WATER SENSITIVE URBAN DESIGN FOR ENVIRONMNETAL QUALITY IMPROVEMENT OF RIVERS IN ADDIS ABABA: THE CASE OF FINICHA RIVER

MSc. Thesis in Urban Design and Development

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DECLARATION

I, the undersigned, declare that this thesis is my own and original work and has not been presented for a degree in any other university, and that all sources of material used for the thesis have been duly acknowledged, following the scientific guidelines of the Institute.

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CONFIRMATION

The thesis can be submitted for examination with my approval as an Institute's advisor.

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ACRONYMS

SMPs: Stormwater Management Practices

AAEPA: Addis Ababa Environmental Protection Authority

MUDC: Ministry of Urban Development and Construction

OAAOSZIDP: The Office of Addis Ababa and the Surrounding Oromia Special Zone Integrated Development Plan

CLUVA: Climate Change and Urban Vulnerability in Africa

BEPA : Bole Sub-city Environmental Protection Authority

WEPA: Woreda Environmental Protection Authority

CBGB: City Beautification and Greening Bureau

BBGB: Bole Sub-city Beautification and Greening Bureau

WBGB : Woreda Beautification and Greening Bureau

CSA: Central Statistics Agency

LOCAL TERMS

Ato : An Amharic word for Mr.

W/rt: An abbreviation of "woizerit " for Ms.

Chicka Shum: An Amharic word for local chief

Edir: A social organization mainly for taking care of death of member families

Woreda : An administrative unit at local level

ABSTRACT

Nearly all urban areas developed on riverbanks. For centuries, people have settled along rivers for the purpose of irrigation, transportation, water supply, etc. Rivers are also important source of food for people settled close to their banks. Intensive usages of rivers by human beings for the aforementioned purposes have resulted in the loss of aquatic fauna and flora. This is true for Ethiopia as well. Specially, in Addis Ababa, rivers and riversides are neglected places where solid and liquid wastes are dumped. Additionally, it is also a place for legal and illegal settlers. For this reason, the riparian areas along the city's rivers were shrinking in size, and there are no greenways along the city's Rivers. Therefore, the main objective of this study is to develop design strategies by testing on a specific site.

In order to achieve the objective, cross-sectional study method is selected. This method is chosen because it examines one specific site, while several outcomes are expected at the same time. In addition, study area was selected based on location, land use, exposure to flood and river pollution using purposive sampling techniques.

During the study, it is found that the factors for shrinking of the riparian zones of case area are population growth; settlements along the riverbanks; waste dumping site; lack of awareness and coordination as well as inadequate manpower. Furthermore, the factors that increase flood damage and river pollution of the study area are absence of Stormwater Management Practices (SMPs); due to lack of coordination among different concerned Institutions such as AAEPA, MUDC, CBGB,OAAOSZIDP as well as disposal of solid and liquid wastes around the river. There are no greenways along the river. For these reasons, Finicha River is not suitable for the community of the study area.

Therefore, the concerned bodies should take appropriate action as soon as possible. There should be coordination among the concerned sectors. In addition, SMPs should be incorporated into built environments such as buildings, road, parking areas and open spaces. Site-specific design solutions should be provided with a view to having urban river spaces that are accessible, attractive and environmentally sound.

KEY WORDS

Riparian zone: describes as long and linear strips of vegetation adjacent to streams, rivers, lakes, reservoirs, etc.

Stormwater: water that originates during precipitation events.

Stormwater Management Practices (SMPs): techniques used to reduce stormwater runoff by treating the stormwater as close to the source as possible

Greenways: linear open spaces for public access and recreational activities.

ORGANIZATION OF THE RESEARCH PAPER

This research paper is composed of seven chapters and is organized in the following manner.

The first chapter gives a brief introduction to the research problem objectives, question significance, scope and limitation of the Study

The second chapter elaborates the type of research method selected for this study and why it is chosen. The criteria used to select the study area are also discussed briefly in this chapter. Furthermore, this chapter briefly explains, the various techniques and tools adapted and used to gather the necessary information for the study.

The third chapter will review literatures regarding riparian zone, SMPs, greenways as well as connection between city's settlers and riversides.

The fourth chapter focuses on the major areas of the research is going to revolve around. Broadly the issues to be discussed include riparian zones of the city, water quality and flood control in the city's rivers, greenways of Addis Ababa as well as relationship between city's settlers and riversides.

The fifth chapter discusses at length the case area's riparian zones, flood, greenways and water quality of the research site as well as the connection between the city's settlers and riversides.

The sixth chapter presents the analysis of different data gathered from the field and concerned offices. It also includes the findings of the study. The last chapter provides recommendations on the findings of the study and final conclusion. The recommendations contain different designs hat can bring important lessons for the future provision of riverside development in the city.

CHAPTER ONE

INTRODUCTION

1.1 Introduction

Virtually all our cities and urban cultural spaces grew up on riverbanks. For instance, early civilizations were settled along the Euphrates- the Tigris River in Mesopotamia; the Nile in Egypt; the Ganges in India; Indus in Pakistan and the Huang-Ho river in China throughout the history.

Urban rivers have economic benefit as they enhance business opportunities and food productions (MUDC, 2013). They have social benefit as it increases social cohesion. They have also ecological benefits as urban rivers and rivers sides are places for various fauna and flora (ibid., 2013).

According to EPA, in Addis Ababa there are 7 major and 6 medium rivers which are fed by 75 small river tributaries. The rivers begin from the northwest and northeast part of the city and flow south wards and meet at Beseka and create Lake Aba Samuel (Hayal D. et al., 2011).

However, rivers and riversides of Addis Ababa seem to have given the aforementioned benefits. On the other hand, most industries and hospitals found in the city discharge their wastes into nearby rivers without any treatment. (Getaneh G., 2008). The riverbanks are also a place for legal and illegal settlers.

To reduce loss of urban river spaces, the study tries to design rivers and riparian areas of Addis Ababa in order to have environmental friendly relationship between the city settlers and rivers.

1.2 Problem Statement

All over the world, there is intensive usage of river by human beings for irrigation, hydroelectric power, etc. (Darbyet al., 2008).Such activities have resulted in the loss of fauna and flora (Darbyet al., 2008). According to the report of MUDC (2013), urban riversides developments have social, ecological, economic and environmental benefits. However, nowadays urban rivers of Addis Ababa seem to be neglected. For instance, the city's rivers seem to be places for taking bath and washing clothes by some people. In addition to this, different industries and hospitals, without any form of prior treatment seem to discharge wastes into the nearby rivers. Also riparian zone of the city seems to be occupied by legal and illegal setters. Therefore, riparian zone of the city appear to shrink in size. As a result, the settlements near to the rivers seem to be exposed to natural hazards such as flood and erosion. The problems of Addis Ababa's urban riverbanks appear to be increasing from time to time. Therefore, in order to minimize the problems, the study tries to develop design that can guide the riverside developments of the study area.

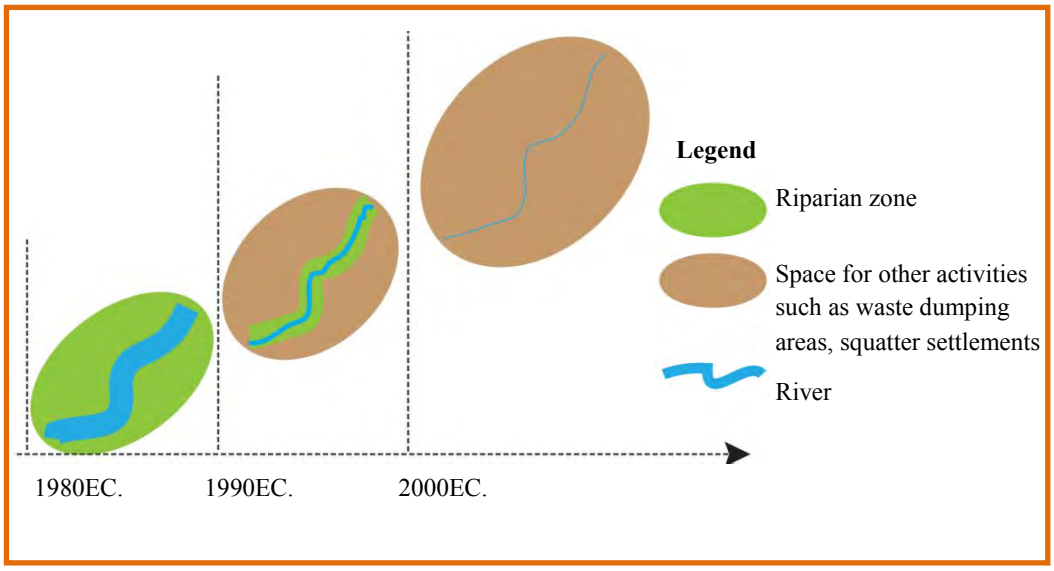


Figure 1.1: Diagrammatic representation of shrinking riparian zone in Addis Ababa

1.3 Objectives of the Study

General Objective

- General objective of the study is designing rivers and riparian areas of Addis Ababa that enhance the environmental quality of the rivers and nearby neighborhoods.

Specific Objective

- To identify factors that contribute for shrinking case area's riparian zone ;
- To device flooding control and water quality improvement mechanism for Finicha Rivers ;
- To delineate recreational-oriented urban green ways along Finicha River;
- To create healthy connection between the study area's settlers and riverside;

1.4 Research question

1. What are the major factors for shrinking the case area's riparian zone along Finicha river banks?
2. What are the main factors that increase flood risk and water pollution in the river system of the study area?
3. How recreational oriented urban green way can be delineated along the riparian zone of Finicha river?
4. What measures shall be taken to create healthy connection between the study area's settlers and riversides?

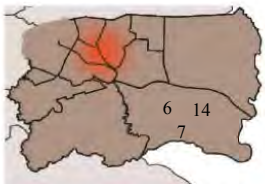
1.5 Significance of the study

- In the future, governmental organizations, private sectors, non-governmental organizations, politicians, planners, practitioners and the public at large can use the study as a possible solution for future provision of riverside development. This is because, the study will provide recommendations and design strategies that are cost-effective to remove pollutants from Finicha River, and mitigate flood risk. In addition, the paper provides site- specific design solution.

1.6 Scope of the Study

The thematic scope of this research is limited to water sensitive urban design and some design consideration including the hard and soft landscape elements. Hydrology of the study area is also considered within the scope range of the research as the study focus on concept of rainwater management at urban level. According to AAEPA report, Addis Ababa has seven major and six medium rivers with 75 tributaries. For this specific study, the chosen urban river is Finicha River , and its 30 hectare of mainly residential development that is found at Yerer (woreda 7), Bole sub City Timely, the research took eight months to finish.

