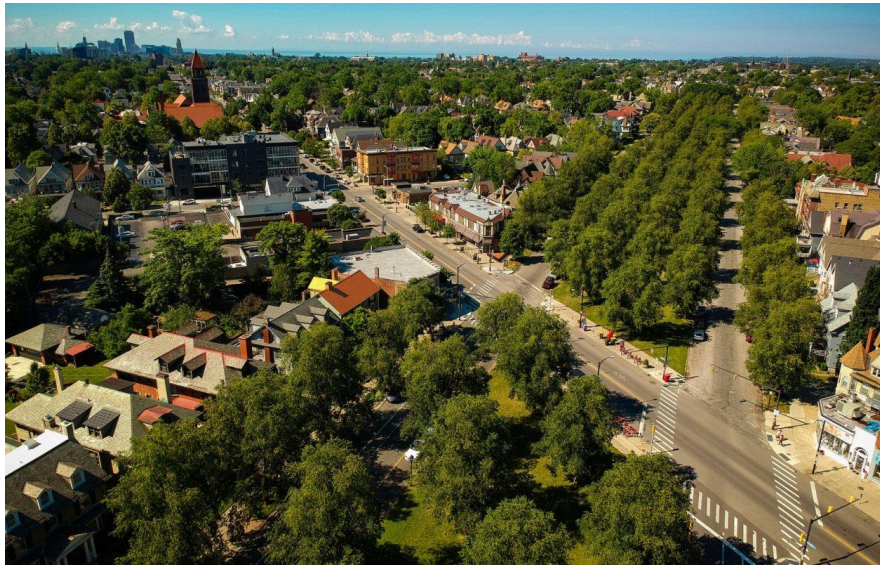


Figure 1: Rod Watson: Will ‘city of good neighbors’ only want rich people next door

For purposes of economic and fiscal analysis, the TIF proposal is sub-divided into four activities or projects:

- Project 1: Rehabilitation of Existing Properties. This includes the aesthetic and structural improvements to existing properties, demolition and the rehousing of displaced residents, rehab of commercial properties, parks, and recreation.
- Project 2: Construction of New Homes.
- Project 3: Construction of the Social and Commercial District, including apartments and senior residences.
- Project 4: Restoration of Streets, Sidewalks, and Sewers.

These projects should be carried out concurrently in a phased geographic manner with street-by-street improvement across the Fruit Belt, beginning with the area closest to the Medical

Campus. The results are reported here for census tracts within the City of Buffalo, highlighting the findings for the tracts adjacent to the Fruit Belt (Henry L. Taylor, 2004).

Case Study 2: Adams County Fruit Belt, c. 1875-1960

The Adams County Fruit Belt consists of a 4-6 mile wide swath of land extending along the east slope of South Mountain and including major portions of Latimore, Huntington, Tyrone, Menallen, Butler, Franklin, and Hamiltonban Townships. Within the county, the fruit belt occupies the northern and western townships.



Figure 2: Mercersburg Academy Photo – Mercersburg Academy’s campus

The idea of a “farming system” opens the way to a more comprehensive and accurate interpretation of the historic rural Pennsylvania landscape (Diehl, 2012). Even by the early nineteenth century, it was known that northern and western Adams County enjoyed special conditions favorable to tree-fruit culture: sloping land (to promote cold-air drainage), suitable soils, and protected sites.

However, the Adams County fruit belt itself did not develop until late Adams County Fruit Belt, c. 1875-1960



Figure 3: Young and middle-aged orchards, Arendtsville vicinity, 2009.

Case Study 3: Southern Ontario's Greenbelt

The Toronto and Hamilton Metropolitan Areas are one of the fastest growing regions in North America, with the annual population increase exceeding 1.5% between 1996 and 2001 (Felix Fung and Tenley Conway, 2008). The Greenbelt Act is not the first provincial attempt to establish a greenbelt in southern Ontario. The Protected Countryside is comprised of an agricultural system, a natural system, and a system of settlement areas. The natural system incorporates land supporting natural heritage and water resource protection while creating connections to other natural systems in southern Ontario.

Key policies of the greenbelt plan (Felix Fung and Tenley Conway, 2008):

1. Prime agricultural areas cannot be re-designated in municipal official plans for non-agricultural uses.
2. New multiple units or lots for permanent residential dwellings are not permitted on lands classified as rural areas.
3. New development or site alteration in the natural heritage system must demonstrate that there will be no negative effects on the ecological functions of the feature, that connectivity between key natural heritage and key hydrologic features is maintained, and that the removal of other natural features not identified as key natural heritage and key hydrologic features (such as hedgerows) will be kept to a minimum.
4. New and expanding infrastructure should avoid key natural heritage or key hydrologic features unless it has been established that no alternative exists.

2.9 Urban greenery and valuing ecosystem services in urban areas

Urban greenery as a process, approach, and a concept are synonymous with urban green space, urban green infrastructure (UGI), urban natural vegetation and organized open space. All are geared towards livable and sustainable human settlement (Solomon D., et al., 2017). In West Africa, urban forestry practices that have contributed to improvement in food security include the collection of wild edible plants, planting of fruit-bearing street trees and establishment multifunctional parks or medicinal public parks (Joseph A. Fuwape, Jonathan C. Onyekwelu, 2011). Urban forests have played important roles in social, cultural, economic and environmental development of urban centers in West Africa through benefits such as landscape enhancement, provision of recreational and cultural facilities, erosion control, watershed protection and supply of fruits and fuelwood (Joseph A. Fuwape, Jonathan C. Onyekwelu, 2011).

Ecosystem services are defined as benefits that humans obtain from ecosystem functions or as direct and indirect contributions from ecosystems to human well-being, such as clean air, food, water filtration, flood prevention, noise reduction, recreation, climate regulation, and nature education. The value of biodiversity and ecosystem services need to be integrated into urban decision making in order to enhance urban resilience, health, and quality of life while reducing the ecological footprint of cities and saving costs. Advancing the understanding of the multiple values of urban ecosystem services is essential for their integration in urban planning and moving towards more sustainable and resilient cities. The provision of ecosystem services in cities depends on the quality and quantity of urban green infrastructure.

2.10 Green infrastructure and Urban Ecological systems

The term GI is the network of natural landscape assets which underpin the: economic, socio-cultural, environmental functionality of our cities and towns. The concept of GI has emerged internationally as a way of understanding how green assets and ecological systems function as part of the infrastructural fabric that supports and sustains society (Philip Harrison, et al., 2014). GI refers to the interconnected set of natural and man-made ecological systems, green spaces and other landscape features. GI is the network of natural and semi-natural features, green

spaces, rivers, and lakes that intersperse and connect villages, towns, and cities. Individually, these elements are green infrastructure assets, and the roles that these assets play are green infrastructure functions (Illman, 2013). GI includes parks, gardens, urban allotments, urban forests, wetlands, lakes, and ponds in cities, but also the natural areas such as forests, mountains, and wetlands surrounding urban spaces. Therefore, those place must be planted by productive trees and vegetation type for social, economic and environmental development and the places were given multi-purpose such as food production, recreation, job opportunity, environmental protection, and pollution reduction.

A network of green spaces which provide life support functions including food, fiber, air to breathe, places for nature and places for recreation (England, 2010).

The fruit belt development in this context is to hit the whole environmental parameters for social change in the form of common fate. And taken as an input for green infrastructure with addressing of community demand in the city. Rainwater is soft, which means less detergent is used and released into the environment. Also, rainwater harvesting systems (RWHS) with a connected vaporization system can raise site humidity and create a healthier microclimate (ABC, 2015). Water harvesting is compulsory for a fruit belt city development with different mechanisms.

RWH is a technique to collect and store runoff that could provide water for livestock, domestic use or small scale irrigation (Saskia Deborah, Alemayehu Muluneh, and Maaik Hartog, 2012).

2.11 Green streets

Green streets such as Park Avenue, Ocean Parkway, and Eastern Parkway are landscaped traffic islands and medians, some of which could be suitable for fruit tree cultivation (New York State Energy Research and Development Authority, 2013). The major issue with converting green streets for food production is access and pollution. On busy thoroughfares, accessing the medians could pose a safety hazard. Unless any agricultural activity taking place in such spaces are designed to be completely open to the public for participation and harvesting (and potential vandalism), access would have to be restricted, which is contrary to the spirit of the program.

2.12 Community Orchards

Community orchards are a newer concept, particularly for urban areas, but are growing in popularity. An orchard is a grouping of fruit trees (Brodhead, 2009).

A community orchard “should be open and accessible at all times... As well as enjoying the place, local people can share the harvest or profit from its sale, taking responsibility for any work in the orchard.” In urban areas where food security is an issue community orchards act as both an excellent source of food, and an awareness builder of food security in the community. They are also very conducive to complementing other green space initiatives.

2.13 Theoretical planning framework and sustainable development

The evolution of twentieth-century urban space can be traced predominately by studying the Garden City movement and the paradigm of Modernism – Functionalism, Post Modernism and Sustainable Development. The ultimate aim of sustainable development is to leave to future generations a stock of natural capital that equals or even exceeds our own inheritance (e.g. an effective ozone layer, clean air, fresh water, a clean sea, fertile land, and diversity of species) (ERDF, 2016).

The sustainable city is (ERDF, 2016):

- A Just City: fairly distribution of justice, food, shelter, education, health; participation in government
- A Beautiful City: art, architecture, and landscape spark the imagination.
- A Creative City: open-mindedness and experimentation..; fast response to change
- An Ecological City: balanced landscape and build development, resource-efficient infrastructures
- A City of Easy Contact: A public realm to encourage community; face-to-face and electronic information
- A Compact and Polycentric City: dense urban structure, maximizes proximity, protects the countryside
- A Diverse City: overlapping activities create animation, inspiration and foster vital public life.

2.13.1 Policy, legislation, and regulation

The Federal Democratic Republic of Ethiopia included the protection of public health in the 1995 National Constitution. The Article 90.1 states that “to the extent the country’s resources permit, policies shall aim to provide all Ethiopians access to public health and education, clean water, housing, food and social security” (Veses, 2016). Since that time, several documents have been redacted to guide the implementation of national policies regarding water and sanitation (Wash) developed by the government.

The main ones are listed as follows:

- Ethiopian Water Resource Management Policy (1999).
- Universal Access Plan for Water and Sanitation (2005).
- National Sanitation and Hygiene Strategy (2005).
- National Protocol for Hygiene and “On-Site” Sanitation (NPHOSS) (2006).
- Needs Assessment to Achieve Universal Access to Improved Hygiene and Sanitation by 2012 (2007).
- National Sanitation and Hygiene Implementation Guideline (2011).
- Urban Sanitation Universal Access Plan (2011).
- One Wash National Program (OWNP) (2013).
- National Sanitation Marketing Guidelines (2014).

The Ethiopian Water Resource Management Policy (EWRMP) developed in 1999 by the Ministry of Water Resources, currently, the Ministry of Water, Irrigation and Energy (MoWIE), aimed to promote the development of adequate management of water resources in Ethiopia to contribute to the accelerated economic growth of the country.

The Ministry of Water, Irrigation, and Energy (MoWIE) is responsible for water policy, coordination and monitoring whereas the Ministry of Education (MoE) tries to build an education and training system which assures quality and equity education. The Ministry of Finance and Economic Development (MoFED) is responsible for budgeting and managing economic resources in both federal and regional governments (Veses, 2016).

2.13.2 LDP in the Context of Ethiopian Urban Planning System.

In the Ethiopian Urban Planning System, the local development plan (LDP) may be conceived as a detailed urban development plan of a locality or neighborhood or part of an urban center. It is a major tool through which structural plan (SP) is implemented and may have a life span not exceeding that of the SP.

LDPs have two major objectives (Bekele, 2009):

1. To guide a long term development of a locality by providing tools such as building permit procedures; design guidelines and brief;
2. To facilitate efficient and effective implementation of projects such as city center business development, real estate projects, etc. by providing detailed land use and urban design proposals.

2.13.3 Local Practices

The practice of LDP evolved as a distinct planning component during the Addis Ababa Master Plan Revision process (1998 – 2002). Since then, this planning component has been considered as an important planning tool and is practiced in few urban centers, namely, Addis Ababa, Adama, Dessie, Dire Dawa and Mekele (Bekele, 2009).

3. CHAPTER THREE

3 Methodology

3.1 Study area and project description

The study area is located in the Oromiya region, East Shewa Zone, Bishoftu city. Bishoftu is located 47.9kms (29.8 mi) southeast of Addis Ababa along its route 4 highway and has an elevation of 1,920 meters (6,300 ft.). A name of Bishoftu is derived from Afan Oromo which means “*the land of Lakes*”. Its astronomical location is 8° 43’- 8° 45’ North Latitude & 38° 56’- 39° 01’ East Longitude. The study was focused on planning and design of fruit belt neighborhood development using rainwater harvesting and recycling of wastewater, their function, and the development of greenway to have a quality environment and attractive cities and beautiful fruit belt neighborhood in Bishoftu Town. The area coverage of the selected site is around 260 hectares and suitable for fruit belt development.

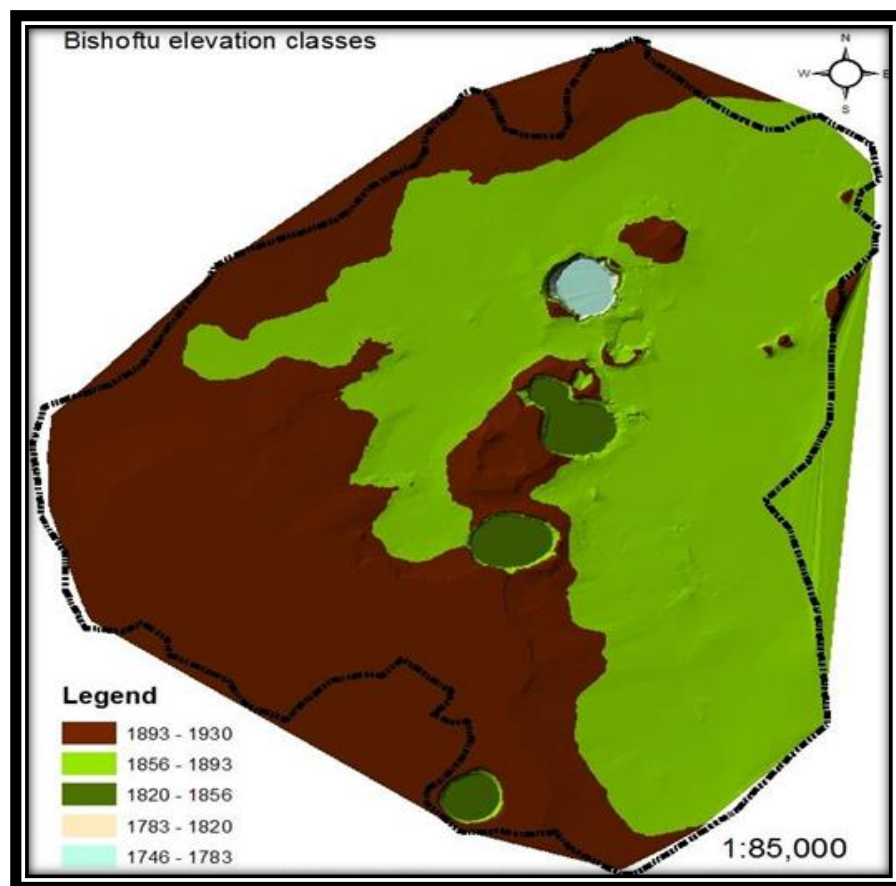
The study would be established on, 260-hectare using rainwater harvesting and partially recycling of wastewater for fruit belt neighborhood design and shrubs development with an improvement of social, economic and environmental quality.

The study is included different parts in addition to neighborhood standards such as water harvesting planning, open space and urban design structure with an analysis of watershed and new land use planning related to for fruit belt development and incorporating peri-urban agriculture. Fruit belt is opening up a diverse development and its processes of economic growth and positive opportunity. Fruit belt development is also part of the ecosystem through the form of ecosystem service to get more benefit than usual economic status and ecosystem function by providing suitable places. Ecosystem development is the interaction of the organism with an environment that is important to calm our environment and to keep its biodiversity in the Town.

3.3 Topographic feature

Its topography is undulating and characterized by flat land on the north and east parts of the city, locked by several lakes, while the south is dominated by hills (BCP, 2015). The geographical area of the city is about 15,273 ha, and it lies at an altitude in the range of 1900 m. to 1995 m.

The greatest proportion of the altitude of the town ranges between 1893 to 1930 meters and almost covers western, northern, and southwestern parts of the town (Daniel W/Gebriel, Melesse Firdissa and Habtamu Legese, 2012). The site is located on the west side that has the greatest altitude as per the city of Bishoftu map. Refer to map 1.



Source: clipped from Ethio_DEM by overlaying base map of Bishoftu town



Figure 5: Selected area of contour map from the whole map of Bishoftu

3.3.1 Slope Analysis

There is a slight slope different in the selected site that is almost flat related to the city topography. In fact, the site is located in the highest altitude with relative to the whole city land topography. The largest slope class of selected site ranges between 0-2percent. This slope class occupies an area of 240 hectares of land (92.3%) from 260 hectares.