Addis Ababa, Bole Sub City



Bole Sub City Woreda 14, 7, & 6

Action Area, Woreda 7

Planning Area, Woreda 14 & 6

Figure 1.2: Location map

1.7 Limitation of the Study

Due to time constraints, only Finicha River was selected from rivers of Addis Ababa. Existence of blurred maps that illustrate different activities along Finicha River was also limitation of the study

CHAPTER TWO

METHODS

2.1 Introduction

The intention of the study is to develop design strategies. In order to achieve the objectives, the type of sampling technique, which is useful to select case area, will be explained below. In addition, the data collection techniques, methods of data analysis for each objective will be discussed in this chapter.

2.2 Type of the study

The research design used in this study was cross-sectional study method[1]. This is because; the study selected one specific site to examine several outcomes at the same time. For instance, the researcher tried to identify factors that contribute for shrinking of riparian zone of rivers in Addis Ababa , and at the same time the researcher also collected data regarding source of water pollution in order to device mechanisms for improving water quality of the study area's river. This was performed by choosing one specific site. Furthermore, sources of data, which are relevant to the study, were gathered within two months time.

2.3 Sampling Technique and Criteria for Selecting Case Area

The researchers applied purposive sampling techniques[2] because; the researcher had chosen case study area based on well-defined characteristics. **Sampling to Achieve Representativeness or Comparability** is a type of purposive sampling techniques that is used in the study (Bonita et al., 2006). This is because; the technique enables the researcher to select a purposeful sampling that represents a broader group of cases as closely as possible (ibid.,2006). As a result, case area for the study had chosen based on location (CBD), land use, exposure to flood, water quality.

A purposive sampling technique used for interviewing the case area's communities. The selection criteria for interviewing the case area's communities include/ are former settlers; households that are exposed to flood hazards as well as live along the river and around the open space were interviewed.

---

[1]Cross-sectional studies are also descriptive in purpose (Bonita, et al., 2006).

[2] It is a form of non-probability sampling that involves selecting certain units or cases based on specific purpose rather than randomly. Such sampling techniques are applied since the researcher uses his/her prior knowledge to choose cases (Bonita, et al., 2006).

2.4 Methods of data collection and analysis

Methods of data collection and analysis for each and every objective are explained as follows.

2.4.1 Methods of Data Collection and Analysis for Specific objective one

Specific Objective- one: to identify factors that contributes for shrinking of case area's riparian zone.

Methods and Materials for data collection

Reports that are obtained from AAEPA, MUDC, OAAOSZIDP and other local documents were reviewed**.** Beside different books such as Landscape Architectural Graphic Standards, sustainable urbanism: urban design with nature, The Environmental planning Hand book: for sustainable communities and region referred. Additionally, journal, which is Riparian Areas of Greece, their definition and characteristics were referred. International reports such as Design Recommendations for Riparian Corridors and Vegetated Buffer Strips, Functions &Recommended width. A review of the Scientific Literature on Riparian Buffer: Width, Extent and Vegetation were also referred. Soil map was obtained from OAAOSZID

Formal and informal interview with workers and officials of EPA and MUDC; professionals of OAAOSZIDP; elders and community of the study area were onsulted. Site Observations were used as means to collect data regarding riparian zone.

Method of data analysis:

Temporal dimension[3]of urban design was used to interpret and analyze the data gathered from the field and concerned offices. Maps, table, charts, sketch and explanatory diagrams were used to explain change of riparian zone of the study area through time.

2.4.2 Methods of Data collection and Analysis Specific Objective-two

Specific Objective- two: to device flooding control and water quality improvement mechanism for Finicha Rivers.

Methods and Materials for data collection

Water Quality: in the selected case area, water quality of the river was tested in laboratory, which is found in EPA (see laboratory procedures in appendix 2).

Data concerning water quality of the river were obtained from the woreda officials as well as residents and elders of the study area. Data were also collected from direct observation of the study area. Additionally, different books such as Landscape Architecture: A manual of Environmental

[3]Temporal dimension is the one of urban design dimension that deal with time and space (Carmona et al., 2003). According to Carmona et al. (2003), urban environments relentlessly change over time.

planning and Design, Water Sensitive Urban Design Engineering Procedures: Stormwater, Water Sensitive Urban Design in the UK: idea for built environment Practitioners, Water Sensitive Urban Design Principle and Inspiration for sustainable Stromwater Management in the city of the future-Manual, The Environmental Planning Handbook: for sustainable Communities and regions, Environmental Land use Planning and Management and Time Saver Standard for urban design were refereed in order to provide solution through urban design perspective.

Flood control: In order to device flood control mechanisms, it is important to refer to different publications that dealt with flood reduction. As a result, books such as Time Saver Standard for urban design, Environmental Land use Planning and Management, Water Sensitive Urban Design in the Australian , Landscape Architectural Graphic Standards, The Environmental Planning Handbook: for sustainable Communities and regions, Water Sensitive Urban Design Engineering Procedures, Water Sensitive Urban Design in the UK: idea for built environment Practitioners, Water Sensitive Urban Design Principle and Inspiration for sustainable Stromwater Management in the city of the future-Manual were referred. Watershed and river map of Addis Ababa were collected from OAAOSZIDP. In addition to this, construction materials of the case study area's ground surfaces were observed to know the run-off volume. Picture that illustrate permeable, semi- permeable and impermeable surfaces of the study area were taken. Formal and informal interview with the case area's local elders, communities and workers of OAAOSZIDP were carried out.

Data Collection and analysis Method for the Specific Objective- two:

Run off volume of the case study area's surface will be calculated. The data regarding water quality and flood were analyzed using the concepts of SMPs .Tables, Maps, pictures, text were also used to analyze water quality and flooding. Suitability map were carried out by overlaying the slope, building and road.

2.4.3 Methods of Data collection and analysis for data collection for specific objective -three

Specific Objective-three: to delineate recreational-oriented urban green ways along Finicha River;

A Book such as Time Saver Standard for urban design and Public was referred. In addition to this, The Human Dimension of Urban Greenways: Planning for Recreation and related Experience was reviewed. Interview with professionals of OAAOSZIDP and AAEPA were conducted. Site observation was carried out on the selected case area. Informal interview with elders and community of the case area were conducted.

Methods of data analysis

The data that is obtained from interview, observation and the like were analyzed using pictures and texts through Human Dimension of Urban Greenways[5].

2.4.4 Methods of Data collection and Analysis for Specific objective- four

Specific Objective-four: to create healthy connection between the study area's settlers and riverside.

Methods and Material for data collection

Time Saver Standard for urban design and Public Places- Urban Spaces: The Dimension of Urban Design was referred. An article such as integrating public safety and use into planning urban greenways was reviewed. Formal interview with professionals, officials of woreda 7 administration were conducted. Direct observation was carried out on the selected case area. Informal interviews with elders and settlers at Finicha riverside were carried out in order to understand the connection between the settlers and riversides.

Methods of data analysis

Functional dimension[6] of urban design was used to analyze that data. All form of data that will be obtained from the site will be analyzed using pictures and texts.

[5] Human Dimension of Greenways deal with cleanliness, naturalness, aesthetic, safety, access and appropriateness of development

[6] Functional dimensions of urban design involve how place work and how urban designer can make 'better' places (Carmona et al., 2003).

CHAPTER THREE

REVIEW OF RELATED LITERATURE

3.1 Introduction

This Chapter deals with review of related literature on riparian zone. The section will discuss in detail the techniques that can reduce flood risk and improve water quality using the concept of Stormwater Management Practices (SMPs). Additionally, greenways and healthy connection between the city's settlers and riversides will be explained. Moreover, relevant topics that are associated with the research objectives will be discussed briefly.

3.2 Urban Rivers

There are different types of water features in urban areas. For instance, in urban areas, there are four types of water feature (Moughtin, 2003, p.171). The first type is the water point or fountain; while second type is the pool and the third is the coast. The last type of the water feature which is associated with city is the linear water course that is streams and rivers (ibid, 2003).

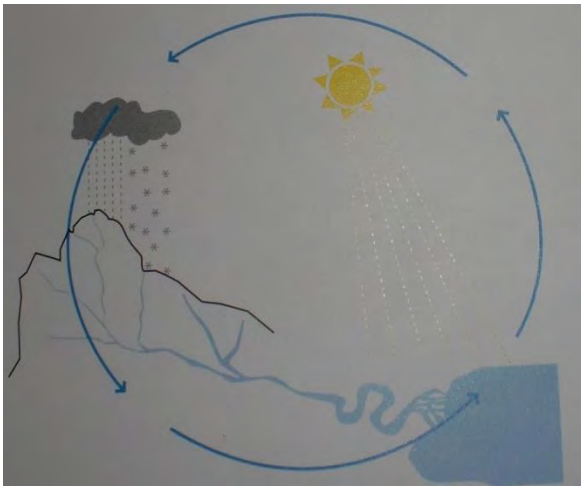


Figure 3.1: water process and their driving forces

Simonds et al. (2006) described that river is a course of water that originates in the mountains and flows downwards until it reaches the oceans. "Rivers are dynamic" (Prominski et al., 2012, p.18). The Sun is source of the energy that drives all the dynamic process (ibid., 2012, p.18).It causes water to evaporate, condenses and changes to snow or rain (ibid, 2012, p.18)."In contact with the earth or rock, the kinetic energy of water can erode materials and thus shape the terrain. These processes are not constant and linear but occur in irregular phases" (ibid, 2012).

Lynch (1960) as cited in Carmona et al., (2003, p.90) noted that rivers are edges[7] for many cities such as Chicago, Hong Kong, Stockholm, etc. For instance, the River Bosphorus structured the image of Istanbul (ibid., 2003, p.90). The river also forms an edge for both the European and Asian sides of the city (ibid., 2003, p.90). Rivers are also considered as external public spaces (Carmona et al., 2003, p.111).Rivers shape landscape and human life as well (Darby et al., 2008).

[8]Edges as cited in Carmona et al. (2003,p. 89 & p.90), Lynch defined edges as linear elements that are either line, among which regions are connected or barriers, which disconnect regions.

3.2.1 Benefits of Urban Rivers

For centuries rivers were important source of food for people settled close to their banks (Birkhauser,2012). Urban rivers have environmental, cultural, social and economic values (Darby et al., 2008). Human beings are using river for drinking water, irrigation, industry, power production, transport, fishing boating, swimming and aesthetic enjoyment (Darby et al., 2008 and Hopper et al., 2007;). Rivers provide connection between landscape and communities.

Hopper et al. (2007, p.104), throughout human history, people have settled along rivers and lakes for the purpose of transportation, water supply, and waste disposal .As a result, most cities and towns, which are near to rivers, have converted riparian areas to settlements and waste disposal areas (ibid, 2007,104).According to Farr (2008, p.299) riparian areas are vegetation near water bodies, and they are characterized by high water table.

3.3 Riparian Zone

Riparian is derived from Latin word "riparius" that means river bank (Zaimes et al., 2010, p. 176).Zaimes et al (2010, p. 176) also noted that riparian areas is also known as "riparian woodlands", "riparian forests", "riparian buffer zones", "riparian strips", "riparian zones", "cottonwood floodplains", "alluvial floodplains", "floodplain forests", "bosque woodlands", "cienegas" and "meadows."Fischer et al. (2000) defined riparian zones or riparian areas as linear strip of vegetation along streams, rivers, lakes, reservoirs. Riparian zones are ecotones[8] between aquatic and upland terrestrial habitats (Fischer et al., 2000 and Zaimes et al., 2010).Riparian areas are located along streams, lakes, and the like (Zaimes et al., 2010, p. 176). Riparian areas or riparian zones have unique characteristics as are described below (ibid,2010).

Zaimes et al. (2010, p. 177) described that riparian areas have unique characteristics due to three main features. These features are water, soil and vegetation. As a result, riparian areas have, highly moisturized soil; vegetation which are denser, taller and in many cases with different species as well as higher water table compared to their adjacent terrestrial upland ecosystem (ibid., 2010, p.177).

[8]Ecotones are transitional areas (Zaimes et al., 2010, p.177 & p.182)

Different scholars explained the benefits of riparian zones. For instance, According to Hopper et al. (2007, p.104) and Fischer et al. (2000, p.2), riparian areas are areas that provide shelters for different biodiversity on the banks of rivers, stream and other water bodies. Daniels et al. (2003, p.124) and Fischer et al. (2000, p.2) also explained that riparian forests filter sediments and storm water before entering into waterways such as rivers, streams and the like. As a result, they improve water quality of waterways. Daniels (2003, p.120, 219&p.235) described that riparian zones minimize soil erosion and run off volume as well as stream bank stabilization. Fischer et al. (2000) also noted that riparian areas attenuate flood.

According to Wenger (1999), removals of riparian forests have negative effect on both terrestrial and aquatic habitats. This is because, such logging increases temperature, riffle sediments, soil erosion, water pollution etc. Therefore, to minimize the negative effects of cutting down of forests, scientific studies show that the recommended width of riparian buffer zones based on the function that they give to human, water bodies and other biodiversity. This concept is described below briefly.

In a view of Fischer et al. (2000, p.4), riparian strips are classified into two based on the concept of riparian strip-width. These are fixed-width riparian strip and variable-width riparian strips. Johnson et al. (1994) as cited in Fischer et al. (2000), fixed-width buffer strip recommendations tend to be based on a single parameter or function. They are easier to enforce and administer by regulatory agencies but often fail to provide for many ecological functions. Variable width buffer strips are generally based on a variety of functions and usually account for site-specific conditions by having widths adjusted along the length of the strip depending on adjacent land use, stream and site conditions (e.g., vegetation, topography, hydrology), and fish and wildlife considerations (Fischer et al., 2000) (see table 3.2). Wenger (1999) also forwarded recommendation for width of riparian buffers based the function they provide to natural communities along water bodies such river, stream, lakes and so on.

Table 3.1: General riparian buffer strip width Guidelines (source: Richard, et al., 2000)

Function	**Recommended Width in meter (m)**
Water Quality Protection	5 to 30m
Riparian Habitat	30 to 500m+
Stream Stabilization	10 to 20 m
Flood Attenuation	20 to 150m

Buffer widths for effective sediment removal vary as slop of ground surface different from place to place. For instance, width of the buffer can be few feet in flat area. In contrast to this, to reduce riffle sediment, the required riparian strip width is several hundred feet in steeper areas (Hawes et al., 2005, p.4).

Water quality: riparian forests have the capacity to trap nutrients such as nitrogen and phosphorous before entering into rivers if the width of the buffer ranges from 16 to 164 feet (Hawes et al., 2005, p.4). Unlike narrower buffers, wider buffers provide long-term storage (Wenger, 1999 and Hawes et al., 2005). In addition to this, the two scholars also agreed with the idea that riparian buffers have the potential to remove nitrogen more easily than phosphorous. Wenger (1999) explained in detail the reasons why riparian buffers can easily remove nitrogen. The reasons are nitrogen gas can uptake by vegetation and denitrification[9] (Wenger, 1999).

As understood from the above description, riparian buffer zone can more easily remove nitrogen than phosphorus. Pesticides that are applied manually require less of a buffer area than aerially-sprayed pesticides (ibid, 2005). Wenger (1999); Army Corps (1991); Fisher and Fischenich (2000); Broadmeadow and Nisbet (2004) as cited in Hawes et al.(2005) illustrate effective width of riparian buffer for temperature control, nutrient retention, sediment control, Bank stabilization, pesticide retention, aquatic and terrestrial habitat (see table 3.2).

Table 3.2: width of Buffer based on function (Source: Hawes et al., 2005)

	Effective width of Buffer (in feet)					
Wenger (1999)	Aquatic Wildlife	Terrestrial Wildlife	Stream Temperature	Litter/ Debris input	Nutrient Retention	Bank Stabilization
Army Crop (1991)		220-574ft.	33-98 ft.	50ft.	50-100ft.	-
Fisher and Fischenich (2000)	98ft.	30-656ft.	33-66ft.	66-102 ft.	52-164 ft.	49-98 ft.
Broadmeadow and Nisbet (2004)	>98 ft.	98-1,640	-	10-33 ft.	16.4-98 ft.	30-66 ft.

Therefore, the width of the riparian buffer zone is different based on the function they provide to terrestrials and aquatics wildlife. Hawes et al. (2005) described the different factors that influence the effectiveness of buffers. The factors are explained as follows.

According to Hawes et al. 2005 slope, soil and vegetation type in the buffer and other characteristics specific to the site influence the effectiveness buffers. (Hawes et al. 2005).

[9]Anaerobic microorganisms convert nitrate into nitrogen gas, which is called denitrification (Wenger, 1999).Denitrification also occurs within stream channels themselves, though at rates much lower than in riparian

Slope

As slope increases, the speed at which water flows through the buffer increases (ibid., 2005). Therefore, the steep areas require wider buffer width in order to slow the water flow and trap pollutants (ibid., 2005, p.6)

Soil type

Different soil types absorb water at different speed. For instance, clay soils are less permeable and may have high runoff (Ibid, 2005, p.6). In contrast, sandy soils drain water quickly into the groundwater. As a result, those roots are not able to trap pollutants effectively (ibid, 2005,p.6).

Vegetation mix

Wenger, 1999 and Hawes et al., 2005 noted that riparian buffers that comprise mix of trees, shrubs and grasses have the capacity to trap wide range of pollutant than a riparian buffer that is merely trees or grass.

Table 3.3: Reduction water contaminant

Buffer Type	Nitrogen	Phosphorous	Sediment
Forested	48-74%	36-70%	70-90%
Vegetated Filter Strips	4-70%	24-85%	53-97%
Forested Vegetation Filter Strips	75-95%	73-79%	92-96%

In General, the grass filter strip removes sediment effectively, while the forested buffer work best at removing nitrate from subsurface flows. Additionally, a forested buffer provides shelter for terrestrial wildlife. Grasse has better capacity to minimize greater runoff and riffle sediments as it characterized by a shallower and denser root. Trees have a deeper root system that can trap and uptake nutrients from the groundwater, stabilize banks, and regulate the flow of water to the stream. Furthermore, trees shade the river and provide an input of leaf litter and branches that are necessary for many aquatic species. In addition, Native plants species are preferred to ornamentals or exotics due to the habitat advantage they provide for wildlife.

In a view of this, the most effective riparian buffers should include a mix of trees, shrubs and herbaceous plants native to the region and appropriate to the environment in which they are to be planted.

3.4 Flood Control and Water Quality of Rivers

3.4.1 Flood

According to Watson et al. (2003, p.7.5-4) and Randolph (2004, p.206), when water flows exceed stream channel capacity, water will overflow onto the adjacent land as flood. Flood can be termed as "overbank flood" (ibid., 2003, p.7.5-4). The aforementioned authors noted that flood can destroy properties and downstream drainage structures. For instance, Randolph (2004, p.206) and Daniels et al (2003,p. 258) noted that flooding have been the reason for the loss of Americans' life. In the United States of America, flood also cause more than $1 billion per year damage on property (ibid., 2004, p.206; ibid., 2003 p. 258).

3.4.2 Flood Type

Scientific studies have shown that have showed that flood can be classified based on some characteristics. For example, Daniels et al. (2003, p. 264) described that flood can be classified into three based on their physical characteristics. Hopper et al. (2007, p.783) noted that flood also categorized into five based on location or physical behavior of the water bodies. Additionally, Watson et al. (2003) floods are ranked in terms of their statistical return frequency. Each classification of flood types is explained below.

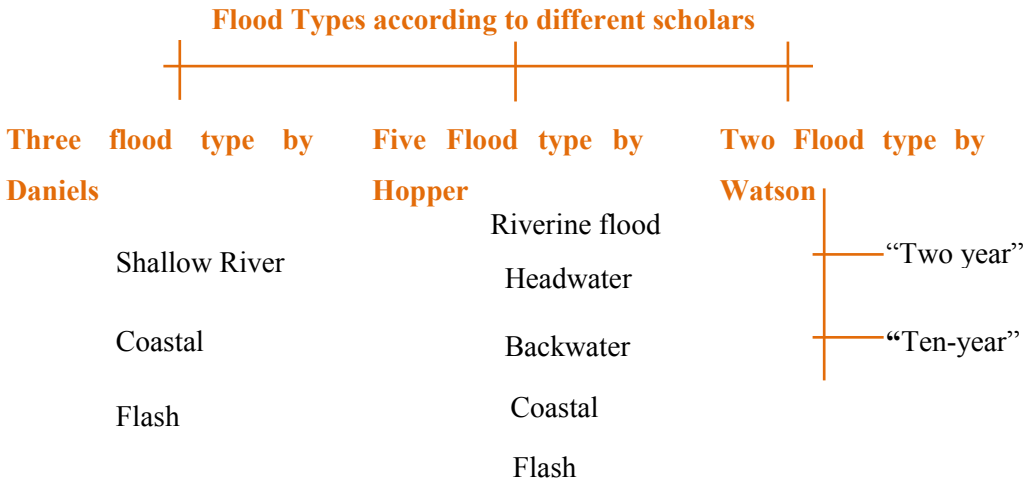


Figure 3.2: Flood type

Box 3.1: Types of flood according to different scholars.