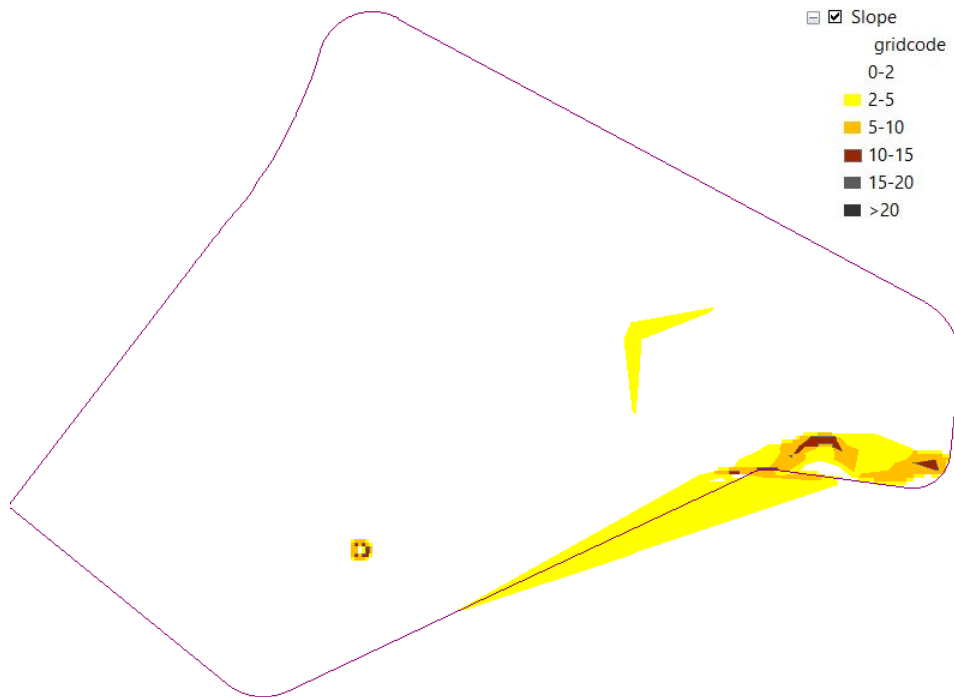


Figure 6: Slope analysis map

3.3.2 Drainage

Surface flow direction is determined by topographic features, nature of the soil, vegetation cover and human-made impacts. Seasonal streams flow from northern direction and south direction into the central part of the selected site (some draining to the gorge) and then flow to northeast direction. Similarly, surface runoff from southwestern parts of the selected site flows to southeast direction. The map contour and slope below shows that the drain flows of surface water from the northwest, southeast to northeast direction. And the overflow direction of reservoir and stormwater goes to Lake Chileleka.

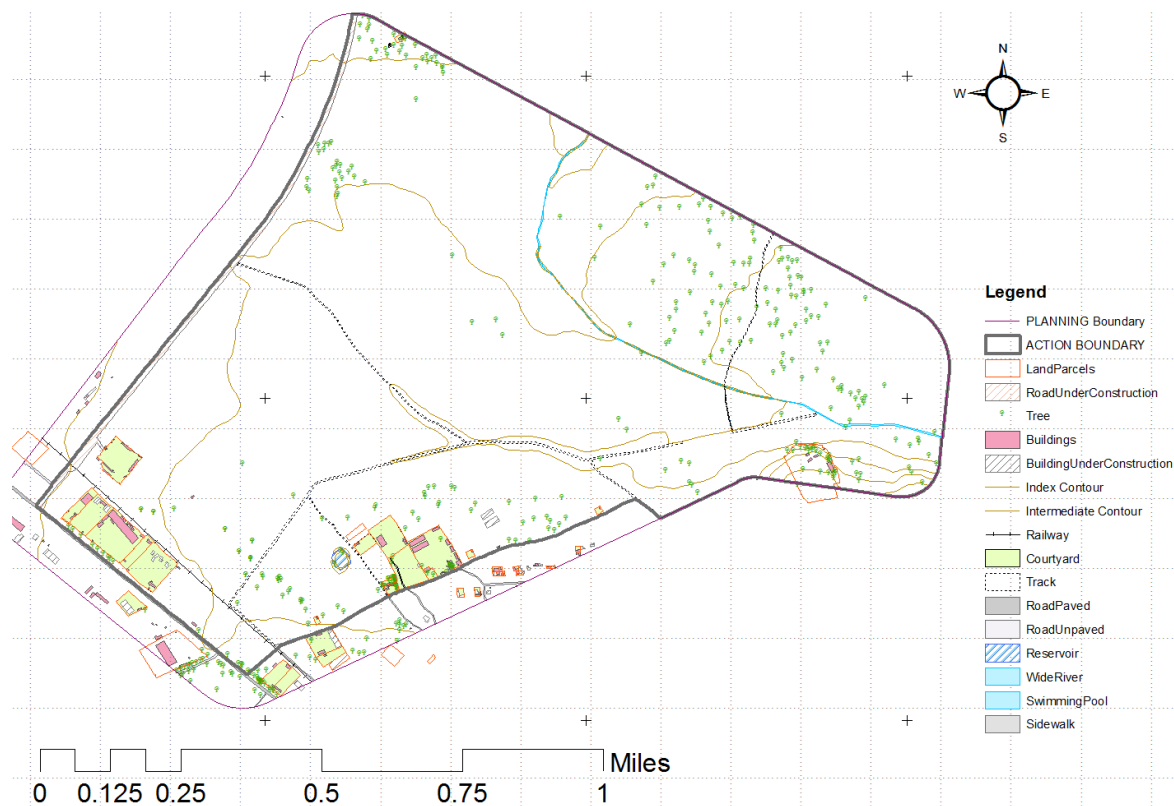


Figure 7: contour and drainage flow

3.4 Climate

Climate is one of the prominent factors that influence the activities of people either directly or indirectly. The elements of climate include temperature, rainfall, and wind. It is mainly the altitude that makes the climate to vary from place to place. The climate of the city, in general, belongs to Woina Dega (Agro-climatic zone). The Maximum annual temperature is 26.25 °C and the Minimum is 11.18°C. The annual average rainfall of the city is 762 mm.

April is the hottest month of the year (31.1⁰C), while December is the coldest month (7.6⁰C). December is the driest months, while August is the rainy month (209.9mm) of the year. The highest wind speed is registered in March (2.24m/s) and the most common wind direction seen in the city is easterlies the data was obtained from the National Meteorological Agency (NMA).

3.4.1 Temperature

The temperature in Bishoftu varies so little throughout the year that it is not entirely meaningful to discuss hot and cold seasons.

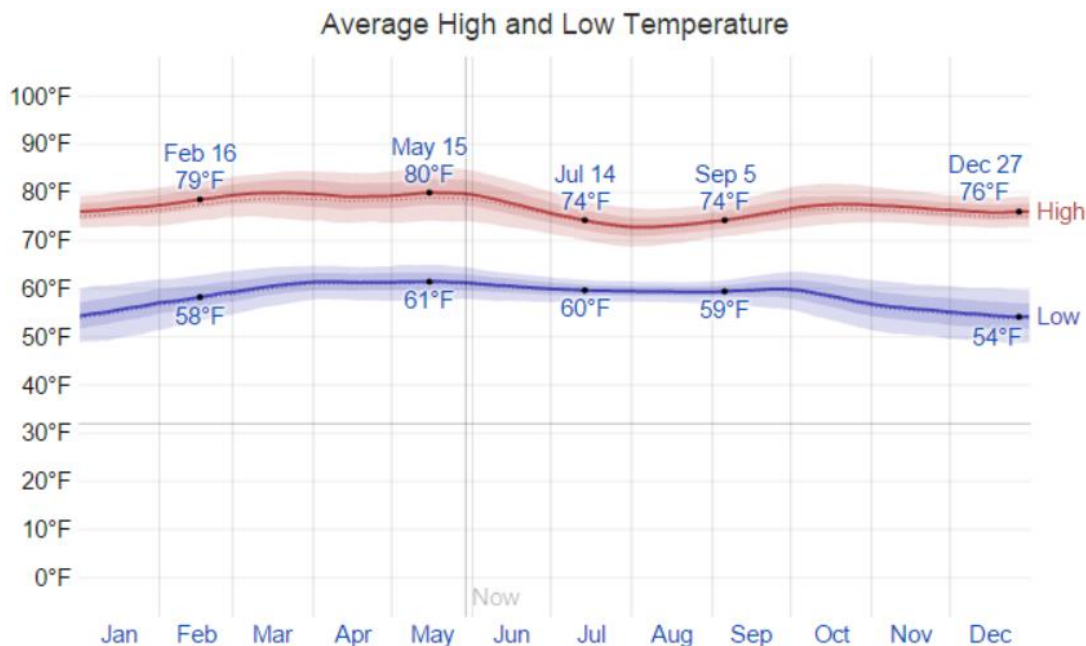


Figure 8: Average high and low temperature

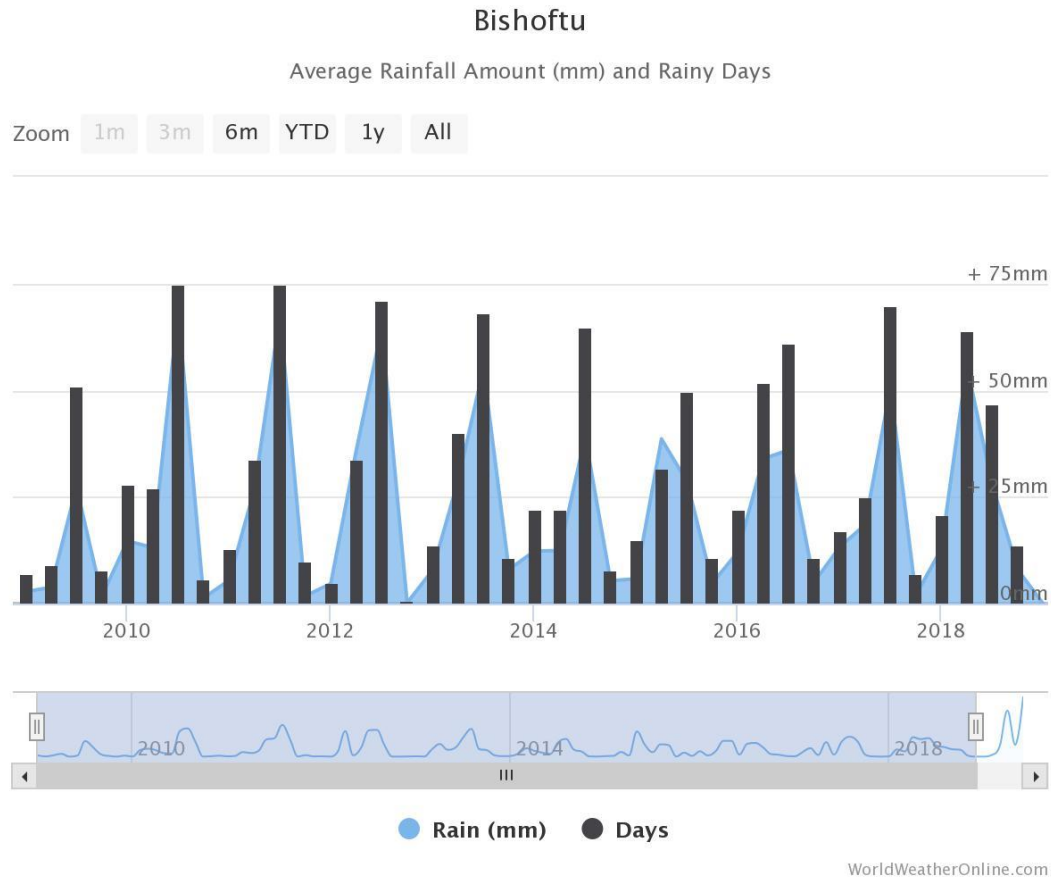
The daily average high (red line) and low (blue line) temperature, with 25th to 75th and 10th to 90th percentile bands. The thin dotted lines are the corresponding average perceived temperatures.

3.4.2 Rainfall

To show variation within the months and not just the monthly totals, the rainfall accumulated over a sliding 31-day period centered on each day of the year. Bishoftu experiences extreme seasonal variation in monthly rainfall.

The rainy period of the year lasts for 9.2 months, from January 27 to November 3, with a sliding 31-day rainfall of at least 0.5 inches. The most rain falls during the 31 days centered on August

4, with an average total accumulation of 6.3 inches. The rainless period of the year lasts for 2.8 months, from November 3 to January 27. The least rain falls around December 17, with an average total accumulation of 0.2 inches.



Source: NMA (National Metrology Agency)

Figure 9: average monthly rainfall

The average rainfall (solid line) accumulated over the course of a sliding 31-day period centered on the day in question, with 25th to 75th and 10th to 90th percentile bands. The thin dotted line is the corresponding average liquid-equivalent snowfall.

Analysis of average annual rainfall of Bishoftu in (mm)

year	Jan	Feb	Mar	April	may	June	July	August	Sep	Oct	Nov	Dec	sum	Ave/year
2009	0.11	0.14	17.76	33.81	136.08	163.42	118.82	39.52	39.11	1.96	0.28	0	551.01	45.9175
2010	0	0.31	0	0.65	95.36	71	93.47	159.68	174.71	169.31	59.6	2.91	827	68.91667
2011	0.81	1.23	2.1	13.08	147.4	317.21	125.46	139.74	184.91	209.68	17.27	0.45	1159.34	96.61167
2012	0.35	0	0.05	15.93	205.22	226.43	197.25	177.07	170.91	127.71	74.19	0.17	1195.28	99.60667
2013	0	0	2.48	2.93	167.86	213.8	152.16	180.65	144.7	154.56	73.43	0	1092.57	91.0475
2014	0	1.14	113.16	126.63	265.06	258	168.85	161.24	167.54	225.15	35.81	0	1522.58	126.8817
2015	0	0.66	30.69	37.2	194.05	265.22	277.54	239.14	301.66	236.16	6.12	0.01	1588.45	132.3708
2016	0	0	27.53	26.12	140.16	179.96	212.31	256.14	136.84	120.83	4.88	0.05	1104.82	92.06833
2017	0	0.7	4.46	41.88	194.82	158.36	216.16	231.97	163.61	77.66	2.75	0	1092.37	91.03083
2018	0	0.89	13.6	8.83	135.02	182.25	196.3	126.72	213.3	64.8	2.4	0	944.11	78.67583

Source: NMA (National Metrology Agency)

The total sum of 10 years annual rainfall is 923.13mm and its total average is 92.31mm

This data analysis is important for rainwater harvesting calculation.

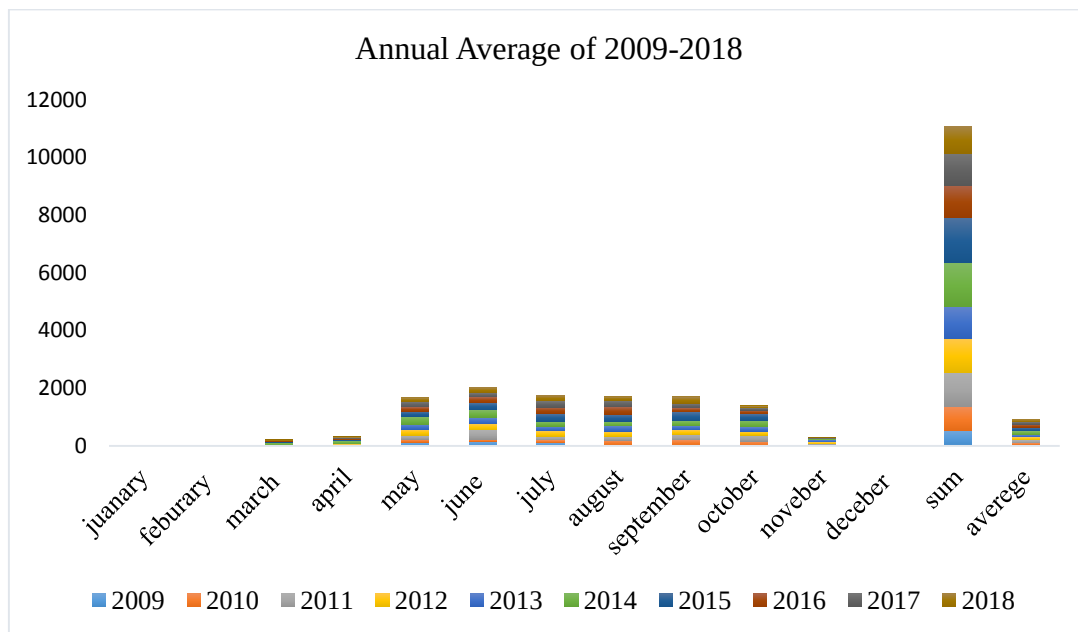


Figure 10: Analysis of 10 years of annual rainfall

3.4.3 Humidity

The perceived humidity level in Bishoftu, as measured by the percentage of time in which the humidity comfort level is muggy, oppressive, or miserable, does not vary significantly over the course of the year, remaining a virtually constant 0% throughout.