Flood type based on physical characteristics

According to Daniels et al. (2003, p.264), there are three

Shallow River flooding: it occurs due to rainstorms and melting snow. As result of this, rivers spill out on to their banks.

Flash floods: it is caused by heavy downpours from thunderstorms

Coastal flooding varies in location, season, intensity, and impact

According to Hopper et al. (2007, p.783), there are five types of flood

Riverine flood: Great overflows of water from a river channel onto a floodplain caused by precipitation over large areas, melting snow, or both. Over-bank flow is a normal geophysical event that occurs on average every two years for most rivers.

Headwater flood: A riverine flood that results from precipitation directly in a basin.

Backwater flood: A riverine flood caused by high stages on downstream outlets, which prevent drainage from tributary basins or even reverse the flow.

Coasta1 flood: Overflows onto coastal lands bordering an ocean, estuary or lake. Coastal floods are caused by tsunamis (seismic sea waves), hurricanes and northeasters.

Flash flood: A local flood of great volume and short duration. Flash floods differ from riverine floods in extent and duration. Flash floods generally result from a torrential rain or "cloudburst" covering a relatively small drainage area. Flash floods may also result from the failure of a dam or sudden breakup of an ice jamb.

According to Watson et al. (2003), flood type based on their return

Flood type based on the rate of occurrences

"Two year" flood: it has a fifty percent chance of occurring in any given year (ibdi., 2003).

"Ten-year" flood: it has a ten percent chance of occurring in any given year (ibdi., 2003).

3.4.2.1 Approach to Flood Hazard Mitigation

According to Randolph (2004) Randolph (2004) and Daniels et al. (2003), to minimize flood damage, structural and nonstructural measures have been taken as approach. The nonstructural measures[10] provide affordable insurance for flood damages and information regarding flood issues, etc (Randolph, 2004). For instance, Daniels et al (2003, p. 265) and Randolph (2004, p.207-209) indicated that structural measures were used to mitigate flood risk. Such structural measures include traditional flood control (Dam and Reservoirs), channel modification (widening, straightening and lining) and floodwalls (Randolph, 2004, p.209). However, both scholars described that those flood control structures never decrease flood risks. According to Randolph (2004, p.207-209) and Daniels et al (2003, p. 265), in United State of America, the structural measures caused serious damage to human life and properties (see table 3.4). In contrast, innovative structural measures ("*Innovative Stormwater Management"*) are effective in controlling flood (ibid., 2004) .

. Table 3.4: The effects and problems of structural flood mitigation measures

Measures	**Effects**	**Problems**
Traditional Flood Control **(Dam and Reservoirs)**	Detain runoff (Randolph , 2004, p. 209)	Dams and reservoirs permanently flood riparian zones. That is "false *sense of security*" (Randolph, 2004, p. 209). According to Daniels et al (2003, p.77), dams have environmental impact such as flood wildlife habitats, wetlands and destroy aquatic habitats. Furthermore, dam are not economical to construct.(ibid.,2003, p.265)
Modification of Channel by widening straightening & lining.	Increase capacity, speed of water drainage	Destroy natural channel and high peak flows downstream.
Levees, Floodwalls	Protect one side	Daniels et al (2003, p. 265), levees can break. As a result it requires maintenance.
Innovative Stormwater Management	Reduce speed of flood flows	

[10]nonstructural measures provide flood maps, flood warning (Randolph, 2004). For more information regarding non-structural measures refer Environmental Land Use Planning and Management book.

As discussed earlier innovative stormwater management work best at mitigating flood damage. Additionally, Farr (2008), Watson et al (2003), Daniel et al., (2003), Randolph (2004) and other scholars explain in detail the importance of stormwater management at reducing flood risks. According to Lloyd (2001)and Kelly et al. (2005) Stormwater management is one of the elements of water sensitive urban design that reduce stormwater runoff by treating the stormwater as close to the source as possible. Water sensitive urban design is the integration of urban water resource management with urban design and planning (Kelly et al., 2005). Lloyd (2001) also described WSUD as new method to urban design and planning that bring sustainable solution by integrating natural water cycle and land development.

3.4.2.2 Flood Control through SMPs

The followings SMPs elements are effective in controlling flood damage

Rainwater Harvesting

Rainwater tanks are designed to capture and store rainwater from gutters or downpipes on a building (Kelly et al., 2005). In addition, they can retard a flood. (ibid., 2005).

Detention and Infiltration

Infiltration and detention measures have their own contribution in reducing flood damage as they reduce surface water flows and stress on stormwater and restore natural hydrology (Hoyer et al., 2011;). Such measures include green roof, permeable paver as well as infiltration measures (Randolph, 2004, p.454 and Hoyer et al., 2011) Infiltration measures are concentrated planted spaces for rapid infiltration of surface water.

Figure 3.3: Water tank

Figure 3.4: Green Roof

Figure 3.5: Infiltration

Conveyance and open channels

Randolph (2004, 456) indicated that open channel system reduce runoff speed. Open channel systems include swale, spread and flow diverters. **Randolph (2004) and** Hoyer et al. (2011) described that swales are vegetated open channels designed to convey and attenuate stormwater runoff.

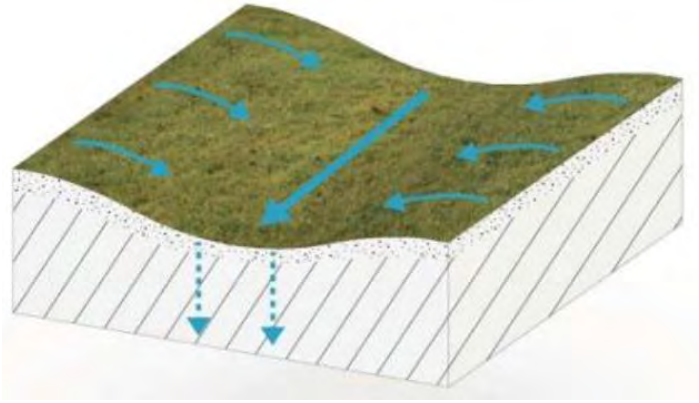


Figure 3.6: Swale

Stormwater ponds

Watson et al (2003, p. 7.5-5) described that Stormwater ponds consist of a permanent pool, extended detention or shallow marsh equivalent. According to Randolph (2004, p. 450) Wet Pond, Wet Extended Detention Pond, Multiple Pond System, dry ponds and "Pocket" Pond design alternatives/ variants. They detain and store runoff for slow release (Randolph, 2004). Stormwater ponds[11] are good in controlling flood.

Figure 3.7: Detention pond (wet) in Tanner Springs Park, Portland, Oregon, USA

Figure 3.8: Detention pond (dry) Gelsenkirchen Germany

[11] For more information refer Environmental Land Use Planning and Management book.

Stormwater Wetlands

Kelly et al. (2005) and Randolph (2004) explained that storm water wetland systems are shallow vegetated water bodies. According Randolph (2004, 452 &453), there are four types of wetlands. There are shallow marsh, extended detention (ED) wetland, wetland-pond system, "pocket" wetland. Except pocket wetland, the aforementioned wetlands are good in controlling flood.

Figure 3.9: wetland

3.4.3 Water Quality of Rivers

3.4.3.1 Water Pollutants

Major pollutants carried by surface runoff include the following:

Oxygen- demanding or organic wastes deplete / reduce dissolved oxygen (DO), which is required to support aquatic animals in rivers and other water bodies through biological decomposition, of water Randolph (2004, p.393).

Plant or inorganic nutrients comprise phosphorous and nitrogen (ibid., 2004,p. 393). Wenger (1999, p. 21) noted that Potential nonpoint sources of phosphorus consists of agricultural fertilizers, animal wastes, septic drain fields, leaking sewer pipes, lawns' fertilizers . Wenger (1999, p.24) mentioned that nonpoint sources of nitrogen are like those of phosphorus. Wenger (1999, p. 21 & p.24) and Randolph (2004, p.393) indicated that enhance in phosphorous and nitrogen can quicken plant growth, algae blooms, low dissolved oxygen, temperature increment as well as resulted in the death of certain aquatic animals. According to Randolph (2004, p.393), excess amount of nitrates and ammonia together with phosphorous can accelerate aquatic plant growth and change the type of aquatic animals.

Suspended solids: sedimentation in rivers, streams and the like occurred due to suspended solids Randolph (2004, p.394). "They include particles that will not pass through a 2-micron filter, including silt and clay, plankton, algae, fine organic debris, and other particulate matter" Randolph (2004, p.394).

Dissolved solids: disturb the water balance in the cells of aquatic organisms (ibid., 2004, p.394). They contain calcium, chlorides, nitrate, phosphates, iron, sulfur and other ions particles that dissolved solids.

Disease- causing microorganisms include pathogenic bacteria, viruses and protozoans that also live in human and animal digestive systems. Members of two bacteria groups, coliforms and fecal streptococci, are used as indicators of possible sewage contamination because they are found in human and animal feces. Disinfection reduces microbial contamination. In addition, natural waters can provide breeding areas for carriers of disease, such as mosquitoes, which carry malaria and the West Nile virus Randolph (2004, p.395).

3.4.3.2 Improving Water Quality of Rivers by SMPs

Different scholars explained in detail water improvement mechanisms by using the concept of SMPs. For example Randolph, Hoyer and Watson discussed at length elements of WSUD, which are means to improve water quality. For instance, according to Randolph (2004, p.448-456),Watson et al. (2003, p. 7.5-5)and Daniels et al (2003, P.413) , in order to reduce water pollutants, it is advisable to use SMPs as the treatments are effective in removing the pollutants before they leave the site. Such SMPs have the capability to remove 80% of the Total Suspended Solids (TSS) (ibid., 2003, p. 7.5-5). SMPs are the most cost-effective ways to remove nonpoint source from waterways. (ibid.,2003, P.413). Such treatment practices are described below.