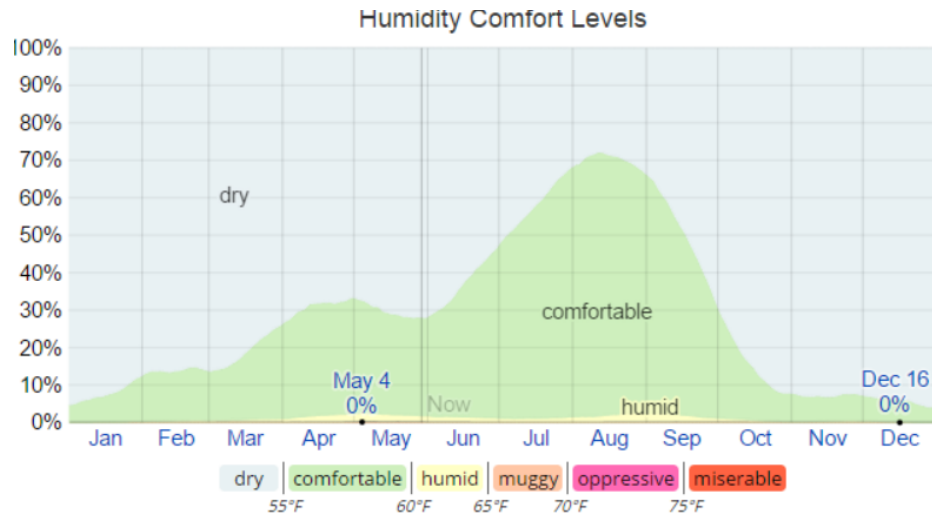


Figure 11: humidity comfort level

3.5 EIA in Ethiopia

EIA was first introduced in Ethiopia through Proclamation No.299/2002 (Government of Ethiopia [GoE], 2002b), and entered into force in 2002 following the incorporation of environmental issues under Articles 43 and 92 of the 1995 constitution of the country, regulating the “environmental right” and “environmental objective,” respectively (GoE, 1995a), and after the establishment of the country’s EPA in 1995 (GoE, 1995b), and the formulation of the EPE in 1997 (Environmental Protection Authority [EPA], 1997). The goal of Proclamation No. 299/2002, the EIA Proclamation, is to avoid the adverse environmental impacts of projects related to certain activities that are likely to have significant impacts on the environment (GoE, 2002b) (Worku, 2017).

3.5.1 Biological Environment

A. Impacts on terrestrial fauna

As the project area does not contain forest, there is no forest as habitat for wild animals. The project site area is bare land that proposed for urban expansion and taken as a neighborhood site in this research for fruit belt development with integration of neighborhood design by harvesting of rainwater and treating of wastewater for renewable woodland development such as bamboo and other non-edible trees. The project will be suitable for wildlife habitats, and not disrupt habitat use patterns of the wild animals and aquifers in different aspects.

B. Impacts on terrestrial flora

The project activities that will affect the vegetation and the terrestrial habitats will include land clearing and leveling, building access roads and establishment of site facilities. When the project is implemented there would be a consequent change in the natural vegetation of the area. The present bush and grasslands will be changed to fruit and vegetable farms with indigenous trees that appear it.

3.5.2 Impacts on Socio-Economic Environment

A. Impacts on Households

Some houses are located within the boundary of the project site and protect it when to design and forecast this project. The householders would be productive when this project is implemented and adaptable in the city. In another way, the development of this fruit belt project may be affected that are common in the expansion of urban development when to proposed land use planning as a result of the project planning. The district administration will take the entire responsibility in relocating and compensate them. The futurity of the project is very worthwhile in multi-directional ways for society and the environment.

B. Loss of land under various land use types

The reservoir place is sunken land and gorge that passes on the project site and to be proposed as a reservoir as per project uses water from boreholes. Hence the reservoir area will be substantial for this project features and gives multi-purpose. However, there will be proposed sufficient land use plan to be utilized for fruit belt development and vegetable farm. The total area of land under the boundary delineated for the project area is about 260 hectares with the keeping of neighborhood land use stocks and a new concept of fruit belt considerations. At the time of the inception of the project, the land use planning is included fruit land as planning and covered by fruit trees and some other woodland place. Therefore, changing this area into an intensive agricultural land does not affect neighborhood design or urban standards.

C. Soil Erosion and Land Degradation

In the neighborhood soil erosion and land degradation are major problems but the extent and its severity vary from place to place. Considering natural/normal erosion highlands with steep slopes are more exposed to erosion than the nearly level and rolling topography of the hinterland. But, the site of this fruit belt planning area is almost all flat and suitable places. However, due

to accelerated erosion-man induced: population pressure, widespread and sometimes inappropriate cultivation, overgrazing, deforestation, and loss of vegetation cover resulted in severe soil erosion and land degradation in plain areas of the hinterland. This project is an important input to rehabilitate our environment and social developments.

D. Soil characterizations of Bishoftu city

The physical and chemical analysis made in the laboratory of Bishoftu Agricultural Research Center shows that the soil type in Bishoftu area is dark clay and very dark gray clay with high organic content and hence, good agricultural potential (Institute, 2003). It is very suitable for fruits and edible vegetation. The black clay soil has expansive nature that swells when wet and shrinks when dry and hence, not good for engineering construction activities.

3.5.3 Water assessment of Bishoftu

A. Groundwater Conditions and Movements in Bishoftu Area

The flow direction of groundwater around Bishoftu is towards north and northwest in the same direction with surface drainage (Institute, 2003). Groundwater potential is identified on the north and northwest of the town known as Dambi and Qurqura along the extensive flat surface of Cheleleka. Shumbura Meda and Garbi where the existing wells are located at present are also good potential areas.

B. Groundwater Hydrology

The hydrogeological characteristics of the Bishoftu area can be described based upon the geologic, topographic and climatic conditions of the interest area. According to the study on aquifer characteristics of different rock units on the Hydrogeology of Ethiopia (Institute, 2003), the rock units that form Bishoftu area are classified as rocks of moderate to high permeability and productivity in general. Therefore, the high aquifer permeability and productivity characteristics indicate that there is high groundwater potential around Bishoftu.

3.5.4 Species assessment and selection

Important in shaping these spaces is the selection of species to include in the neighborhood. Precedence in selecting fruit trees and plants has to be given to that physically enhance the air quality and food production with oxygen production, fine dust capturing and air pollutants filtering are the principal processes through which enhancing the physical environment.



Figure 12: Species assessment and selection

3.6 Data Collection

The study collected both qualitative and quantitative data on the assessment of the required information through document analysis, interviews, field observation, key informant interviews, and semi-structured questionnaires. And to use different separate tools to collect the data from the actual place and to use the net to look up rainfall data from the reliable and documented resource for fruit belt development. This is because data collection is the primary thing to exercise problem-solving research in a cost wise and environmentally friendly way. The question of fruit belt development is discussed in the context of adaptability and availability, now and the future.

Planning reports of the Town of Bishoftu were also used to assess planned developments and future agricultural centers and fruit production. The data gathered were arranged systematically, tabulated, processed, and graphed were analyzed using Microsoft Excel software as per the structured questionnaires.

3.6.1 Survey Method

Both direct and indirect approach questions were used with the help of structured surveys and unstructured surveys. The structured survey contained suitability of soil types, adaptability of fruit trees and vegetation's, preferable place to plant it, and other reliable documented data were included. The other survey methods were used to gather the information that adds for the physical observations and assessment of project site using GIS and AutoCAD to know the existing site. The interview and questionnaires help to measure the attitudes, perceptions, and motivation of people about fruit belt development using rainwater harvesting and partially wastewater recycling systems.

3.6.2 Sampling frame and units

The frame that was used to limit the number of sample and assessment study that is taken under consideration of the following points.

- Soil types and its suitability for fruit tree and edible vegetation development were assessed from reliable documented data, city and sub-city dwellers with both direct and indirect survey methods.

- The preferable places in the city or sub city were assessed for fruit trees and vegetation developments.
- The challenges of fruits and vegetable productions in the Town or sub-Town of Bishoftu were assessed with water availability, land availability and suitable places.
- The roles of fruit belt city development in Bishoftu Town and its effectiveness as a planning mechanism and feature sustainability.

3.6.3 Sampling size and sampling techniques

The sample size of the project area (action area) is 260 hectares and its planning area is 1206.8 hectares. The planning area is contained 617 householders exist and to take 200 householders from 617 to participant in the structured questionnaires, which is 32.4% of householders participated in this research. The participants were taken from different places in the Bishoftu city for this new concept of urban design with the incorporation of fruit belt development in Bishoftu sub-city. The study and planning of this thesis project focused on surface water flow to harvest it. The natural water flows to establishing of a comprehensive eco-landscape planning and suggesting of possible and suitable fruit trees and vegetation types in the selected action area with an assessment of suitable places, soil types, and roles of the project.

3.7 Data Analysis

The collected data were stored into Microsoft excel program for further analysis. ArcGIS was used to analyze the existing site features, which are slope analysis, contour, and watershed analysis that helps to design and planning of fruit belt development in the Town of Bishoftu, Ethiopia. Summarized data was presented in the form of a map, graph, tables, and figures. The questionnaire survey data, obtained in this study were analyzed using descriptive statistics. The questionnaire result was synthesized and demonstrated that more important for social, environmental, economic and ecological balances when the design and planning of fruit belt development with the keeping of urban stocks is a vital role in all perspectives.

4. CHAPTER 4

4 Results

The result was synthesized and demonstrated that more important for social, environmental, economic and ecological balances when to design based on this thesis results. And to plan the fruit belt development with respect to urban stocks.

4.1 Questionnaire survey

4.1.1 Demographic breakdown

Table 3: Gender distribution of respondents

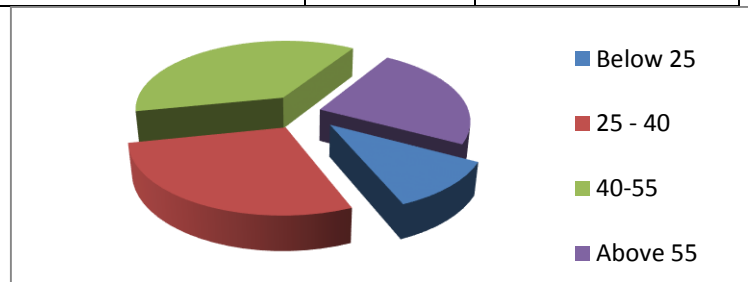
sex Female 41% Male 59% Gender distribution of respondents			
No	Sex	NO	%
1	Male	118	59
2	Female	82	41

Gender distribution of respondents

The sample size has been determined to be (N=200, 40%) from forecasting of (N=500, 100%) households as per the socio-economic study. Accordingly, N= 200 samples were purposively selected from the city dwellers; the sample size from households constitutes (N=118, 59%) male and (N=82, 41%) female. In this study, women can play a crucial role and understanding of the existing problems and feature benefits in actor's collaboration towards fruit belt city development of Bishoftu sub-city at Ganadaa Qurqura Kebele as a neighborhood design.

Table 4: Age distribution of respondents

No	respondent	Frequency	%
1	Below 25	22	11
2	25-40	48	24
3	40-55	74	37
4	Above 55	56	28
Total		200	100



Age distribution of respondents

Among the age distribution of the sample population, the majority of the respondent's age is from 40-55 which accounts for 37%. The second dominate respondent is above 55 age which accounts 28%. The third level respondent is among 25-40 which accounts for 24% and the last and lest respondent survey is below 25 which accounts 11%.

Table 5: Educational status of the participant

No	Educational statues	Respondent	Percent
1	primary	22	11
2	secondary	44	22
3	college/ university	89	44.5
4	no education	45	22.5
total		200	100

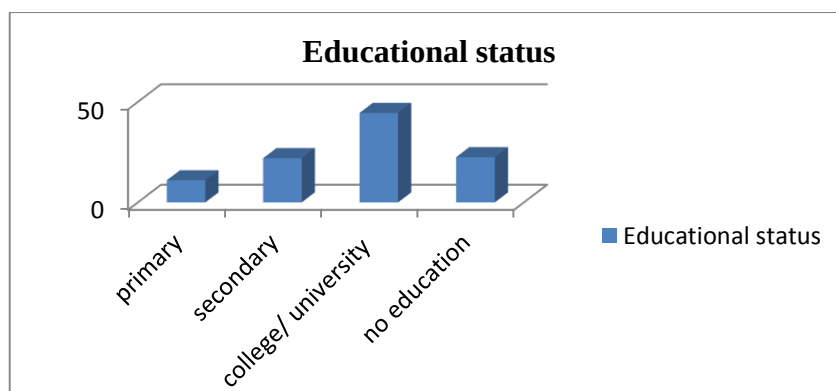


Figure 13: Educational status of the participant

As it is presented in table 3, the greater part of the educational qualification of the participants are

College/university which accounts (N=89, 44.5%) followed by less no educational accounting (N=45, 22.5%). The least participant is a secondary and primary school which accounts (N=44, 22%) and (N=22, 11%) respectively.

Table 6: Occupation stats of the participant

No		Respondent	%
1	Agricultural expert	52	26
2	Municipal expert	21	10.5
3	City dweller	25	12.5
4	Farmer	49	24.5
5	Trading	32	16
6	Governmental employee	19	9.5
7	others	2	1
Total		200	100

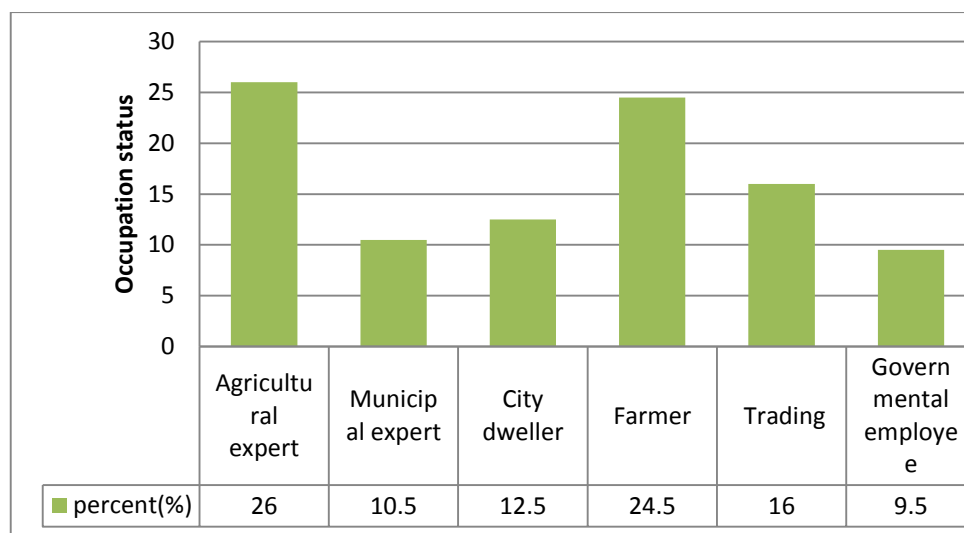


Figure 14: Occupational status of the respondent

The greater part of the occupation status of the sampled populations is agricultural experts those who covered about (N= 52, 26%) followed by farmers (N= 49, 24.5%). The survey finding also shows that occupation status of the population which run the trading participants are about (N= 32, 16%) city dweller, municipal expert, governmental employee, and others are (N= 25, 12.5%), (N= 21, 10.5%), (N= 19, 9.5%) and (N= 2, 1%) respectively. Here one can conclude that agricultural experts were more dominant respondents and they were given detail information about fruit tree and vegetation developments as per their performance. They can be an important transformative engine for the development of fruit belt city and fight against the environmental living environment.

4.1.2 Analysis of soil suitability

Table 7: Types of soil is suitable to plant fruit trees & vegetable in Bishoftu city

No		Respondent	%
1	Black soil	44	22
2	Semi-black	22	11
3	Ruddy soil	8	4
4	dark clay	58	29
5	dark grey clay	68	34
Total		200	100

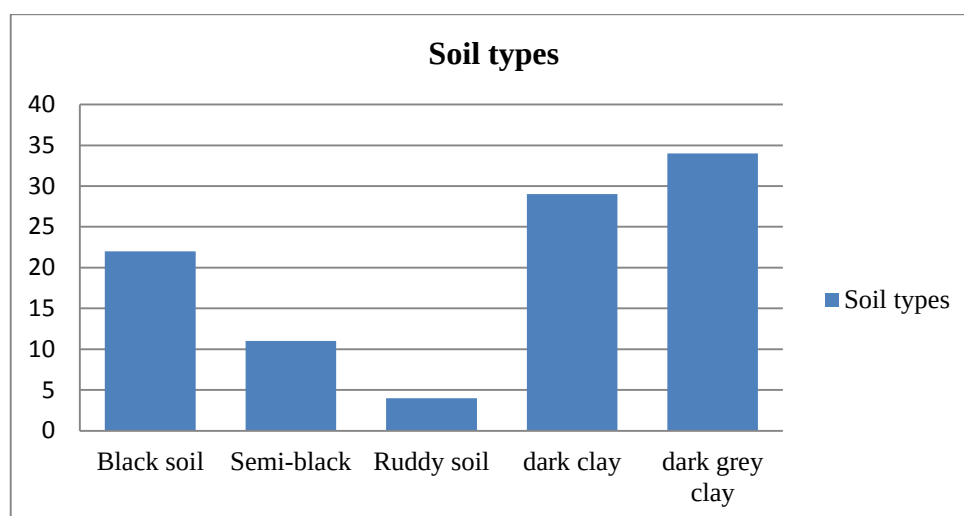


Figure 15: Soil type assessment

The suitability of soil types to plant fruit trees & vegetables in Bishoftu sub-city from questionnaire survey was presented in table 5, in addition to the physical and chemical analysis made in the laboratory of Bishoftu. The ministry of Bishoftu Agricultural Research center (MBARC) shows that the soil type in Bishoftu area is dark clay and very dark grey clay with high organic content and hence, good agricultural potential (Institute, 2003). The majority of the respondents were answered dark grey clay which accounts (N= 68, 34%), dark clay (N= 58, 29%), Black soil (N= 44, 22%), semi-black (N= 22, 11%) and the last and least result is ruddy soil which accounts (N= 8, 4%).

4.1.3 Analysis of suitable places to plant fruit trees and vegetation

Table 8: Where to plant fruit trees & vegetable in the city is preferable

NO		Respondent	%
1	Roadside	63	31.5
2	In each block round	50	25
3	Buffer zone.	77	38.5
4	Others	10	5
Total		200	100

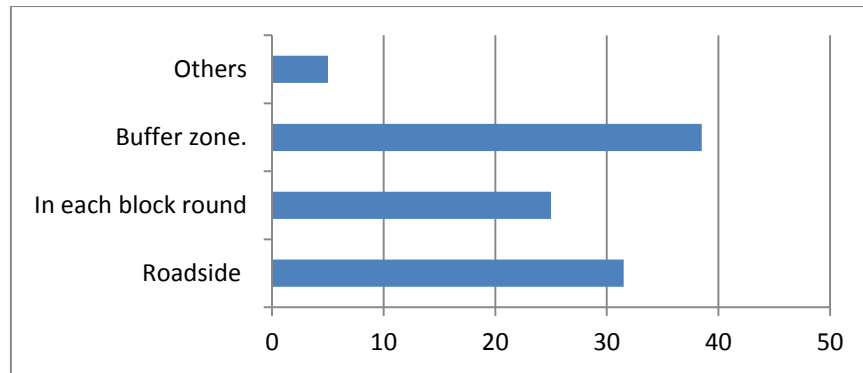


Figure 16: Preferable place assessment

The chart showed that buffer zone is the most suitable places to plant fruit trees and vegetation, which accounts (N= 77, 38.5%), roadside (N= 63, 31.5%), in each block round (N= 50, 25%), and others (N= 10, 5%).

4.1.4 Analysis of adaptable fruit types

Table 9: What kinds of fruit trees are being adaptable in Bishoftu city and there surrounding

No	Fruits	Respondent	%
1	Mango tree	48	24
2	Appletree	15	7.5
3	Banana	26	13
4	Avocado	42	21
5	Papaya	19	9.5
6	Orange	22	11
7	Cabbage tree (Shiferaw tree)	28	14
Total		200	100

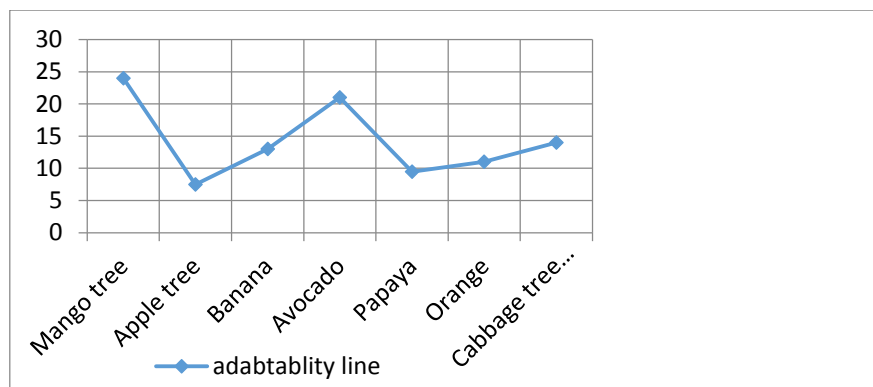


Figure 17: Types of adaptable fruit trees

The figure demonstrated that mango tree was the most adaptable fruit types in Bishouftu city, which accounts (N= 48, 24%), and the second adaptable fruit types was avocado as per the assessment of the participants depending on the structured questionnaires, which accounts (N= 42, 21%), the others were Cabbage tree (Shiferaw tree) (N= 28, 14%), banana (N=26, 13%), orange (N= 22, 11%), papaya (N= 19, 9.5%) and apple (N= 15, 7.5%). According to this data analysis to mix it as per the result of data and to plant it in the proposed project plan when to implement this thesis project.

Table 10: kinds of vegetables are being produced in Bishoftu city and their surroundings

No	Fruits	Respondent	%
1	Beetroot	31	15.5
2	Potatoes	43	21.5
3	Cabbage	54	27
4	Chillies	17	8.5
5	Onions	21	10.5
6	Tomatoes	25	12.5
7	Other	9	4.5
Total		200	100

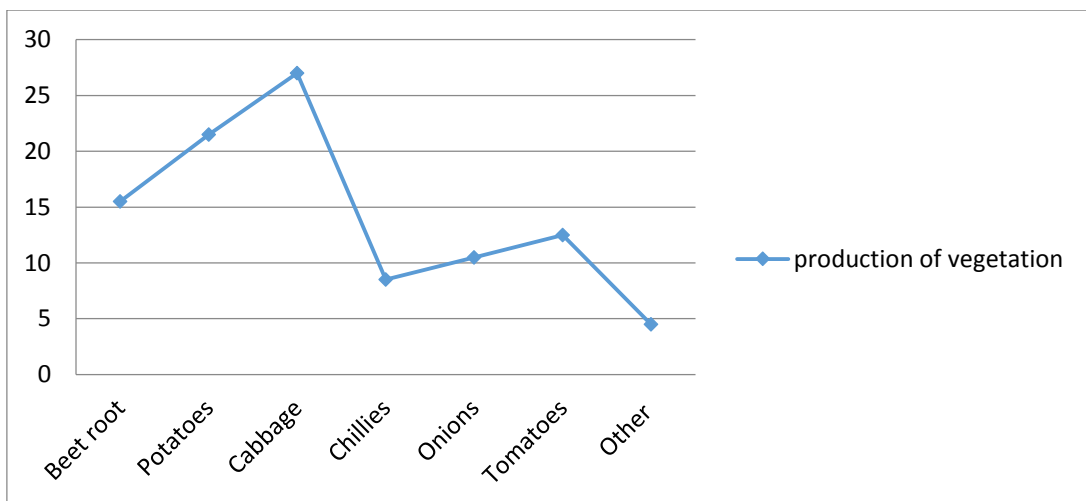


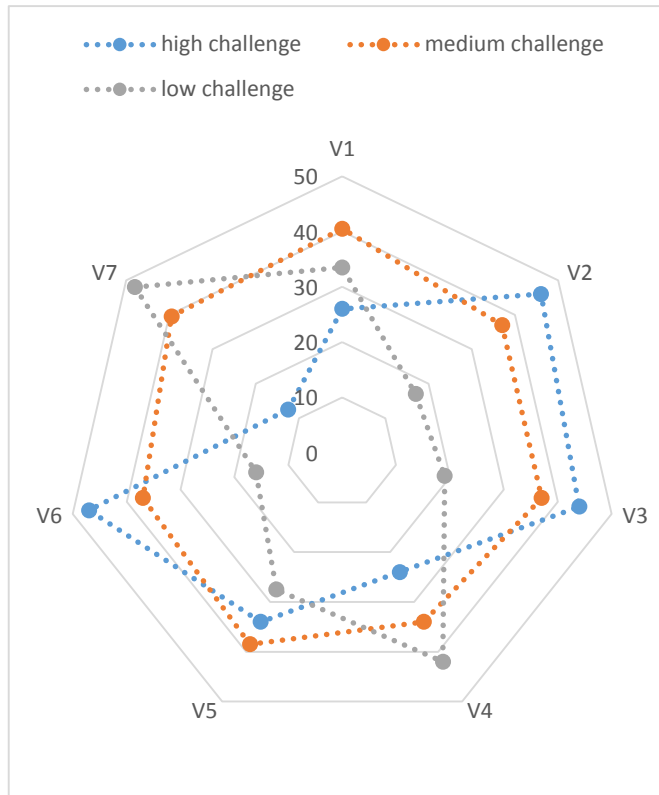
Figure 18: Assessment of vegetables being produced in Bishoftu city

The figure demonstrated that the more being produced vegetables in Bishoftu city were cabbages, which accounts (N= 54, 27%) followed by potatoes which accounts (N= 43, 21.5%) and others were beetroot, tomatoes, onion, chillies, and others, which accounts (N= 31, 15.5%), (N= 25, 12.5%), (N= 21, 10.5%), (N= 17, 8.5%), and (N= 9, 4.5%) respectively. Therefore, due to this data analysis result to plan and will implement when to vegetate the proposed planning program with respect to environmental and economic features in the city.

4.1.5 Analysis of challenges to produce fruits and vegetation's

Table 11: Challenges of fruits and vegetable productions in the city or sub-city of Bishoftu (Rank your answer according to importance; 1, 2, 3) 1 is a high challenge.

No	variables	high	%	medium	%	low	%	total	total %
1	V1	52	26	81	40.5	67	33.5	200	100
2	V2	92	46	74	37	34	17	200	100
3	V3	88	44	74	37	38	19	200	100
4	V4	48	24	68	34	84	42	200	100
5	V5	68	34	77	38.5	55	27.5	200	100
6	V6	94	47	74	37	32	16	200	100
7	V7	25	12.5	79	39.5	96	48	200	100



Note: Challenges of fruits and vegetable productions in the city or sub-city of Bishoftu.

V1. Lack of fruits &Vegetable source to plant it

V2. Lack of organized information to plant it in the city

V3. Government regulation

V4. Land availability

V5. Water access and supply

V6. Lack of planning system

V7. Others

Figure 19: Challenges of fruits and vegetable productions

The result shows that lack of fruits and vegetable source to plant it(V1) was low challenges its ordered values were medium, low, and high ordered values from the assessment of field survey study, which accounts (N= 81, 40.5%), (N= 67, 33.5%), and (N= 52, 26%) respectively. The data analysis of fruit production challenges demonstrated that lack of planning system (V6) had high challenged, its result was high, medium, and low challenges from the assessment of field survey study, which accounts (N= 94, 47%), (N= 77, 38.5%), and (N= 32, 16%) respectively. Hence, the planning system must be focused on space allocation according to the assessment of structured field survey and interviews to achieve fruit belt city development. As the whole assessment demonstrated that lack of planning system (V6), lack of organized information to plant it in the city, and government regulation were challenged issues to forecast fruit belt city development in Bishoftu, Ethiopia. Water access and supply, land availability and others were medium challenges when to develop fruit belt sub-city and again lack of fruits and vegetable source to plant it (V1) had low challenges according to data inventory and analysis.

4.1.6 Analysis of fruit belt development roles

Table 12: what are the roles of fruit belt city development in Bishoftu sub-city and its effectiveness as a planning mechanism? (Rank your answer according to agreement and importance: strongly agree, agree, and disagree).

No	variables	Strongly agree	%	Agree	%	Disagree	%	total	total %
1	V1	52	26	67	33.5	81	40.5	200	100
2	V2	49	24.5	60	30	91	45.5	200	100
3	V3	91	45.5	71	35.5	38	19	200	100
4	V4	96	48	72	36	32	16	200	100
5	V5	89	44.5	78	39	33	16.5	200	100

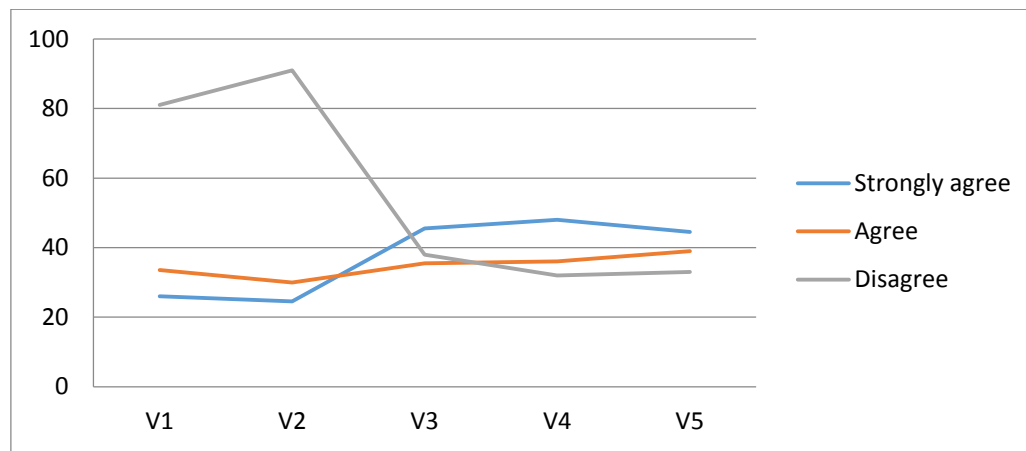


Figure 20: Roles of fruit belt city development in Bishoftu sub-city and its effectiveness as a planning mechanism

Note 1: Depends on its role in environmental management

V1. Does the fruit belt designation impact on the management of land in the urban fringe?

V2. Have the land use objectives for fruit belt land encouraged positive land management?

V3. Does the fruit belt development preventing degradation of land in the urban fringe and maximizing the productivity of land and the benefits to people?

Note 2: Depend on its effectiveness as a planning mechanism.

V4. Does fruit belt, as a planning designation, support sustainability by encouraging urban regeneration and concentration of homes, services, and employment opportunities?

V5. Are other tools, such as strategic gaps and green wedges, more effective at creating a sustainable urban form?

From the total 200 householder surveyed data analysis of designation impact on management of land in the urban fringe (V1) shows that the more disagree which accounts (N= 81, 40.5%) and on the objective of land management for fruit belt development encouraged positive land values(V2) demonstrated that the more agree to encourage a positive land management, which accounts (N= 91, 45.5) due to this surveyed analysis to plan a fruit belt development had a positive land values when to plan it in an eco-effective ways. V3, V4, and V5 demonstrated that as shown in the above graph the fruit belt sub-city development would prevent degradation of land, support sustainability by encouraging urban regeneration and concentration to fill the gaps of the sustainable urban environment.

5. CHAPTER 5

5 Discussion

5.1 Interpretation of summary

From a total sample of 200 participants were participated in the structured surveying questionnaires more than half (N= 118, 59%) were male participants. The most respondents (N= 74, 37%) ranged in age between 40 and 55 years. The least respondents (N= 22, 11%) ranged below 25 years. In this thesis project, most respondents were college/university (N= 89, 44.5%), the least respondents were primary and secondary level ranged in educational level. Agricultural experts were the most dominated participants on this thesis project based on the structured and semi-structured questionnaires which account (N= 52, 26%) and the least respondents were governmental employees and others (N= 19, 9.5%, N= 2, 1%) ranged in occupational status respectively. The suitability of soil types in Bishoftu was dark grey clay (N= 68, 34%) followed by dark clay (N= 58, 29%) those are the most suitable soil types for fruit trees and vegetations. The most suitable places to plant fruit trees and vegetation's were buffer zone and roadsides, which accounts (N= 77, 38.5%, N= 63, 31.5%) respectively. From the assessment of fruit types, mango trees were more adaptable in Bishoftu city, which accounts (N= 48, 24%), the least fruit types were apple trees in the current station which accounts (N= 15, 7.5%). The most challenges of fruit and vegetable productions in Bishoftu city lack of planning system and government regulation were high challenges. Land availability and water access and supply were the least challenges which show that an opportunity to develop a fruit belt sub-city. Designation of fruit belt development impact on the management of land in the urban fringe was the more disagree on the objective of land management, which accounts (N= 81, 40.5%).

The more agree to encourage positive land management which accounts (N= 91, 45.5%) due to this reason to plan a fruit belt development for feature urbanism with eco-effective manners.

5.2 Implications

The result demonstrated that it's possible to forecast a fruit belt development with a high value of multi-purpose development in sub-city of Bishoftu. According to the assessment of the physical environment were more suitable and it's substantial to enhance natural environment with incorporation new urbanism concept using the natural resource of water sources for fruit, shrubs and vegetation productions to address the demand food consumption for city/sub-city dwellers. The assessment of fruit trees and vegetation's were more adaptable and available and again it has suitable soil characters to implement this thesis project in sub-city of Bishoftu.

The FBD helps to rise water cycling system and it's a double face knife to cut our social problems, falling of rain and harvesting of rain is to facilitate the cycling systems of water when to use for multi-use development. The FBD has a different initial point of views, which are social, environmental, ecological and economic values. Hence, this thesis project implies a new concept for any city or town and creates multi-dimensional benefits with full option other developments using rainwater harvesting and partially wastewater recycling systems for plantation of fruit trees, vegetation's using rainwater, and non-edible using wastewater. Indeed it has great options to develop apiculture (beekeeping) development, aquaculture (fishing and other eco-system) development in addition to the basic objective of fruit belt sub-city development.

5.3 Applications

According to data analysis to suggest the possible fruit trees and vegetation's on the proposed right place for the right productivity. The planning of FBD in the city/sub-city integration of fruit belt structure with urban design principle and socioeconomics service should be incorporated. The other application in the development of fruit belt is to shape up of a holistic water system approaches would collaborate it with urban planning system depends on site topographic features and slopes to harvest rainwater, surface water, run-off, and stormwater into the proposed reservoir and ponds with respect to overflow routine as a resource. In the assessment and data analysis of fruit trees and vegetation's has its own result to plant and adapt it depends on soil characters. Due to this reason adjust it for more productions of food products when to implement the proposed land use plan.