Bioretention

Hoyer et al. (2011, p.18) and Randolph (2004, p. 448 &449) explainedthat bioretention areas are soil- and vegetation-based SMPs that filter runoff from developed site. Further, they are located either in parking lot islands or residential areawhich are natural pollutant removal mechanism (ibid., 2004,p.448 &449). Kelly et al. (2005, p.81) also agreed with this concept. Randolph (2004, p. 449) described that bioretention consists of channels[12] and benches[13].

[12] Bioretention channels provide conveyance, filtration and infiltration (Randolph, 2004).

[13]Bioretention benches deposited soil bed, mulch and vegetation as a bench on slope to slow, store and filter runoff (ibid., 2004)

Forms of Bioretention

Figure 3.10: Stormwater planters:

Figure 3.10: Stormwater planter: are typically used in ultra urban areas adjacent to buildings.

Figure 3.11: Rain gardens:

Figure 3.11: Rain gardens: capture roof, lawn and driveway runoff from low to medium density residential lots in a shallow depression in the front, side, or rear yard of the home depending on the development's drainage pattern.

Figure 3.12: Extended tree pits

Figure 3.12: Extended tree Pits: (also known as parallel bioretention) are located within the road right of way and take advantage of the landscaped space between the sidewalk and street.

Constructed wetlands

Constructed wetlands are the most effective stormwater practices in removing pollutant and enhancing aesthetic value (Kelly et al., 2005).

Infiltration Basin

Infiltration basin is a shallow impoundment designed to capture stormwater runoff and allowing it infiltrate into the ground over a period of a couple of days. It has high pollutant removal capacity.

Filtering Measures

Watson et al. (2003, p. 7.5-5) explained that Stormwater filtering systems capture and temporarily store the water, and pass it through a filter bed of sand, organic matter, soil or other media. Filtered runoff may be collected and returned to the conveyance system, or allowed to partially filtration into the soil (ibid., 2003). Design variants include: Surface Sand Filter, Underground Sand Filter, Perimeter Sand Filter, Organic Filter and filter strip (Randolph, 2004). The filters provide recharge and treat the stormwater.

Figure 3.13: Sand filters can be installed above ground**.**

Swales

Kelly (2005) mentioned that swales are vegetated open channels explicitly designed to capture and treat the water within dry or wet cells formed by check dams. Check dam can enhance storage to achieve water quality volume (Randolph., 2004).

Figure 3.14: Swale

Biotopes

Hoyer et al. (2011) noted that biotope is a plant that improves water quality through natural oxygenation. .Biotopes has two benefits. That is, they improve water quality and add aesthetic value to ponds or water features. (ibid., 2011).

Figure 3.15: Biotopes in Tanner Spring Park, Portland, Oregon, USA

3.5 Urban Greenways

3.5.1 Greenways Meaning

Watson et al. (2003) and Brady et al.(2001) defined greenways as linear open spaces for public access and recreational activities thereby protect natural resources in the urban area. They can be trails or vegetated paths, which can range in width from a footpath to several miles, in urban areas.

> *"The term "greenway" suggests two separate images: "green"suggests natural amenities such as forests, riverbanks, wildlife; "way" implies a route or path. Together they describe a corridors or trails crisscrossing a landscape that has been otherwise transformed by development."*(Watson et al., 2003, p. 5.5-1).

3.5.2 Types of Greenways

Little as cited in Watson (2003) identified the greenways types. These are urban riverside, Recreational greenways, ecologically significant natural corridors, scenic historic routes and comprehensive greenway systems. They will be described below with illustrative/ explanatory images.

Urban riverside (or other water body) greenways: they are formed along neglected city's riversides in order to protect natural resources along rivers (Watson et al., 2003).The waterfronts that are affected by urban activities can be ameliorated by redevelopment program(ibid., 2003).

Figure 3.16: Scioto River Greenways

Recreational greenways: they consists various types of paths and trails, usually long distance, based on natural corridors as well as canals and railway routes (ibid., 2003).

Figure 3.17: recreational greenways)

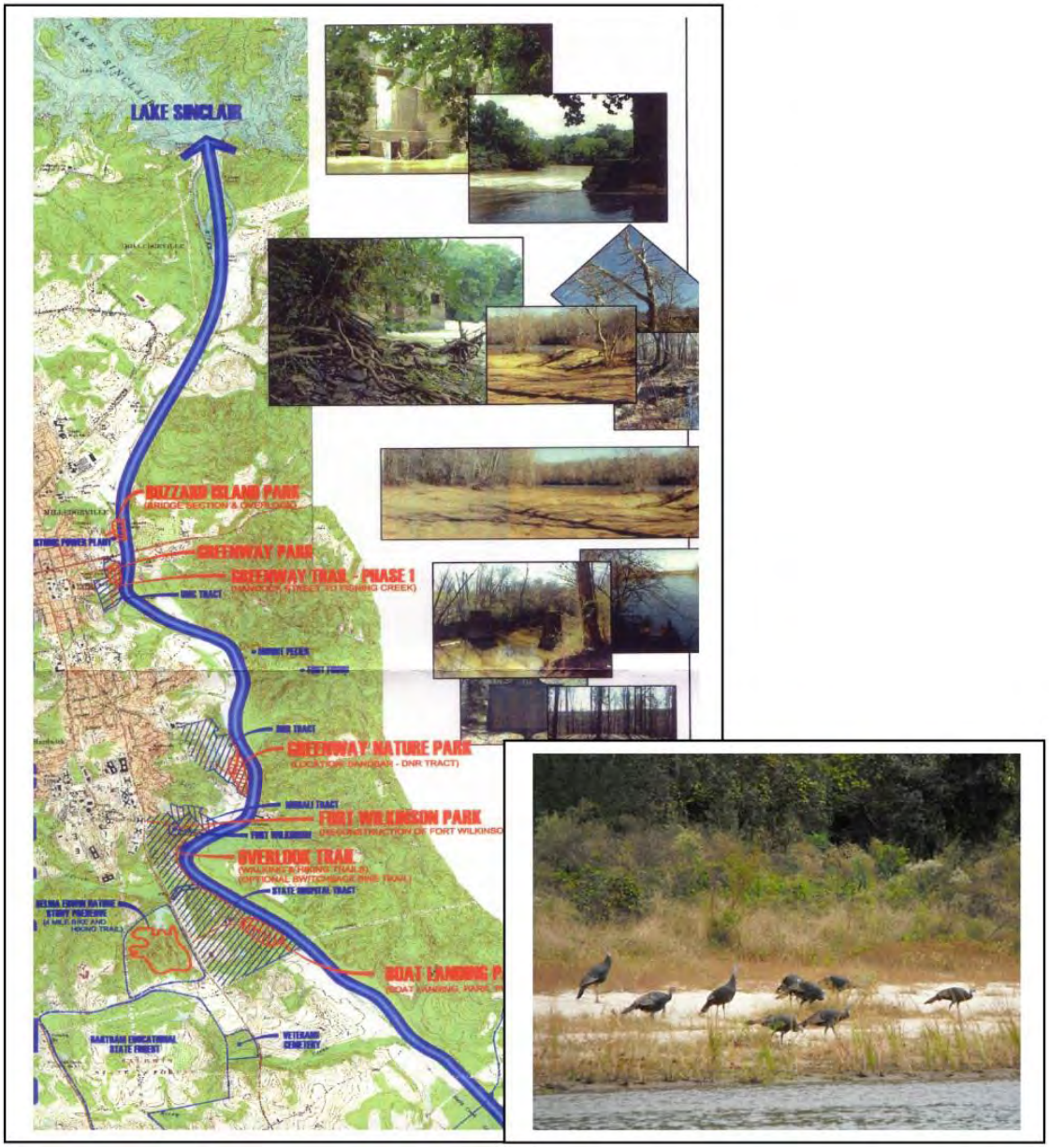


Figure 3.18: Ecologically significant natural corridors

Ecologically significant natural corridors: often along rivers and streams and less often ridgelines. Such spaces make possible migration of species, and natural hiking and protect wildlife (ibid., 2003).

Scenic historic routes: along a road, highway or waterway, the most representative of them making an effort to provide pedestrian access along the route or at least places to alight from the car (ibid., 2003)

Comprehensive greenway systems or networks: sometimes, they are formed by linking different kinds of open areas to greenways in urban and regional scale to create municipal or regional green infrastructure.Usually based on naturallandforms such as valleys and ridges (ibid., 2003).

3.5.3 Benefits of Greenways

Scientific studies indicate that greenways have dualfunction. For instance,According to Watson et al. (2003), Brady et al (2001) and Luymes et al (1995) greenways provide both social and ecological benefits. Social benefits include provide recreational use, paths for non-motorized transportation such as walking, cycling, horse riding, etc. Further,Luymes et al (1995) indicated that social benefits of greenways contain nature education and nature appreciation opportunities for urban residents. Ecological benefits comprise, protect wildlife, stream quality (reduce the negative effect of non-point source pollution), flood hazard and wetland protection as well as moderate microclimate (air quality and reduce cities' temperature) and the like. Greenways are an inexpensive way to meet this need because potential sites consist of relatively narrow corridors of land, often within available bottomlands, floodplains, abandoned railbeds, and other otherwise undevelopable locations.

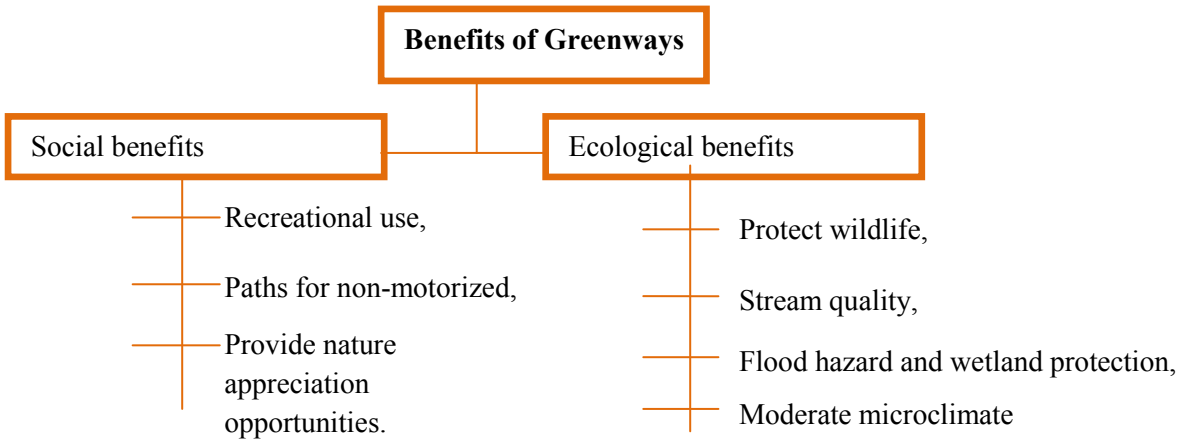


Figure 3.19: function of greenways

3.6 Connection between the City's Settlers and Riversides

According to Carmona et al. (2003), river is also considered as external public space. Comfort, relaxation, discovery, passive and active engagement are community primary needs that people seek to satisfy on external public spaces/ communal spaces (ibid.,2003).Such needs will be discussed briefly as follows.