6. CHAPTER 6

6. Design solution

The design solution would be focused on incorporating the planning of the water provision system in fruit belt development at the sub-city of Bishoftu in new site development within the bounds of the planning area using rainwater harvesting and recycling of wastewater. The concept of fruit belt development is to establish a framework for action, to maximize the use and value of city in Bishoftu sub-city through multi-productive and increased economic values, recreational use, ecological enhancement, and environmental developments.

Fruit belt planning is typically structured around defining the different zone as per the study of suitable places with incorporating the urban planning system. Different types and scales of fruit belt structure that are appropriate for fruit tree and vegetation plantations and provide varying benefits depending upon sub-city of Bishoftu action area. This fruit belt development in the sub-city of Bishoftu is to create a multi-dimensional and enhancing of the natural environment and encouraging any residents in the city and another environment. The plan is considered different principles as the framework, which are seeking to balance the ecology, fruit productive of the city and the built environment should be more productive with the concept of regenerative principles. This study is to promote and support a variety of activities and uses that encourage people to live, invest, socialize, and recreate in and along the sub-city of Bishoftu fruit belt developments.

The design and planning of fruit belt development in the sub-city of Bishoftu to ensure creative, eco-friendly, reliable, high quality of environmental sustainability and eco-landscape developments using regenerative of the natural resources to achieve fruit belt development. This development improves environmental quality and produces food products. Similarly, to balance ecologically appropriate solutions to sub-city initiatives. Increase connections between the fruit belt, the greenway, waterline/storm catchment into the proposed reservoir for fruit tree development and create unique scenic opportunities to view Bishoftu sub-city.

6.1 Existing site features and location map

The study area includes a total of 260 hectares from 1206.8 hectares of the planning area and located a bare land area that was proposed for expansion of the city by municipal of Bishoftu city. The area also includes portions of the north portion of Bishoftu city. As a part of the study's first phase, the assessment of suitability for fruit belt development and analysis of the existing slope to plan a water system for fruit belts.

The existing opportunities for fruit belt in sub-city of Bishoftu study area include natural gorge, available owned land, fruit trees, vegetation, and historically significant places with unique water efficient character, connectivity to the city, pedestrian connectivity and easy access to the area via major roadways and nearby a city.

6.2 Existing digital elevation model and expansion road network of Bishoftu city

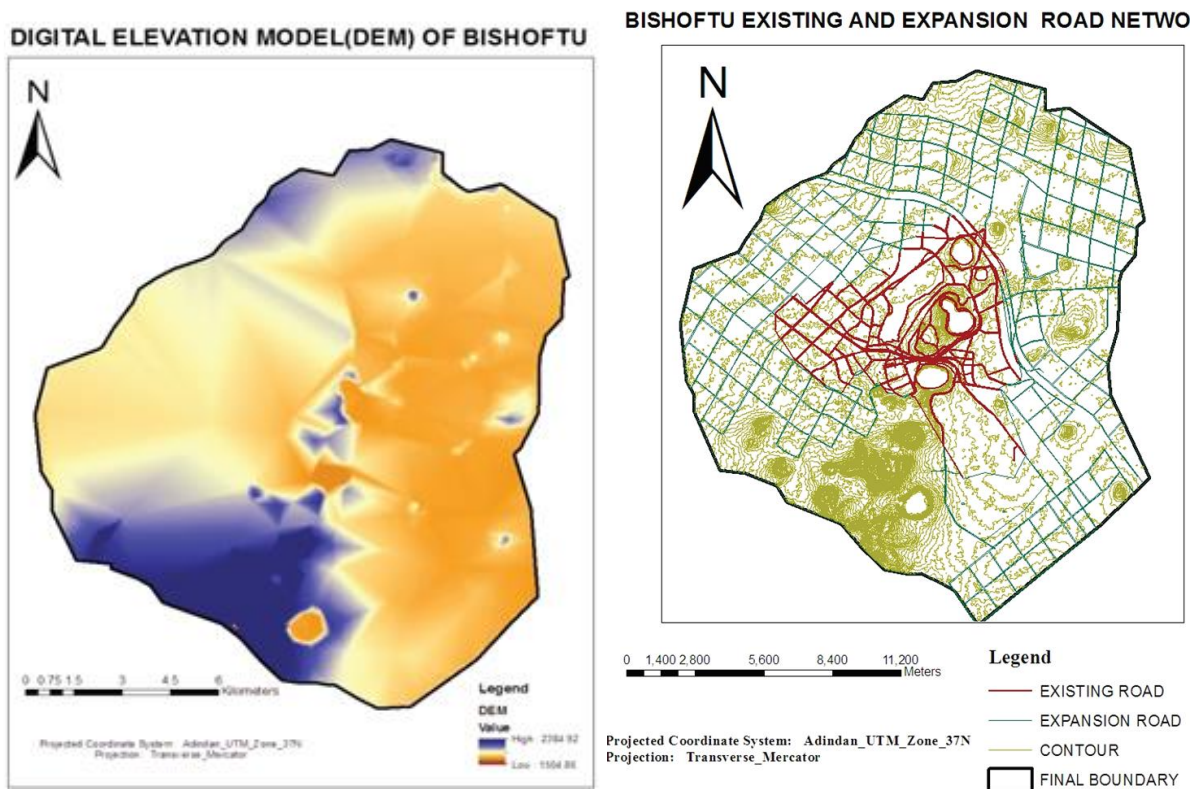


Figure 21: Existing digital elevation model and expansion road network of Bishoftu city

6.2.1 Existing site section of the selected site



A) Cross-sectional section

B) Longitudinal – section

Figure 22: Existing site section of the selected site (A) and (B)

6.2.2 Site futures and site analysis

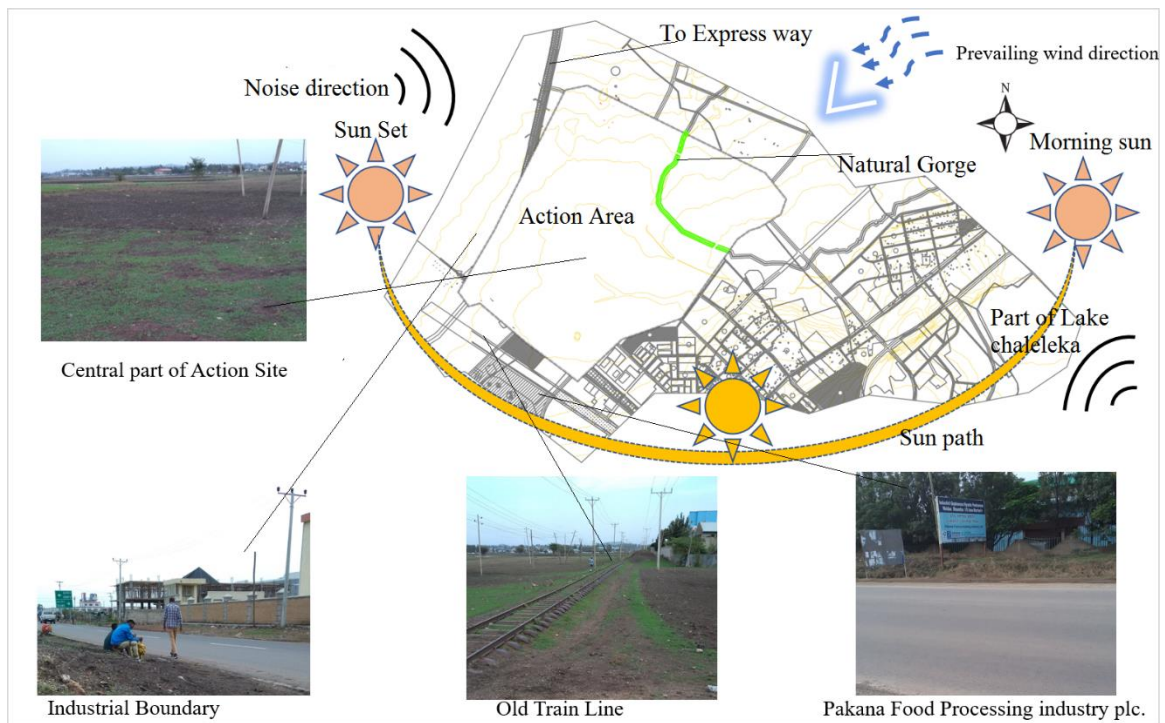


Figure 23: site analysis map and image

6.3 Programming of the proposed site development with eco-nature

Table 13: Planning zones and considerable program

Program of Proposal for Land use planning	Consideration in the program
Urban agriculture/Fruit belt	Agricultural Lands
Administration	Institutional and others
Commercial	Mixed use and offices
greenery/landscape	Green corridors and greenways
Manufacture and storage	Industrial and some other warehouse
Residence	Private Residential
Mixed residence	Apartments and mixed residence
Recreation	Parks, open space and public space
Service	Schools, clinic and other services
Special function water body	Water Futures and Community Orchards
road and Transportation	Transportation Right-of-ways

6.4 Concept development

Concept development and design are based on the concept of green space development with integrations of urban land use development that has its own identity in the sub-city with the harmonious environment for quality living. This concept can increase the level of urban economy, environmental quality, ecological urbanism and healthy social life in the city/sub-city areas. Green network development (GND) was incorporated at the front of the housing, along the roadside, gorge side and extensive network of green space such as parks and public open space with the planting of fruit trees and vegetations. The GND connected the natural habitat and waterway with landscape or productive garden. Along the pedestrian and roadside planted fruit trees and could give economic benefit, environmental benefit, safety, good landscape images as well as shade to the walkers. The general concept of fruit belt development is to incorporate GI elements with urban land use developments for making of better city environment in Bishoftu sub-city.

6.5 Diagram of fruit belt concept development

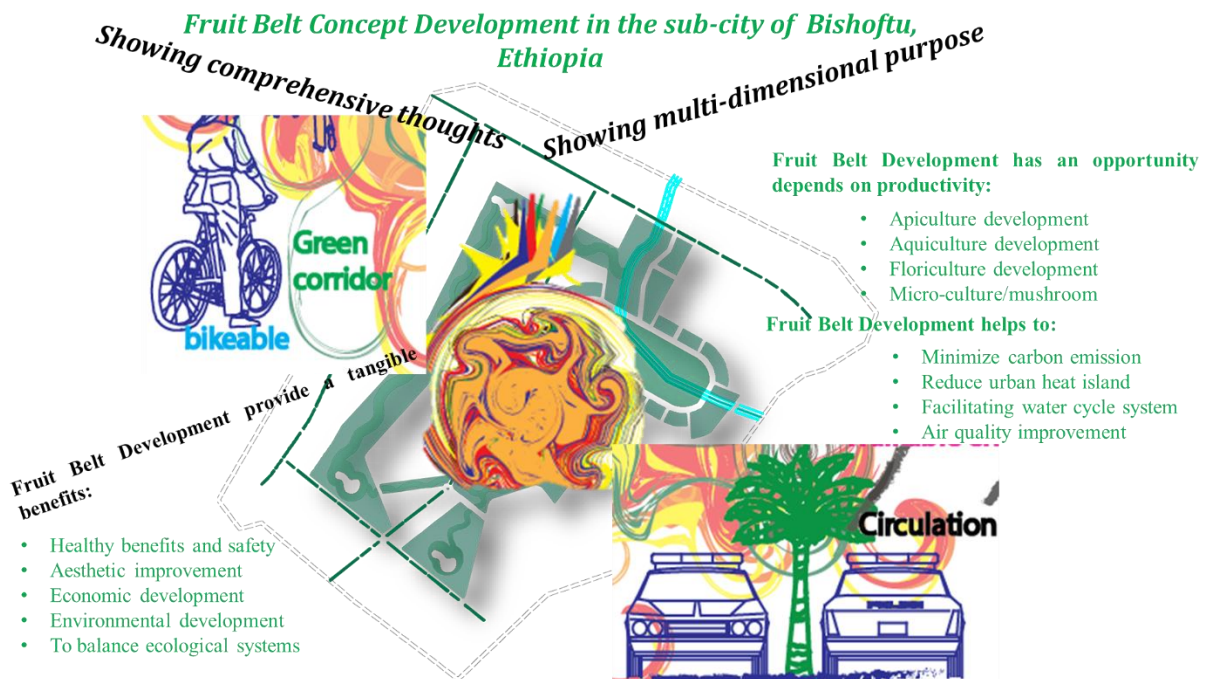


Figure 24: conceptual map diagram

The conceptual plan proposes for multi-dimensional developments, fruit production place development, recreation and ecological improvement that bring the better living environment.

6.6 Watershed development and flow of drainage system

The watershed development plan is to manage stormwater and floodings. This approach is viewed as more cost-effective and environmentally friendly in terms of controlling runoff and protecting water quality. Controlling stormwater runoff at the watershed or sub-watershed level planned through the natural flow of lands and provides an opportunity for fruit belt developments and sustainable solutions in a more effective way.

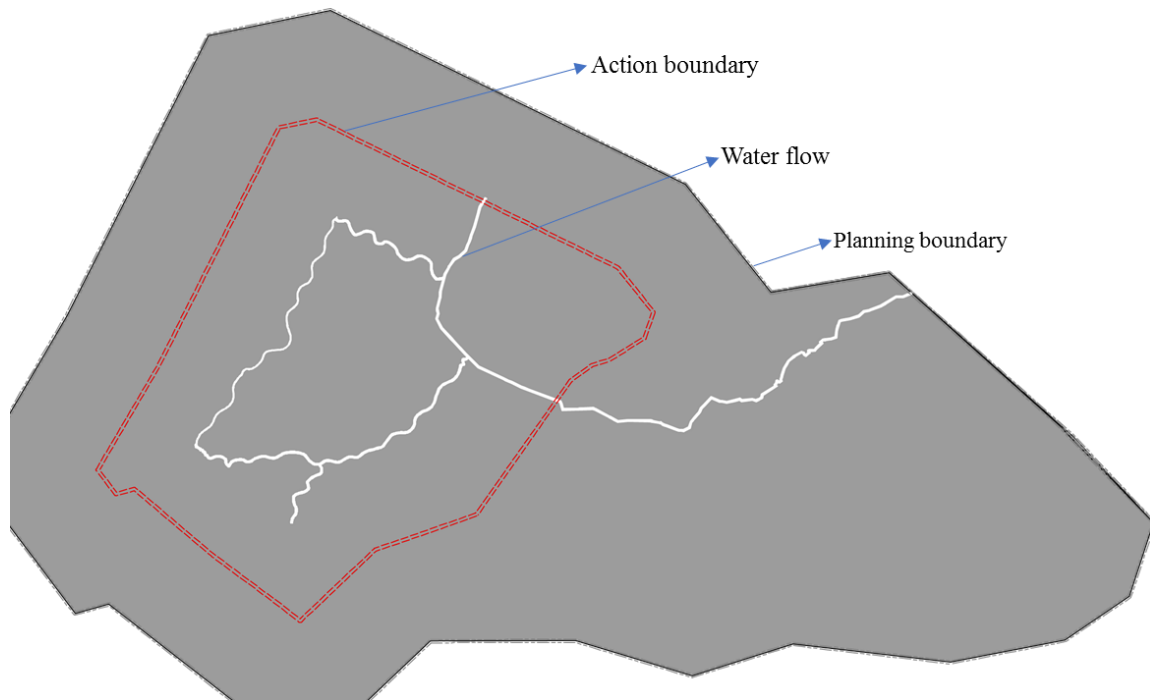


Figure 25: Water flow direction and analysis

The water flow direction and analysis demonstrated that moves on the surface by natural gravity and flows into streams, gorge and its outflow destination is Lake Calalakaa. According to this water flow and analysis, the plan of the water line system is based on its natural flow.

6.7 Water flow map and blue beltlines

Water flow map and blue belt line is formed from the flow of the existing natural water flow direction and planned to water harvesting in the existing gorge and proposed a reservoir in sunken place for the development of fruit belt.

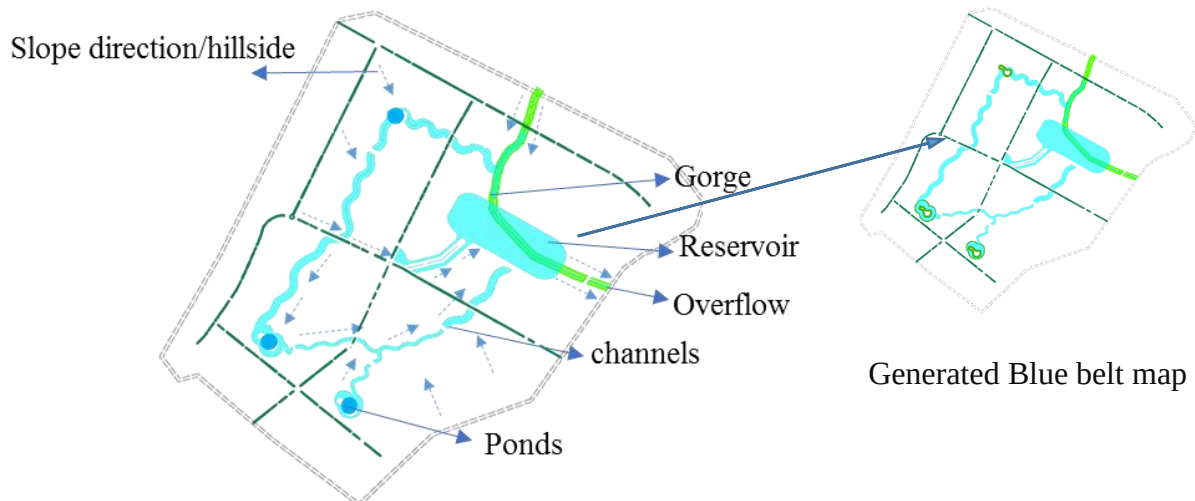


Figure 26: Initial planning of water flow map and blue beltlines

The watershed planning stands from highpoints as per site features into proposed channels and ponds that lead to fruit belt places according to natural topography of the action area. The proposed channels have a Keyline or break line when the site is sloppy to store stormwater because the channel also water reservoir places to harvest storm water. The channel side or boundary is a buffer zone to plant fruit trees and to maximize water infiltrations. This proposed channels and ponds overflow tends to the natural gorge and into a proposed reservoir with consideration of long term development and thoughtful observation of overflow route, which is manageable and continual water as resources and its overflow route ends into Chaleleka Lake.

6.8 Buffer Zone

Buffer zone in this study is the precious boundary of water bodies, which is more suitable for fruit belt developments. The dimension of the buffer zone is 50m in both sides and the channel dimension is 40m. The fruit development in the side of the channel or in the buffer zone has great values for society and the environment. This study is to balance triple bottom lines (people, planet, and profit) and to hit different problems in their environment. Harvesting of water in the city is a great value in life and minimize flooding. Flooding is out of hands in different urban areas, at this time flooding is not an impact when to use it as a resource. It is a potential to create urban blue space and urban water bodies and it's a soul of green space development or fruit belt development.

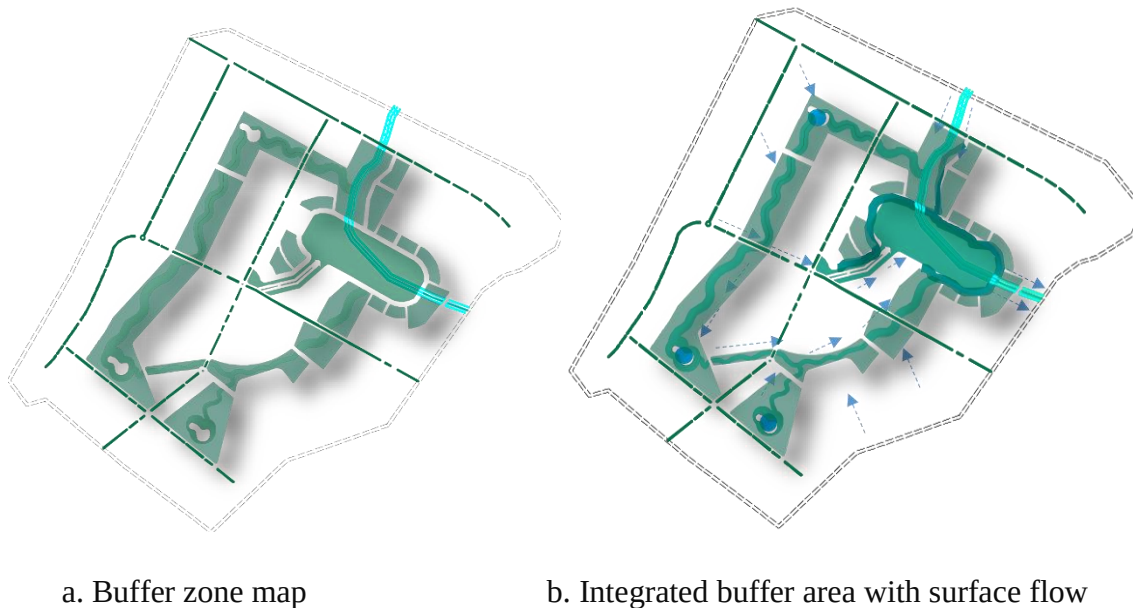


Figure 27: Initial planning area of fruit belt map

City dweller's demands good air quality, food, and other amenities. Therefore, this study addresses social and environmental problems. The buffer area is major resources and production places by planting of fruit trees and other indigenous trees in the channel side development. The place would be producing food, and it's suitable for apiculture development and improvement of economic and tourism development beside of fruit belt and blue belt sub-city development.

6.9 Water harvesting system in Bishoftu sub-city

There are different types of water harvesting systems from urban surface environment, which are blue water (blue belt), surface and groundwater, green water (harvested rainwater). Water harvesting systems will primarily supply the farmer with a tool to stabilize water availability to the crop over time. Hence, in urban environment harvesting of rainwater is the lungs of the city environment to breathe it in a good manner and it's a substantial renewable resource for the improvement of the urban environment. Rainwater harvesting system in the form of the permeable catchment, ponds, and reservoirs were major potentials to develop a fruit belt city environment and to improve the quality of the environment and social life. It became an attractive and complete fruit belt sub-city developments that subsequently provide the improvement of livable environments.

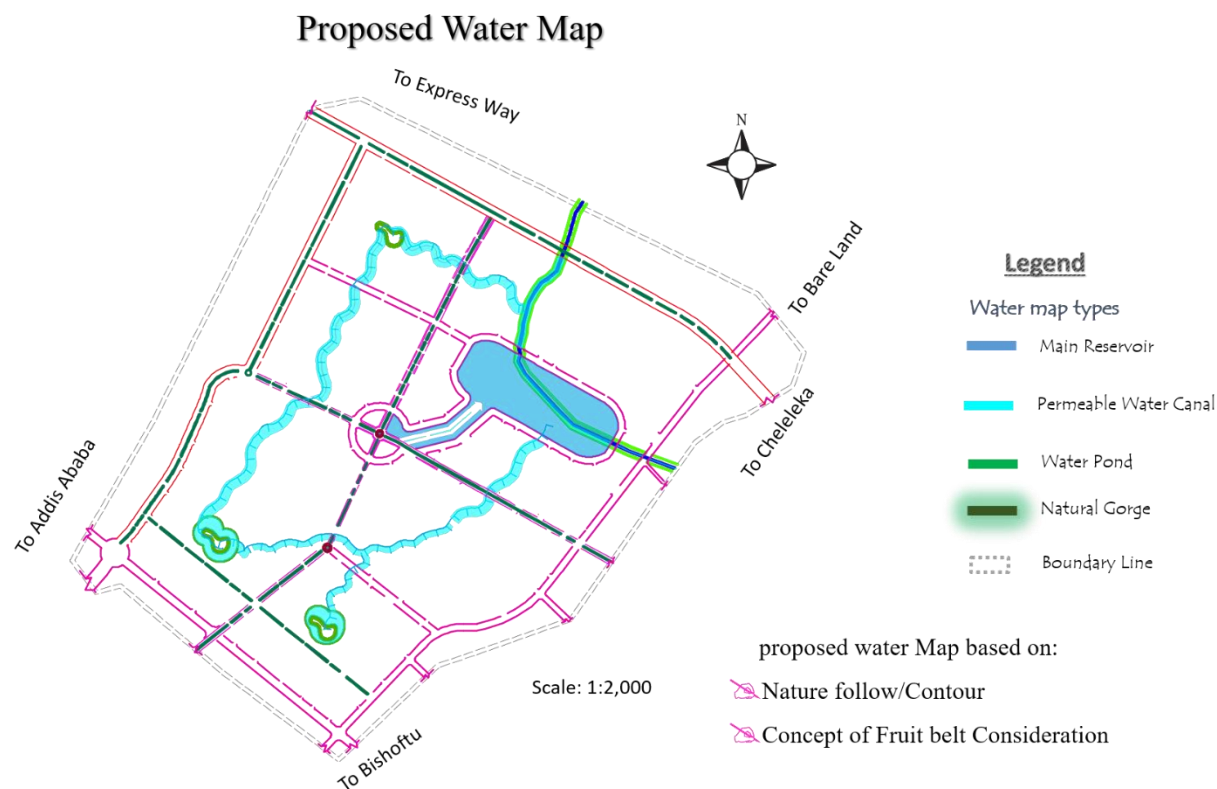


Figure 28: Proposed water map and reservoir

The success of the water harvesting function for FBD has different vital roles, which is able to reduce the flooding level, urban heat island effects, and environmental parameters and to hit our problems in the city.

6.10 Proposed road network plan and design

The road network plan and design is good interaction with fruit belt space consideration to make the roadside development for effective and efficient products in the extension of urban areas, to plan a road network with consideration of fruit belt development. Street design improves neighborhood social qualities that give a priority to a pedestrian with fruit tree canopy and are safe and friendly help to create a unified sub-city development.

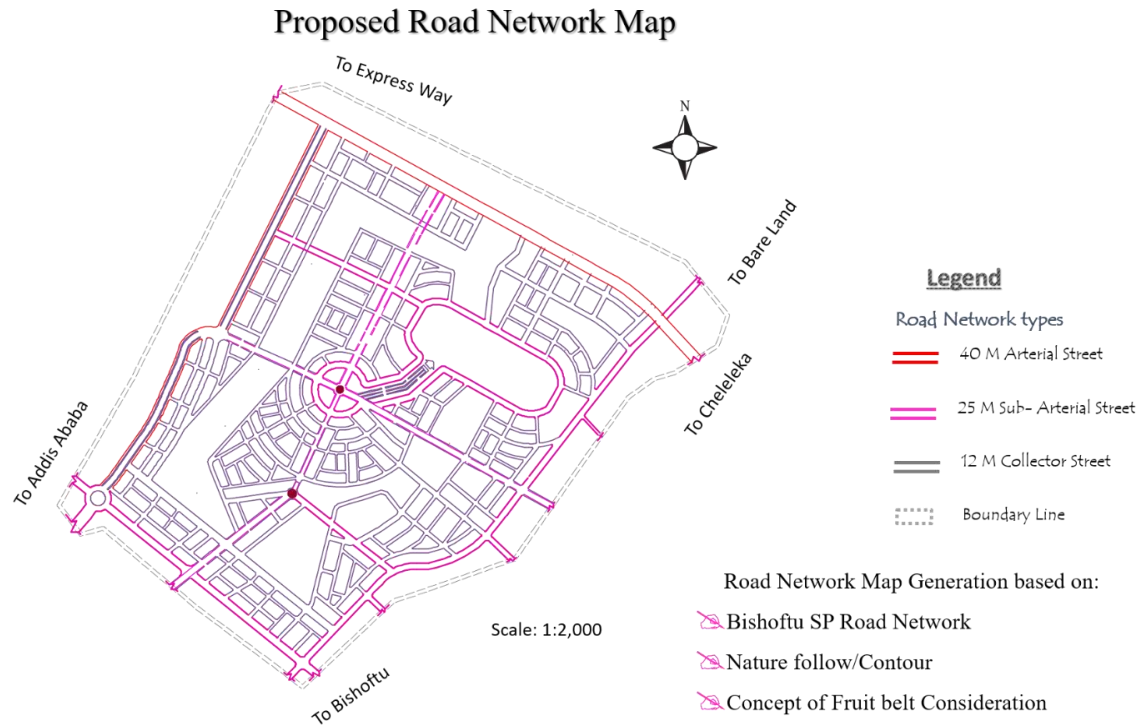
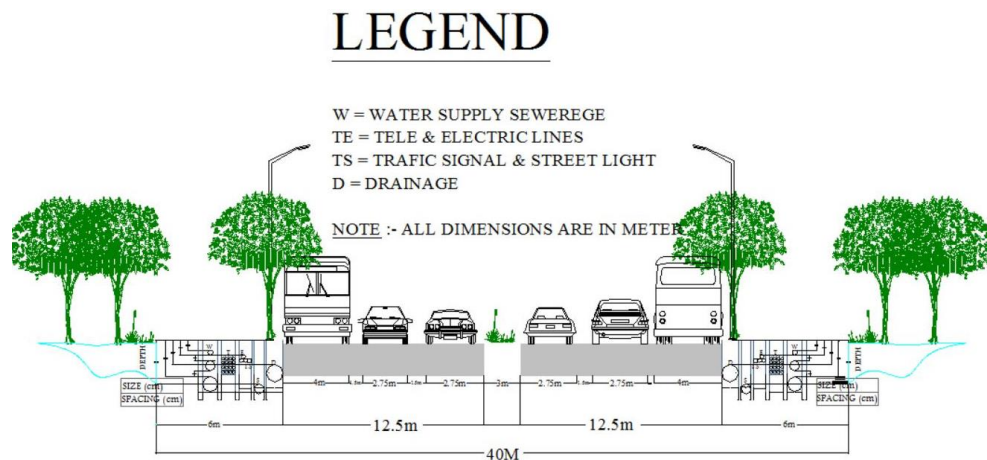


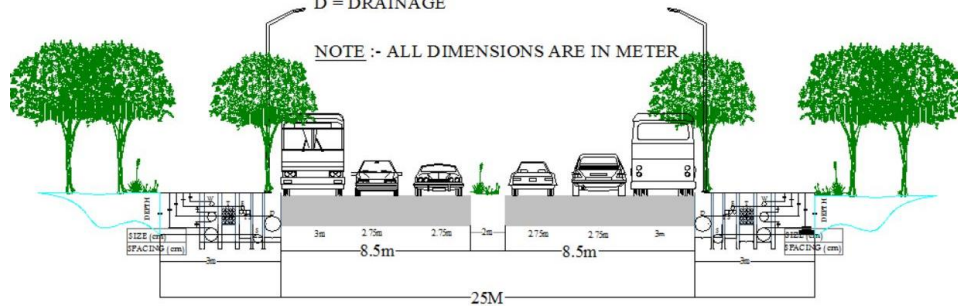
Figure 29: Proposed road network map



LEGEND

W = WATER SUPPLY SEWEREGE
TE = TELE & ELECTRIC LINES
TS = TRAFIC SIGNAL & STREET LIGHT
D = DRAINAGE

NOTE :- ALL DIMENSIONS ARE IN METER

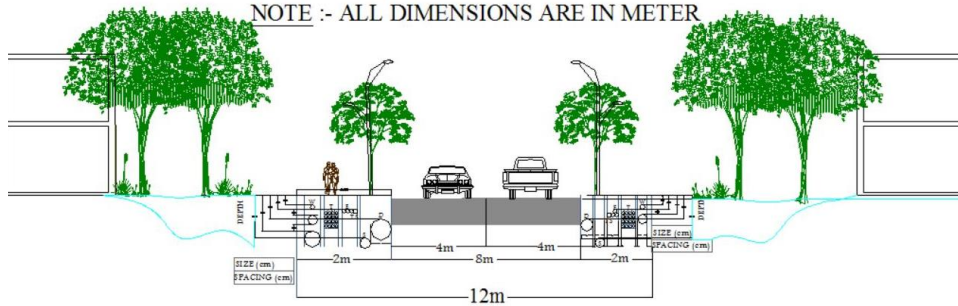


b) Sub-Arterial street section

LEGEND

W = WATER SUPPLY SEWEREGE
TE = TELE & ELECTRIC LINES
TS = TRAFIC SIGNAL & STREET LIGHT
D = DRAINAGE

NOTE :- ALL DIMENSIONS ARE IN METER



c) Collector street

Figure 30: Road section (a, b, and c)