Comfort

Comfort is a prerequisite of successful public spaces. The length of time people stay in a public space is a function and an indicator of its comfort. Acorrding to carmona, the dimensions of a sense of comfort comprise environmental (relief from sun, wind, etc.) physical comfort (sufficient seating, lighting etc.) social and psychological comfort (a sense of security) and by quality of design and management (ibid).

Relaxation

Relaxation is a more developed state with the 'body and mind at ease. 'In public space the most vital things that make it easier to be relaxed are natural elements - trees, greenery, water bodies and separation of the place from vehicular traffic (ibid., 2003). However, such features also obstruct visual access (visual permeability), creating safety problems and sometimes discouraging use. As in all aspects of design, it is necessary to achieve a balanced whole (ibid., 2003).

Passive engagement

It needs to come across with the setting, even if without becoming actively involved. The prime form of passive engagement is people-watching other people and the life and activity that they bring (ibid., 2003). Opportunities for passive engagement are also provided by fountains, views, public art, performances, and so forth. Passive activities are like watching and hearing other people watching children, vegetation, water, wildlife, activities, and other people reading, meeting friends or visiting the garden are some of them (ibid).

Active engagement

It involves a more direct experience with a place and the people within it. The coincidence of people in space and time provide opportunities for contact and social interaction. In this case how the design of public space supports interaction (ibid., 2003). Gehl refer to the 'varied transitional forms between being alone and being together' and suggests a scale of 'intensity of contact' ranging from close friendships' to 'friends', 'acquaintances', 'chance contacts' and 'passive contacts'. Gehl also suggested that design of the public realm can create or inhibit opportunities for contact.

Those community primary needs are necessary to create health connection between the city settler's and riversides. The above mention riparian zones, flood control and water quality improvement

mechanism also contribute to healthy relationship between city's settlers and riverbanks as it provides solution to misused rivers.

CHAPTER FOUR

CONTEXTUAL STUDY

4.1 Introduction

This section will discuss the factors responsible to the shrinking of the city's riparian zone, and the consequences of its mismanagement. It will also clarify the sources of the city's rivers pollution and its causes. Furthermore, it will also discuss factors and effects of floods and greenways of the city along with the measures taken by the concerned bodies such as AAEPA and MUDC to create healthy relationship between the city's settlers and riversides.

4.2 Riparian Zone

Riparian zones of Addis Ababa are also called informal greens along the river banks. Informal greens include highland green areas, buffer along rivers, park developments, and planting trees along the Ring Roads, upgrade existing parks as well as integrate cemeteries with parks (MUDC, 2004EC) . As it can be understood form the above description, riparian zones of Addis Ababa have no single name rather it has more generalized names.

4.2.1 Characteristics of Addis Ababa's Riparian Areas

Riparian zones have more moist soil, mixed vegetation and higher water table than terrestrial ecosystem. This makes riparian buffers to have unique characteristics. But nowadays riparian zones of Addis Ababa seem to lack such characteristics as mentioned by the interview made with officials of AAEPA and OAAOSZIDP.

There are different types of vegetation along the rivers of the city. For instance, Seyoum et al. (2007, P. 20) explained that along the major streams and rivers, there are generally narrow bands of forests. Such forests are dominated by Ficus sycamorus, Celtis crausiana, Diospyros mespiliformis, Lepisanthes senegalensis, Mimosops kummel, Phoenix reclinata, Tamarindus indica, Teclea nobilis, Syzygium guineense, Acacia etc. Most of the trees are associated with wide ranges of shrubs, herbs and grasses. Swamps are dominated by sedges, grasses and herbs. In addition, according to the interview made with Dr. Agzaw, who is worker of Addis Ababa and the Surrounding Oromia Special Zone Integrated Development Plan Office, the vegetation along rivers of the cities are not planned as they are naturally grown. According to the interview made with Ato Samson and w/t Fantu , who are workers in AAEPA under biodiversity and ecosystem controlling and monitoring research team, vegetation type that exist along the rivers are eucalyptus, castor oil ('gulo' in Amharic), vernonia (

'gerawa' in Amharic), grass, 'shembeko', 'sama' , Acaccia ('gerar') and the like. Also Ato Samson explained that the riverside are dominantly occupied by shrubs such as castor oil, vernonia, etc.

However, the size and diversity of vegetations along the city's riversides are diminishing in size as it can be understood form the data obtained from the interview. The causes for shrinking of the city's riparian zone will be discussed as follows.

4.2.2 Factors for Shrinking of the City's Riparian Zones

Population Growth and Housing Demand

Seyoum M. et al (2007, p. 13) mentioned that the coverage of the city's riparian zones are decreasing due to population growth. The fast development and expansion of the city has contributed to the increased population as a result of escalated migration from the rural areas and neighboring towns (MUDC, 2004EC, p.74). The immigrants are beyond the capacity of the city can accommodate and due to the scarcity of enough housing facilities, many of them have settled by riversides where they believe less attention/emphasis is given by the government (ibid.,2004EC, p.74). Birhanu (2007) as citied in the report of MUDC (2004, P. 77 & p. 78) following the fast development and civilization of the city , basic infrastructures such as industries, trade, health and the like have become more improved and advanced compared to the rural areas. For this reason, communities from the rural areas migrate to such areas for a better lifestyle. However, supply of resources to city residents are not balanced with their demand. And for the immigrants to have a stable and settled life in the cities, their housing needs have to be fulfilled first and foremost. However, issues like limited land supply/availability, unfair and unaffordable cost of rental houses, insufficient financial capability to construct houses and so on forced the immigrants to settle illegally around the riverside where they think the government does not want the land for the time being. This holds true in the case of Ethiopia as well.

Settlements along riversides

According to MUDC (2004, p.4 & p.77), Seyoum M. et al (2007 p.13) and Hayal et al. (2011, p.9) the research made on Addis Ababa shows more than 90% of the city's riversides are occupied by residents who settled either illegally or permits granted by Keblele authorities. To take one example, many immigrants have settled around Akaki River without obtaining a legal permit from the government (MUDC, 2004, P.74). Additionally, according to EPA (2002, p.7), riversides of Addis Ketema, Lideta kirkos and Arada are occupied by the formal and informal settlements. About 10,000 ha of the green frame are already used for other purposes: residential, industrial developments, etc (Seyoum et al., 2007). MUDC (2004, p.790) also mentioned that forestes that grew along rivers were

cut down and are used by the residence of the city for fire wood. In this regard, the riparian zone along the city's rivers tends to deteriorate rather than improve.

Waste Dumping area

According to AAEPA (2002 EC., p. 2) and MUDC (2004. P 75), 25-30% of solid wastes of the city are dumped on roadsides, green area and riversides. Specially, rivers of Addis Ababa became waste dumping areas. Dr. Agzaw described that, riparian zones are places that are used for toilet. Instead of making riverside clean and green, institutions,

Figure 4.1: 'minalesh Tera', Addisketama Subcity in 1999EC.

Figure 4.2: Lideta Sub-city, around Saris's river in 1999 EC.

which are constructed along rivers , are using the rivers and riversides for dumping solid and liquid wastes (AAEPA, (2002,p.3). Instead of planting plants along rivers and making river spaces recreational area, riverside become a place for cars wash. For this reason, vegetations along rivers are disappearing. In addition, there are also mining activities in the river buffers (AAEPA, 2002, p.13). According to report of AAEPA (2011, p. 2), most of the river buffers of the city are occupied by illegal quarry developers. Riversides are becoming zones of stone excavation.

Figure 4.3: Waste materials from construction buildings, Lideta Subcity behind china Embassy

Figure 4.4: the riverside became stone exavation area inAkaki kalit, around 'Woreku Sefer'

Lack of awareness and public participation as well as shortage of trained manpower

Shortage of skilled manpower in some of the implementing agencies especially in the AAEPA is also a factor which contributed for the shrinking of the city's riparian areas.

Besides, there is lack of awareness from the decision makers to the public about the importance of riparian areas (Seyoum et al., 2007). Inadequate public participation during the planning stage has also contribution for decreasing the riparian zones in size.

Figure 4.5: Partial view of gully erosion, Upper catchment of Yeka SUB-City (Source AAEPA, 2011)

4.2.3 Consequence of Mismanagement of the City's Riparian Zones

Due to the illegal settlement and mining activities in the river buffers, the size and diversity of the vegetation and wildlife resource of the river buffers are highly diminishing, which, in its turn hinders the mobility of the wild animals from the upper catchments to the lower catchments of the city as a natural movement corridor (AAEPA, 2002EC., P.13 and 2011, p.3). Additionally, According to MUDC (2013, P.28), due to lack of appropriate consideration, they are being used as dumping place of refuse, illegal settlement, and public latrine which make them impose negative effect on the image of the cities and cause health problems to the community .As a result of mismanagement of the riparian zone gully erosion [14] has occurred.

Tabel 4.1: River Buffer in Hectare (AAEPA, 2002)

No	Sub-cities	River buffer (hectares)
1	Addis Katema	38.87
2	Arada	44.87
3	Akaki-Kaliti	1072.17
4	Bole	1309.5
5	Gulele	26.94
6	Kirkos	43.95
7	Kolfee Keranyo	269.74
8	Lideta	43.95
9	Nefas Silk Lafto	746.49
10	Yeka	341.43
total		4197.33

In order to improve the mismanagement and development of the city's riparian zones, the city developmental plan designated 15m of width for riparian zones that are located in inner city. Also along the expansion areas of the city, 50-100m width are assigned. The City Development Plan of Addis Ababa also allocated 22,000 ha of land for the green frame thereby expected to cover 41% the city's territory if successfully implemented. However, the green frame of the city has an area of about 4,197. 31 hectare (see table 4.1).