6.11 Proposed fruit belt layout map

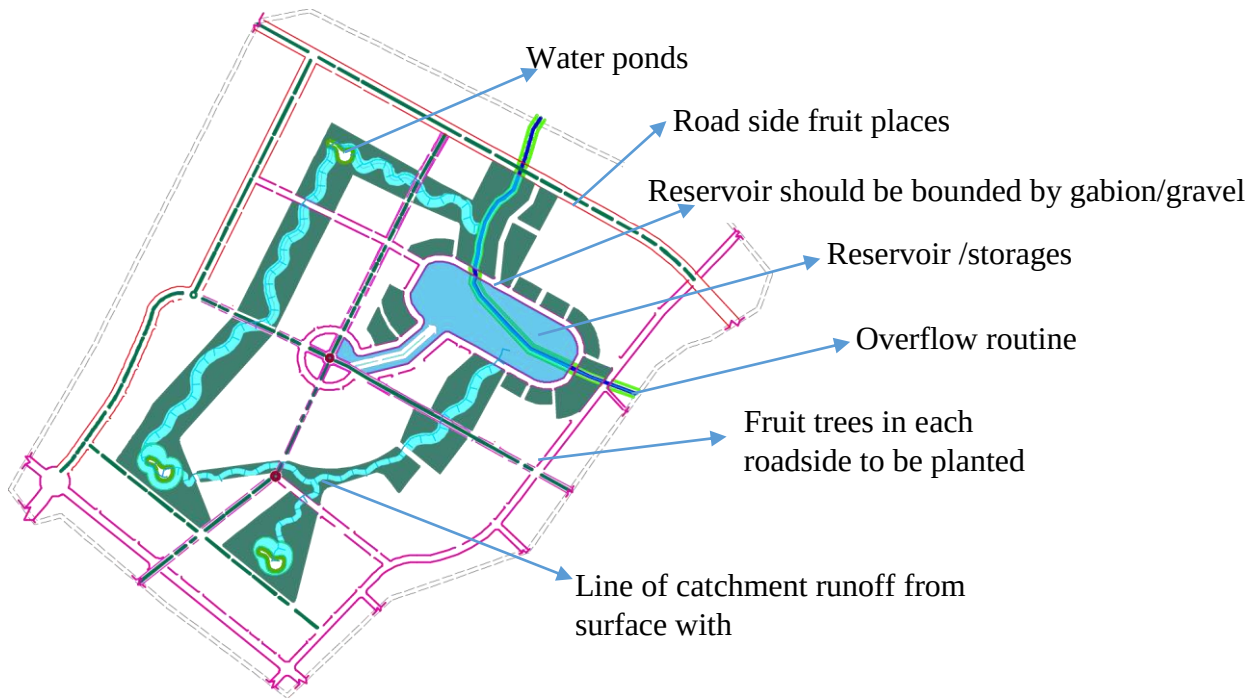


Figure 31: Proposed fruit belt layout map

Proposed Fruit Belt Map

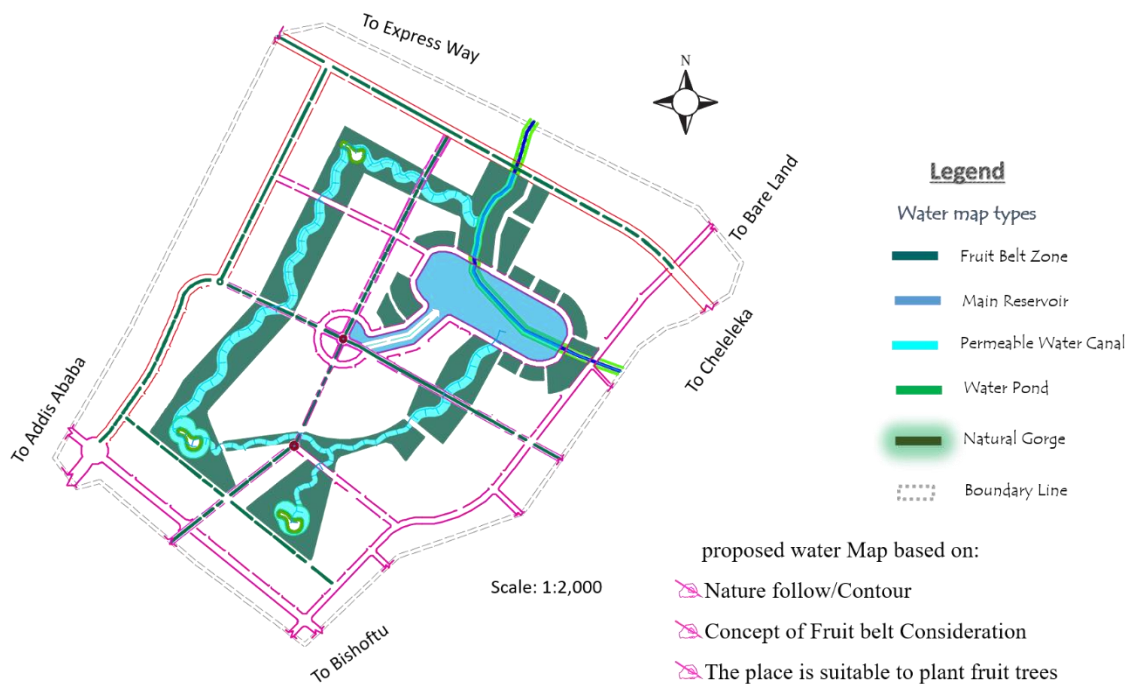


Figure 32: Proposed main fruit belt development map

6.12 Proposed Planning of fruit belt development in the Town of Bishoftu

Planning is an important tool for Town development to achieve sustainability and the proposal is based on urban planning and design principles with respect to fruit belt concept. It helps to formulate medium and long term objectives that reconcile a collective vision and to reveal it in details by design and incorporate with natural resource utilization to achieve the fruit belt Town development. Planning makes the most municipal budgets by informing green infrastructure services and investments and balancing environmental quality and productive city development with the need to protect the environment. Planning of fruit belt development in the city has a positive impact on the urban economy and environment.

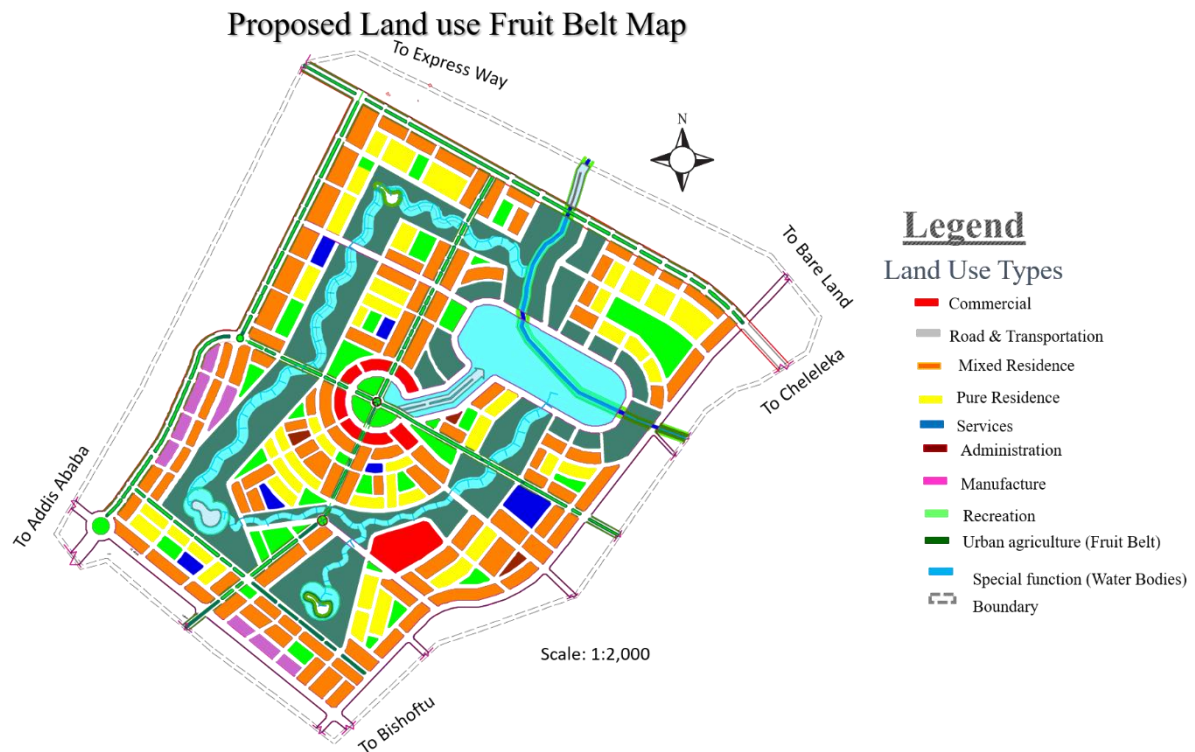


Figure 213: Proposed fruit belt land use plan

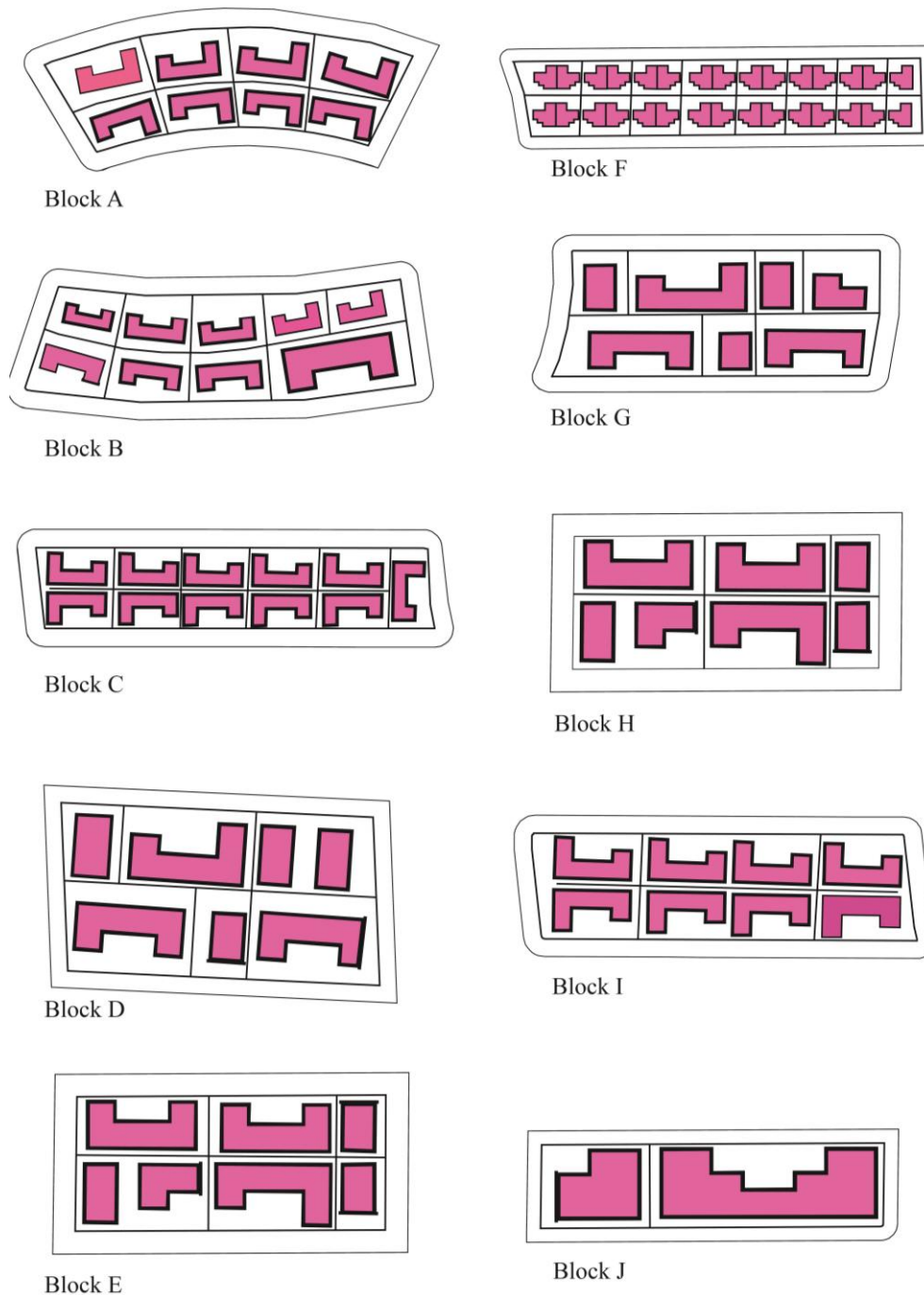
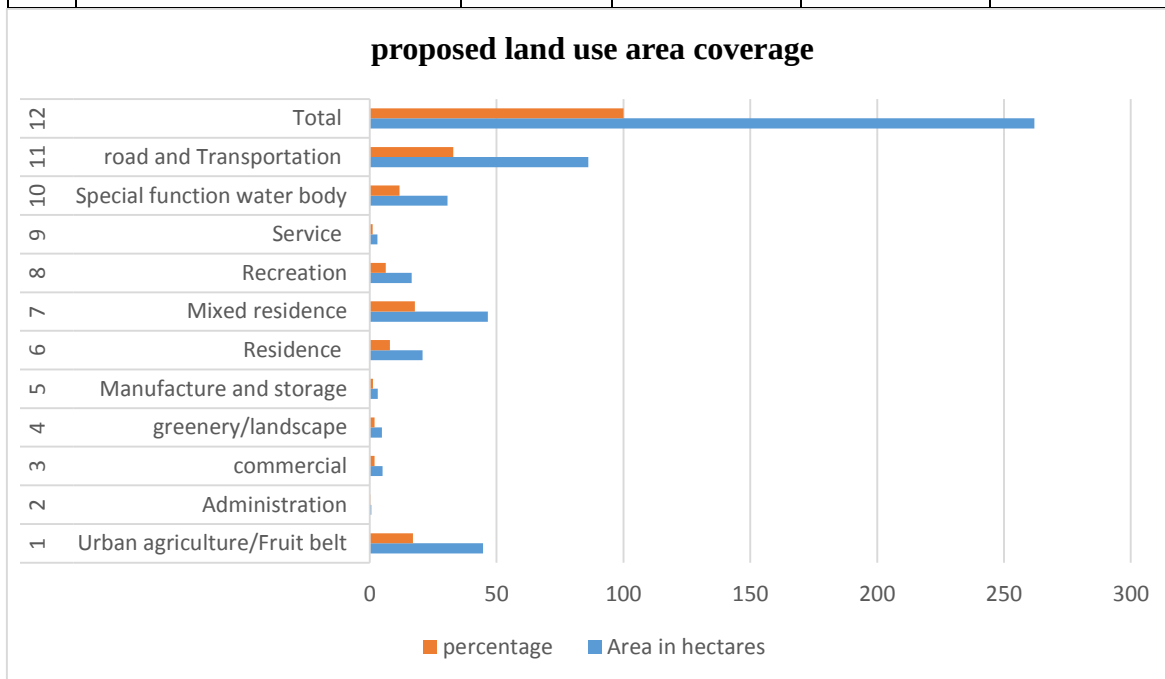


Figure 224: Housing typology map

All proposed blocks were planned in the proposed land use planning. The average ratio of plot standard was taken from (After ORAAMP) 65% for built up, which is impermeable surface and the left 35% is for greenery and vegetation development, which is permeable surface (Graham Tipple and Elias Yitbarek Alemayehu, 2014).

Table 14: Proposed land use area coverage's in hectares

No	Proposal Land use	Area in hectares	percentage	Coverage (%)	Standard (%)
1	Service	3	1.14	30.23%	40%
2	Administration	0.62	0.24		
3	commercial	5.08	1.94		
4	Mixed residence	46.5	17.75		
5	Manufacture and storage	3.21	1.23		
6	Residence	20.77	7.93	36.90%	30%
7	greenery/landscape	4.82	1.84		
8	Recreation	16.51	6.3		
9	Urban agriculture/Fruit belt	44.68	17.05		
10	Special function water body	30.69	11.71		
11	road and Transportation	86.13	32.87	32.87%	30%



The proposed land use plan area is dominated by fruit belt lines, mixed concepts to balance social and environmental developments to maintain ecological balance, addressing food consumption, pollution reduction, and carbon emission. The planning process determined by

the data analysis result and interpretation, proposed for fruit belt developments with comprehensive and mutual benefits.

The planning process determined that the uses within the FBD Study Area should maintain a balance of nature, recreation, and development. The result is a plan that maintains open space as the dominant land use within the area.

6.13 Calculation of annual rainwater and net annual runoff

The major requirements to find the volume of rainwater and net annual runoff in Bishoftu Town are average annual rainfall data of Bishoftu, the catchment area of proposed land use with respect to permeability and impermeability of proposed land use areas, and surface runoff coefficients. The 10 consecutive average rainfall data of Bishoftu is 92.31mm, which is taken from rainfall analysis in chapter three. The total land use of built-up blocks are 79.18ha, from this coverage minimize 19.79ha (5m setback) and left 59.38 is a plot area and again to minimize 17.81ha (30%) from plot area and left 41.57ha for built-up. This calculation was done with consideration of permeable area, impermeable area, building roof, road pavement, agricultural land (fruit belt area), and proposed water features.

The formula of net annual runoff and possible volume of annual rainfall (Design, 2010):

- Estimated Net annual runoff from surface (Liters) = Catchment area (m²) X rainfall (mm) X runoff coefficient
- Volume of annual rainfall(m³) = Catchment area (m²) X rainfall (mm)

Table 15: Calculation of net annual runoff and possible volume of annual rainfall

No	Types of surface	Catchment area(m ²)	Average rainfall(mm)	the volume of annual rainfall(cubic meter)	Coefficient	Net annual runoff
1	Building (roof)	415700	92.31	38373.27	1	38373.267
2	Road/streets	861300	92.31	79506.603	0.6	47703.9618
3	buffer zone	660100	92.31	60933.831	0.2	12186.7662
4	setback	197900	92.31	18268.149	0.25	4567.03725
5	vegetation in a plot	178100	92.31	16440.411	0.1	1644.0411
6	water surface	306900	92.31	28329.939	0.7	19830.9573
7	total	2620000	92.31	241,852.20	-	124306.0307

Note: 92.31 mm is 10 years average rainfall data of Bishoftu town

The stormwater from the surface should be directed to trees and shrubs within passive WHS.

Grey water should be directed to and utilized mulched basin planted for non-edible plantation, which is to reduce the demand of water consumption in a living environment and support rainwater consumption in the development of fruit belt and for shrubs plantations.

The total volume of annual rainfall is 241, 852.20 cubic meter and its total net annual runoff is 124,306.03 cubic meter water. The area of fruit trees and vegetation place is the sum of the buffer zone, setback, and out of built-up areas in a plot is 1,036,100m². For this area coverage the reservoir and channel is a storage place of water its dimension and volume of reservoir and channel is 3.5ha*2m depth, which is (70,000m³) water stored in reservoir and 4.1km (L)*50m (W)*1m (D), which is (2,050,000 m³) water stored in channel and the overflow passes through channel into a reservoir with consideration of natural overflow routine.

6.14 Proposed fruit belt development with an aerial view

The proposed fruit belt development has the best feature according to food production, environmental quality, flood reduction, reduce urban heat island effect, improve habitat rehabilitation, and economic values with related to other side developments, such as apiculture and aquaculture development also incorporate it. The aim is to harvest runoff or groundwater from areas of pavement (surplus) where it is not used, store it and make it water availability for a productive purpose, where and when there is a water shortage. The flood water and surface water spreading into buffer zone (use as flooded fields) from impermeable and outflow of permeable surfaces and filtered by mulch in a buffer area and the water is bonded by gravel to sink flood water and protect it. Fruit trees also to suck rainwater and minimize the amount of floods and its leaf use as mulch to filter floods and the leaf is to facilitate soil fertility.

The buffer area and roadside are planted by fruit trees with the integration of indigenous trees that help to improve urban environmental quality.



Figure 235: Channel side fruit belt development on the proposed buffer area

The roadside fruit trees and other native trees produce oxygen and consume carbon emission and to minimize urban heat island effect. It is important to manage water flow, because the permeable surface is to sink a flood and its level is slowly sunken with relative to road pavement areas.

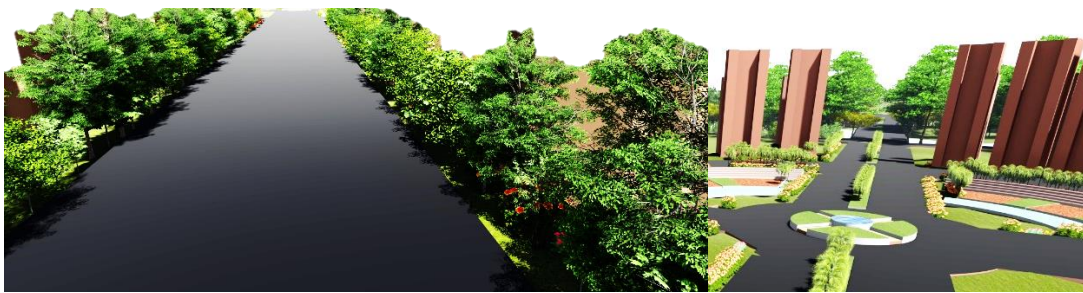


Figure 246: Roadside development of fruit trees with other indigenous trees

The proposed water reservoir design has a great role to harvest rainwater and achieving of fruit belt objectives with positive land use and positive products in the urban living environment. In order to facilitate the adoption of fruit tree and vegetation development in the reservoir side and spread of water, harvesting shows that good practices, awareness raising, promotion, and productivity would achieve it in a city environment. This is important to alleviating poverty when adopted it in each level or scale and reduce other environmental problems with increasing of food production and security, enhancement of biodiversity and ecosystem sustenance.



Figure 257: Reservoir side development of fruit trees and edible vegetation's

The proposed overflow routine is the right place and right direction according to water flow direction analysis that helps to restore chalalakaa Lake and its flow passes through the natural gorge with respect to the development of fruit trees and vegetation and to manage a flood water or rainwater runoff to increase water availability.



Figure 268: Overflow routine of WH with respect to the developments and use it as a resource

The water channel is bounded by rock dam and gravels with different brake line to harvest rain water as it is and its overflow goes into the reservoir area. The buffer area also gives multi-functions such like as an open space, food production center, and recreational centers in the city to get better comfort.



Figure 39: The channel and reservoir of water is bound by gravel to filter surface water



Figure 270: The channel side and reservoir side development is a palace of recreation and food productions

In the development of the fruit belt environment (buffer zone) provide water ponds and water retentions with gravel and sand filtration to suck stormwater and recharging of groundwater as well as to minimize flooding impacts.



Figure 281: Water retention in fruit trees and vegetation with enhancing of the ecosystem in channel side

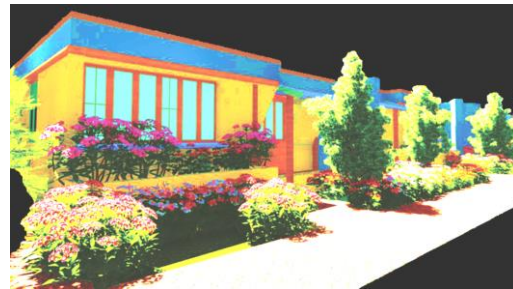
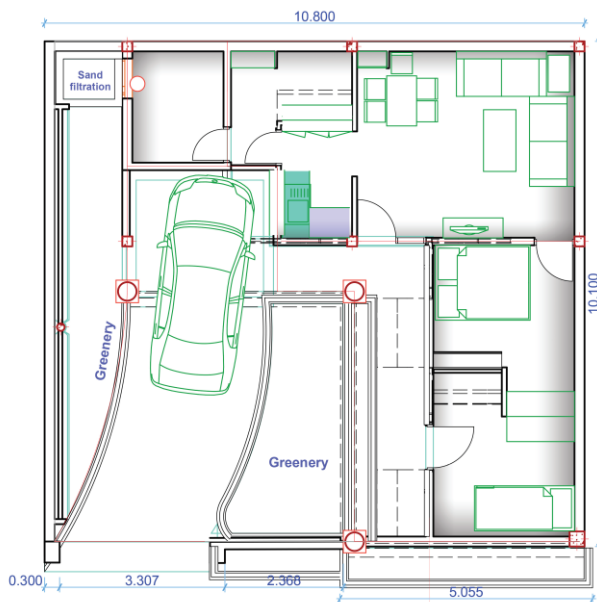
The place of water ponds are manageable and simple, it's simply bounded by gravel and sandy soil is locally available in Bishoftu surrounding environment. And also it has the power to address water scarcity and the demands of fruit belt development, it's a better option to develop this fruit belt project by increasing water availability and by harvesting of locally available resources to achieve water use efficiency in this action area.



Figure 292: Water ponds to restore and retention of groundwater with the boundary of gravel to filters a waste

6.15 Architectural character and placemaking for fruit belt development

Rainwater harvesting under the building for vegetation development and gray water treatment for non-edible plantation such as bamboo, floriculture and other shrubs in the built environment. Using harvesting of any water source should be utilized for beauty place making the environment for the local community's assets and potential to create comfortable public space that people enjoy and productive landscape. Architectural character is one of the defining qualities of a successful fruit belt developments in every place and every space. The overall built environment, building structure should be more functional though different ways and encouraging social interaction and community involvement to get worthwhile in a different aspect.



Wastewater reuse for non-edible plants and renewable plants for instance bamboo products use for construction and furnitures with the mechanism of sand and gravel filtration system to filter wastewater.

Figure 303: Architectural plan in a productive system

Vertical farming system and roof gardens development has a vital role for householders/owners and environmental quality by planting of edible vegetation in each housing as a sub-city district and it replaces green development. Fruit belt and vegetation development are not only getting of food production, but it's also important to refresh themselves, air quality improvement, pollution, and reduce urban heat island effect. This development appears in each housing types such as residential, commercial, office, and another institutional building type should be planted.

Harvesting of rainwater in under building is a very important though, it has two folds. The one is to reduce a load of flooding on the site stormwater management system until it is full and in the site design and planning of this thesis project would provide a routine for overflow off. The second, rainwater harvesting, once treated in the system, then available for edible vegetation developments and other consumptions. It's possible to plant roof gardens development using rain gardens, which is a more informal and organic appearing infiltration basin. The infiltration trench filled with coarse aggregate stone.

The site pavement would be porous pavement that generates high rate and qualities of runoff. The design of this thesis project would be implemented in the concept of planting vegetation on building instead of planting building on the land, because in our country the urban expansion is covered our agricultural lands, simply we are running out of agricultural lands.

Hence, to enhance our agricultural lands on building with a different system like on the top of the building and adopt vertical farming's to address food consumption of dwellers.

Harvesting of rainwater for green roof and site improvement has many functions or benefits, which obtained a careful and considered design process. A green roof would be a great potential for adding habitat enhancement in the city. Similarly, there is great potential for adding open space, community orchard, and other developments. The green roof and fruit belt development can be used as part of a stormwater management system, minimizing and slowing down the release of water into the storm reservoir or sewer. The availability of water includes the recharge of soil water, groundwater, and water stored in reservoirs water harvesting for fruit belt and ecosystem sustenance as well as for ecological balance and agricultural use. Commonly the term water harvesting (WH) and rainwater harvesting (RWH) are used interchangeably.

Finally, it helps the passive cooling system of the city in addition to the main purpose of fruit belt development.

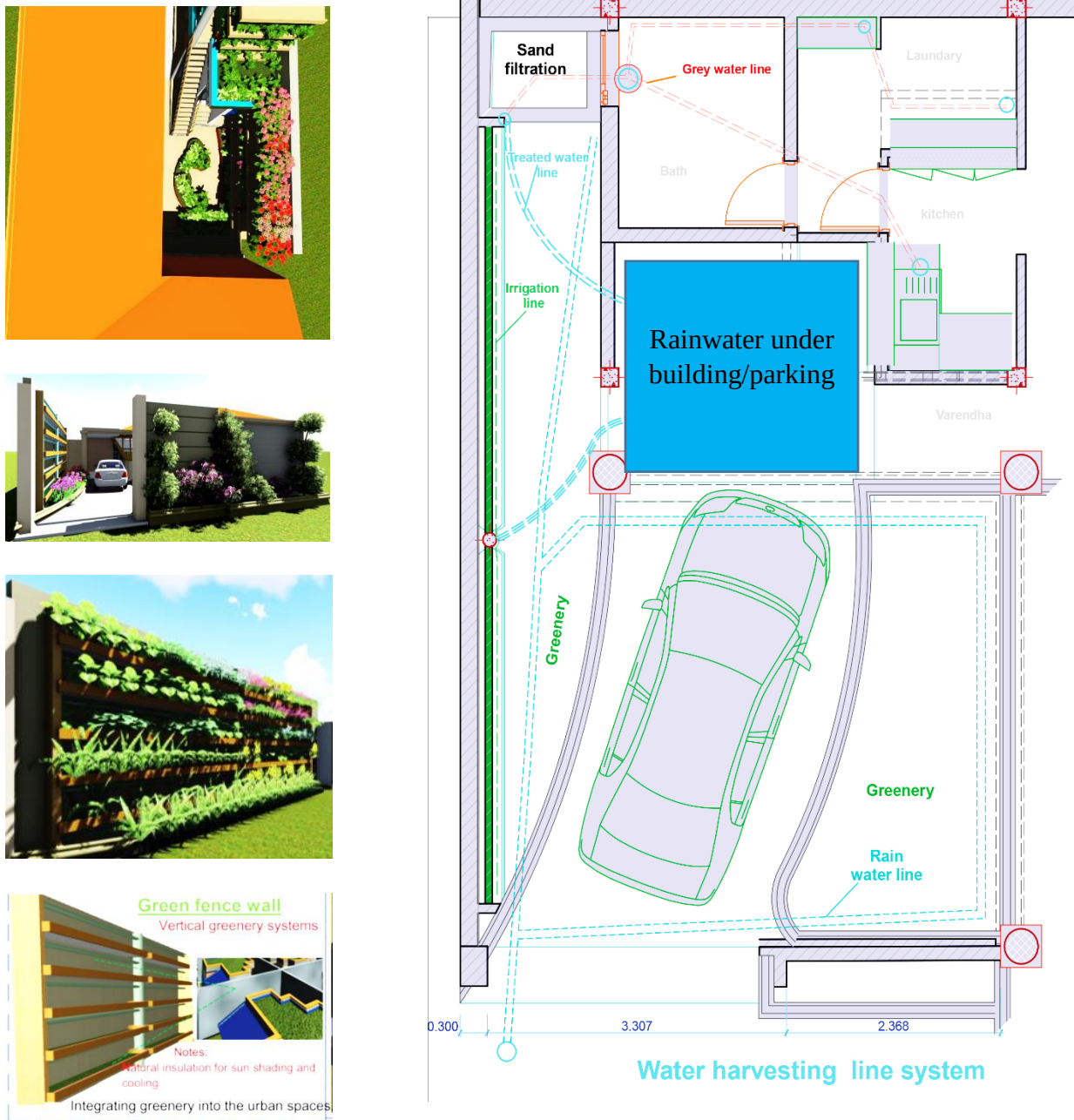


Figure 314: vertical farming and roof garden development plan

7. Conclusion and recommendation

The planner and designers of urban green space should rethink creatively to find innovative thoughts and provide opportunities to develop and enhance fruit belt development in Bishoftu sub-city and wherever in the urban environment. This study encourages the development of Town and urban environment by improving traditional green space into more functional ways. For instance, to alter a traditional urban green space (e.g. urban parks, playing fields) and also informal urban green space (brownfields, vacant plots, streets, and roadsides) are a potential to develop a fruit belt and to hit environmental, economic, and social problems.

The study can play an effective role in an urban environment to nature improvement and productivity and again enhancement of habitats for flora and fauna, which is a great opportunity for other development such as apiculture, aquaculture, and biodiversity. In order to the study result shows, buffer zones are the first and most effective and suitable places to develop a fruit tree and vegetation's and enhance comprehensive urban landscape and improvements with productive ways. Fruit belt development is a conspicuous way to struggle with poverty. A setback along roadside also the second suitable and potential places to plant fruit trees.

According to the data analysis and results, the design and planning focused on incorporating planning and natural water flow provision system for fruit belt development using water flow analysis as planning to harvest rainwater and recycle wastewater for non-edible plantation. Fruit belt planning is typically structured around defining in different zones as per the study of suitable places with the incorporation of urban planning systems. This development improves environmental quality and produces food products. Similarly, to balance ecologically appropriate solutions to sub-city initiatives. Increase connections between the fruit belt, the greenway, waterline/storm catchment into the proposed reservoir for fruit tree development and create unique scenic opportunities to view Bishoftu Town.

As the general recommendation, the study needs sufficient funding and experts in addition to an architectural professions as well as willingness of government also the most important players to implement it. This study is the base for other related professions and it needs collaboration with other professions , especially irrigation and water engineering also an other players to achieve it with respect to environmental protection and development.

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9. Annex: Structured Questionnaires with Semi-Structured interview

English questionnaire on forecasting the fruit belt development using rainwater harvesting and partially wastewater recycling system in Bishoftu sub city, Ethiopia.

Location

Prepared by: **Dereje Girma**

Sign.....

Interviewer Name;.....

Sign.....

Date of the interview; Time period.....To.....

“Encircle number of choice for the following question”

Socio-demographic characteristics of the study area and the required question related to the research topic.

No	Question	A possible answer to the question
1	Sex	1) Male 2) Female
2	age	1) Under 25 2) 25-40 3) 40-55 4) Above 55
3	Education status of the participant	1) Primary 2) Secondary 3) College/university 4) No education
4	Occupation status of the participant	1) Agricultural expert 2) Municipal expert 3) City dweller 4) Farmer 5) Trading

		6) Governmental employee 7) If others.....
5	Which type of soil is suitable to plant fruit trees & vegetable in Bishoftu city	1. Black soil 2. Semi-black 3. Ruddy soil 4. Dark clay 5. Dark grey clay
6	Where to plant fruit trees & vegetable in the city is preferable	1 Roadside 2. In each block round 3. Buffer zone. 4. Others.....

7. What kinds of fruit trees are being adaptable in Bishoftu city and there surrounding of Bishoftu?

- 1) Mango tree
- 2) Apple tree
- 3) Banana
- 4) Avocado
- 5) Papaya
- 6) Orange
- 7) Cabbage tree (Shiferaw tree)
- 8) If other, please specify_____

8. What kinds of vegetables are being produced in Bishoftu city and there surrounding of Bishoftu?

- 1) beetroot
- 2) Potatoes
- 3) Cabbage
- 4) Chilies
- 5) Onions
- 6) Tomatoes
- 7) If other, please specify_____

9. What are the challenges of fruits and vegetable productions in the city or sub-city of Bishoftu?
(Rank your answer according to importance; 1, 2, 3) 1 is a high challenge

NO	Challenges of fruits and vegetable productions	Rank
1	Lack of fruits & Vegetable source to plant it	
2	Lack of organized information to plant it in the city	
3	Government regulation	
4	Land availability	
5	Water access and supply	
6	Lack of planning system	
7	If others (specify)	

If you have any thought and frustration about the challenge that will affect a city environment.
Write on this page:

10. What are the roles of fruit belt city development in Bishoftu sub-city and its effectiveness as a planning mechanism? (Rank your answer according to agreement and importance: strongly agree, agree, and disagree).

NO	Depends on its role in environmental management	Rank
1	Does the fruit belt designation impact on the management of land in the urban fringe?	
2	Have the land use objectives for fruit belt land encouraged positive land management?	
3	Does the fruit belt development preventing degradation of land in the urban fringe and maximizing the productivity of land and the benefits to people?	

	Depend on its effectiveness as a planning mechanism	
4	Does fruit belt, as a planning designation, support sustainability by encouraging urban regeneration and concentration of homes, services, and employment opportunities?	
5	Are other tools, such as strategic gaps and green wedges, more effective at creating a sustainable urban form?	

Write your feelings about forecasting the fruit belt development using rainwater harvesting and partially wastewater recycling system in Bishoftu sub city, Ethiopia depends on roles and effectiveness.