[14]Gully erosion creates large channels. These are so deep that they cannot be removed during normal cultivation with ordinary farm implements. They are formed from small rills that concentrate water and enlarge until several join to form a channel (Figure 1.2).

4.3 Status of River pollution

In cities, the major sources of river pollution are the location of industries, dumping of dry and liquid wastes, oil spills from garages and gas stations as well as car wash near riversides. It is also important to note that dangerous wastes are thrown out from medical centers (MUDC, 2004). The other problem is the construction of houses along rivers. The sources of rivers pollution are discussed at length as follows.

Figure 4.6: From paint factory, liquid waste that is released without any treatments into rivers, Nifas Silk, Lafto Subcity (source: MUDC, 2004, p.24)

4.3.1 Industries

In our country, the establishment of small scale industries started in the 1920s (AAEPA, 2002 E.C, p.15). The purpose of establishing small scale industries was mainly to produce consumable and building materials ((ibid., 2002EC, p.18). In addition to this, from industries that are found in Ethiopia, more than 65% of the industries are found in Addis Ababa. (AAEPA, 2005 EC). These industries are mainly located near riversides, which are mostly found in the western and southern parts of the city. Since 90% of these industries do not have waste cleaning facilities, the industries waste products are thrown out into the rivers and riversides (MUDC, 2004EC and AAEPA, 2005 &2002 EC). Therefore depositing such solid wastes and dangerous substances in rivers and riversides has been a common practice in Addis Ababa. Hence such unwise practices of depositing pollutant substances caused the increasing trends of rivers and riverside pollutions. According to CSA as citied in report of MUDC (2004 EC, p.22 & 23), in Addis Ababa, industries release 1-1000 m^3 liquid wastes every day. Therefore, in year, 4, 877, 371 m^3 of liquid wastes enter into Akaki Rivers. Industries release oil, pesticide, nitrate, phosphate, sulphate, chloride, acid and the like. Such pollutants pollute the rivers and have negative impact on aquatic plants animals.

Figure 4.7: liquid wastes that are discharged from Batu Leather Factory, Kaliti (source AAEPA, 2004 EC).

Table 4.2: Major Pollutant Substances that are discharged into rivers from factories (source: MUDC, 2004, P.3 as citied in EPA, 2005EC.)

No	types of Factories	pollutant substances
1	Food and Beverages	NaoH, detergents fuel combustion)
2	Textile, leather and leather products	Water pollutant Example. chrome, sulphides, amoniumsalts, chlorides and the like.
3	Steel and wood products	Paint, iron rusts ,varnish, etc.
4	Paper and paper products	printing chemicals, Lead
	Tire and plastic products	scraps of rubbers, Pvc,plastics
5	Non-metal materials	Air pollutants: dust & particulates, fuel combustion, etc

4.3.2 Soild and Liquid Wastes

In Addis Ababa, 76%, 9% , 6% , 5% , 3% and 1 % of Solid wastes were generated from residential, commercial, street weeping, industries, hotels and hospitals, respectively. From the total waste generated daily, 60% is collected and disposed at dumping site; 5% is recycle 5% is composted and 25-30 % is dumped to rivers. (AAEPA, 2005E.C & 2002).

Figure 4.8: riversides are being polluted from car wash.

Figure 4.9: Meberathail's garage , Gurde Shola (soruce EPA, 2002 EC)

In addition, there are many private and governmental garages and gas stations in Addis Ababa. The liquid wastes that are ejected from these sites are directly flow or would be washed away by rain water that would pollute rivers and riversides. Hayal et al. (2001, p. 38) explained that in Addis Ababa, most of the liquid wastes from fuel sations and garges are discharged through ditches, and enter nearby rivers. Moreover, government and individual garages as well as fuel stations are sources

of oil waste in Addis Ababa, and are contaminating rivers, underground waters including soils (AAEPA, 2005EC).

Moreover,AAEPA (2011), most of the residential houses, service giving institutions, commerce and the like has directly linked their liquid waste systems including their latrines and septic tanks to the main rivers and their tributaries without any treatment.

Figure 4.10: liquid wastes that are released from houses into rivers (source AAEPA, 2005 EC)

Figure 4.11: Solid wastes that are released from houses into rivers (AAEPA, 2005 EC)

10% of the city's dwellers use flash toilet and 65% of the societies have pit latrine. 25% of the city's residence do not have toilet. As a result, the residents use the river as toilet. In addition, houses that are built at the edges of the city's rivers link their toilets directly to them. Therefore, status of river pollution is increasing from day to day. Therefore, the city's rivers are lacking aquatic animals and plants.

The factors that aggravate the pollution of the city's rivers are shortage of manpower, money and equipments that can assist during implementation phases. Additionally, lack of awareness regarding benefits of rivers among the communities, investors and other stakeholders aggravate the river pollution. There is also no coordination among different sectors such as AAEPA and CBGB. Moreover, the existing sewerage system is also inadequate in the city (Hayal et al., 2011,p.7). The lack of public participation to prevent environmental problem contributed to pollution of the city's rivers.

Furthermore, due to continuous economic growth, urbanization and industrialization, solid and hazardous wastes have substantially increased in volume and types (AAEPA 2005). . Therefore, the quality of the rivers in the city is highly degraded.

4.3.3 Consequence of River Pollution

Water pollution resulted in water-borne diseases such as typhoid, cholera, hepatitis, amoebaiasis, giardiasis, hook worm, strongyloidosis etc. (AAEPA, 2005EC) as chemicals that are released from

factories and fuel stations entering to the nearby rivers are causing diseases on liver, kindeny, nervous systems and reproductive system (AAEPA, 2005EC). Water pollution can also cause social conflict among neighboring countries.

In addition, Rivers Pollution cause economic crisis. In order to solve the problems that have been occurred due to water pollution resulted in unwanted expenses. For instance, expenses for health problems such as water-borne diseases, to prufiy waters, etc. Additionally, the government pays extra compensation for vulnerable groups. In addition, in the city, river pollution has resulted in loss of biodiversity and aesthetic value.

4.4 Flood

According to the interview carried out with Ato Samson, experts of AAEPA, in Addis Ababa, two types of flood occurred. These are flash flood and riverine flood. Flash flood in Addis Ababa has happened/ occurred due to torrential rain, which is occurred typically in rainy season. (CLUVA, 2012). Additionally, torrential rain contribute to water flows exceed the rivers and streams channel capacity, and water to overflow onto the adjacent land as riverine flood. As a result, such flood type cause damage to settlements along their banks. In addition to this, the effect ad impact of flooding in Addis Ababa is described below.

4.4.1 Effect and impact of Floods

Flood has negative impact on social and economic development of the city. It is also contribute to environmental degradation. Different sub-city of Addis Ababa has exposed to flood hazard. Report of CLUVA described that:

"The longest duration of flood incidence is reported from Akaki Kality sub sity, Woreda 12/13, caused by rainfall event occuring for eight hours and is the maximum duration of all incidences in the two years. In Gulele sub city, Woreda 10/11 the flood has caused land slide and ecological disaster. Frequent accidents have occurred in Addis Ketema, Gulele, Nefas Silk-Lafto, Akaki Kality and Bole sub cities"(CLUVA, 2012, P.40)

Figure4. 12: Gurde shola (source AAEPA)

In Addis Ababa, flood has affected people and forced them to reallocate their settlements .For instance, according to report of CLUVA (2011, p.37), due to flood, in 2007, 362 families and 1302 members were eviction. In the city, most of the time, the victims of flood hazard have been those poor households that are living along river banks.

Flood has negative impact on infrastructure, housing, and drainage systems and the like. In Addis Ababa, flood has resulted loss of properties For example, in 2009, 39 housing units were completely destroyed (CLUVA, 2011, p. 40) and furniture as well. Flood also became obstacle for circulation of pedestrians and vehicles (CLUVA, 2011, p. 40). In addition to this, according to interview conucted with the officials of AAEPA, flood had caused destruction of infrastructures such as electric supply system, water sewerage line.

According to the report of CLUVA (2012, p. 17), because of flood, income of farmers reduced as they lose fertile land for agriculture. For instance, community of Mekanissa did not able to get income through farming of their land during rainy seasons.

Flood affects the quality of potable water. This is because, flash flood washed away all the dirty from industries and open ditches of the city, and directly enter into the reservoirs, which are supplying potable water to residents. Beside, due to flood, fertilizers, chemicals, pesticides are also washed away from farm lands within the catchment area and end up in dams and reservoirs. In these regard, many residents in the city are exposed to water borne diseases (CLUVA, 2012, P.40 liku abramh CULVA).

Land slide and erosion in the upper catchment and the low lying areas of the city has resulted due to flood as it can be understood from the interview made with the officials of AAEPA. In addition to these, sloppy topography aggravated the increment of flood in the city.

According to interview made with Ato Samson, experts of AAEPA, there is a mandate conflict between CBGB and AAEPA .Additionally much of the responsibility is taken by AAEPA.

To mitigate flood risk, terrace and retaining wall has constructed on river edges as it can be understood from the interview made with Ato Getachew. Additionally, in Addis Ababa some households placed plastic sheets on their mud walls to temporarily protect their room from excessive moisture while others reinforced the walls of their house with wood and straws to strengthen the structure (CLUVA, 2012, p.18).

4.5 Riverside Greenways of Addis Ababa

In Addis Ababa, there are no greenways along riverbanks. According to Dr. Wubshet 's explanation the reason for the lack of greenways in the city is that rivers are places for evil spirits and sources of nuisance. In the view of this, it is impossible to find greenways along the rivers of Addis Ababa. Currently, OAAOSZIDP is planning to study regarding greenways of Addis Ababa.

4.6 Connection between Settlers and Riversides

Addis Ababa is found by Empress Taitu, wife of Minilik II, in 1886. It was known for dense forests with rivers and streams. However, nowadays, due to the impact of various human activities, the amount of water in rivers and streams have been substantially declined and polluted. Besides, due to illegal construction of houses and industries as well as disposal of waste materials into rivers led to the environmental degradation. As a result, it clear that there is no healthy connection between settlers and riversides in Addis Ababa. It is important to maintain and protect rivers from further degradation with a view to keeping them healthy and safe for the surrounding settlers.

In this regard, to have healthy connection between the city's settlers and river spaces, manual has been prepared by MUDC.

General recommendations by MUDC

By considering experience of developed countries, it is recommended to undertake the following recommendations (MUDC, 2004EC, p. 105).

a. The Addis Ababa city Administration should promote good governance by coordinating with economical, social and cultural entities;
b. Ensure that the community is entitled to live in safe and environmentally clean riverside areas and
c. Since Addis Ababa is the capital of Africa and attract tourists, it is imperative to create environmentally sound riversides
d. In order to maintain and develop riverside, it is essential to allocate reasonable land areas on both sides of the city's rivers. Then on these riverside areas, the community and concerned governmental bodies must coordinate to promote developmental activities. Such activities include planting trees and flowers; constructing path ways and make the rivers clean and attractive for recreation. Besides, there were prior existence of churches, mosques and historical monuments. In this connection, therefore, it is advisable to renovate them as they stand (MUDC, 2004 EC).

Proposed Measures by AAEPA

According to the interview conducted with Ato Masersha, who is working in AAEPA, explained that to reduce river pollution, the office developed regulation base, economic base, information based instrument and color rating. Each of the instruments will be explained as follows.

Regulatory base instruments[15]are legal and administrative instruments can operate according to international conventions and laws; regional environmental agreements and protocols; environmental regulatory framework as well as at international, regional and national levels . Additionally, laws are used to deal with problems specific to the community at the local level. Besides, the environmental policy of Ethipoia formulated (AAEPA, 2005). The policy has three approaches. These include the incorporation of environmental issue into the constitution; formulation of the 1997 national environmental policy and the formulation of environmental laws and proclamations (EIA proclamation, EPC proclamation and Solid waste management proclamation).

Economic Base Instrument Ato Masersha has also mentioned that as a means of controlling river pollution, Economic base policy is being practiced. Factories or manufacturing organizations that do not release pollutants to the river are rewarded in various ways. They will be subjected to pay lesser taxes than other organizations, interest payments will be discounted and technical supports will be offered to them. On the contrary, those Factories or manufacturing organizations that release toxic pollutants into the rivers are penalized on the basis of 'polluters pay principle'. They will pay a penalty payment to the concerned government office in addition to higher taxes rates than other organizations.

Information based instrument is related to environmental education. Educating communities through flyer, media seminar, conference and training will play a great role in protecting water pollution.

Color rating Ato Masersha explained that the method helps to assess environmental performance of factories or firms on the basis of their pollution rate. Then to provide information regarding their rate of pollution using colors to the public through different Medias. These colors are gold, green, yellow, red and black. According to his descripirion the method is not implemented but it is on process to implement.

However, the aforementioned recommendations are not implemented fully. To implement the recommendation, the city government is trying to address the issue of informality through legalizing those built before 1996 and demolishing those built after as can been understood from the interview made with Dr. Agzew, who is expert of OAAOSZIDP

[15] For more detailed information refer report of AAEPA that is written in 2005 E.C.

Moreover, according to the interview made with Ato Getachew and Ato Samson, experts of AAEPA, more than 50 million birr has been allocated for project regarding river rehabilitation. The project will be done by the workers of AAEPA. Therefore, in the future, there might be environmentally sound river spaces if the plans are implemented as it is stated in the paper.

CHAPTER FIVE

CASE STUDY

5.1 Introduction

As discussed in chapter two, the river chosen for this study is 'Finicha River', which is located in Yerer, Bole Sub-city, around Future Park. The river enters Kotebe River. 'Finicha River' is selected because of its unique characteristics listed below.

- the case area is located in sub-center of the city;
- Different land uses such as residential , commercial, industrial and mixed use areas are located within close distance to the river;
- Availability of the earliest recognized open spaces by the 1986 master plan
- the area is affected by flood, and the river has highly degraded water quality;
- No study had been carried out to rehabilitee the river.

'Yerer' is situated in the eastern part of Addis Ababa in Bole sub-city. During the time of Empress Zewditu, the place was owned by 'Shaleka Dejachew Afework'[16]. In former times, there were six different families that lived in Yerer[16]. Agriculture was the means of livelihood of the community. Due to this, 'Yerer' used to be a place for farmers. The area is covered by agricultural land[17].

'Fincha River' was used by the aforementioned settlers for watering their agricultural land, drinking water and the like[18]. In the next section, the buffer along 'Finicha River '; sources of the river pollution as well as the relationship between the settlers and the river will be discussed at length.

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[16]The data is obtained by conducting interview with Ato Fanta Abaye who is one of the earliest settler in Yerer as ' Chika Shum of the area before 1930 EC.

[17] The information was obtained by carrying out interview with the wife of Ato Seta who is the former settler in the study area.

[18] The information was obtained by making interview with Ato Mamo, who is living in the study area before 1930.

5.2 Riparian Zone

Vegetation types, soil and water tables of riparian zones of Yerer and Finicha River is explained below.

In former times, the land use in Yerer was subdivided for different farms related with the uses of forest land, farm land and some part for grazing area .

There was dense vegetation type along Finicha River. There were 'agam', acacia ('gerar'), 'senbelit', ' sededo', grass', kegah', and eucalyptus ('baherzaf') along the river. After 1980, the riparian zone started to be occupied by informal and formal settlers. Nowadays, the residents have constructed their houses at the edge of the river. For this reason, the riparian area shrinks in size.

The soil type that is found along Finicha riparian zone is chromic vertisols and eutric nitisols. Since the soil is not moist, it has very little vegetation cover along the river.

As it is explained above, Finicha riparian area of the sample study is a place for informal and formal settlers. The estimated water depth is 62-73 m (OAAOSZIDP, 2014).

Figure 5.1: Soil Map

Figure 5.2: Water Table Map

5.2.1 Factors for Shrinking the Riparian Zone

In the case area, according to the interview obtained from woreda 7, there are about 2,278 houses. From this, 928 are legal cooperative houses and 1,350 are illegal houses that are located around the river. As a result, informal and formal settlements along Finicha River contribute for the shrinking of the riparian zone. Additionally, according to the interview made with Ato Mamo and Ato Fanta, the factor for shrinking of the riparian zone is the increment of population. There were 27,122 people (CSA, 2007) in the study area. But, currently there are 42,000 people. In addition to this, the resaon for shrinking of the riparian zone is lack of awareness by the communities regarding the use of riparian zone. Beside, the WBGB and WEPA which are reponisble for taking care of Fincha River , did not take any measures for the misuse of the riparian zone. In addition to this, the woreda do not have trained professional that are specialized in environement and other related fields. Furthermore, Finicha River is becoming a place for dumping site for solid and liquid wastes rather than becoming a place for fauna and flora as it can be understood from site observation.

Due to mismanagement of the riparian areas, biodiversities have disappeared and gully erosion has occurred.

5.3 Pollution of Finicha River

In the case area, there are different land uses around the river. The land uses include residences, mixed uses, commerces, social services, open spaces and small scale industries. These land uses have contributed to the pollution of the river.This is because, they discharge their liquid and solid wastes into the river through drainage systems without any treatment. Especially, the houses that are constructed along the river directly link their toilets with the river . Moreover,as it can been understood from the interview conducted with residents, the pollution of the river increased as time elapsed. For this reason, pollutant substances such as fecal coliform colonies are found in the river.

. As a result, the residents mentioned that their children were affected by waterborne diseases while playing around the river. The communities that live along the river also explained that as much as possible they do not allow someone to dump solid wastes into the river. In a view of this, they are always fighting with their neighbors, who are dumping waste into the river.

Furthermore, some of the communities' livelihoods were dependant on floriculture. That is they used to plant flower along the river and sold them to the surrounding residents. However, they stopped their activities due the contamination of the river. As it is mentioned above, Finicha River beame waste dumping site. Due to this, biodiversities and aesthetic quality disappeared.

Figure 5.3: Finicha River as waste dumping site

In order to mitigate further pollution of Finicha River, the woreda give training regarding the management of dry and liquid waste for the communities as it can be understood from the interview conducted with the official. However, the residents mentioned that the woreda did not take any action to reduce the pollution. For example the woreda did not penalize those who are polluting the river by discharging liquid wastes especially from toilets. The residents, who are living along the river, do not permit anyone to dump solid wastes into the river. The communities also mentioned that they post warning notice around the river. However, all the measures taken by the communities did not work.

5.4 Flood

In the case area, floods have negative effects on infrastructure, economy and ecology. For instance, during the 1987 - 1997 E.C. rainy seasons, floods had resulted in loss of properties such as houses, household utensil and furniture as it found from the interview conducted with the residents. Currently, it has also caused damage by cracking unpaved roads during the wet periods, June to September. Beside, as it is explained above, the community used to plant and sell flowers along the river. But when floods damage the space of floriculture, they stopped to work. As a result, their income reduced. Additionally, due to flood gully erosion, lose of terrestrial and aquatic life has occurred.

Besides, there are also factors that aggravate flood in the case area. These are non-existence of SMPs and lack of awareness regarding the benefits of rivers. The use of river is little understood by the dwellers and decision makers. Even some of the community considers the river as simple ditch where they can discharge their household waste as it can be understood by the interview conducted with residents. Furthermore lack of coordination between the residents and the Woreda Administration is the cause for increasing flood risk of the area.

Figure 5.4: Digging deep the bottom surface of the water

Therefore, to mitigate flood damage, the communities of the case area in group have changed direction of the river flow. This is because; naturally Finicha River used to have winding pattern. In the past, during the rain seasons, the water overflew on to the adjacent area, and has caused serious damages to properties. For this reason, the communities in group have changed direction of the river flow in order to reduce flood risks. Nowadays, the river flows along straight line. Moreover, the river, which is situated near the main street, is characterized by underlying rock surface. As a result the water does not infiltrate into the ground, and increase the overflow into the settlement areas. In the dry season, the residents have dug deep the stony grounds that subsequently reduce flood damages. Additionally, to mitigate flooding, some of the residents have planted shrubs and trees along the dwellers' river edge. Also, the residents who are living at the edge of the river reinforced their fence with stone at the base, and corrugated iron above it. Some of the community constructed gabion along the river. Beside, with a view to reducing gully erosion, which is occurring in the wet periods because of floods, they pile up sacks filled with soil, and placed them in row along the river.

Figure 5.5: put soil in sack and place it along the river.

The residents mentioned that the woreda did not make any financial support when they constructed the gabion. In contrast to this, according to the interview conducted with the officials of the woreda,

they make support such as building retaining wall along the river, construct ditches and are give training for those who report to the woreda. But the communities do not report their problem. This is because, most of the residents that live along the river, constructed their houses illegally, and many of them afraid to inform to the government. In this connection, the residents have worked mitigate the flood hazard by themselves without consultation of the Woreda Administration.

Figure 5.6: Old Finicha River

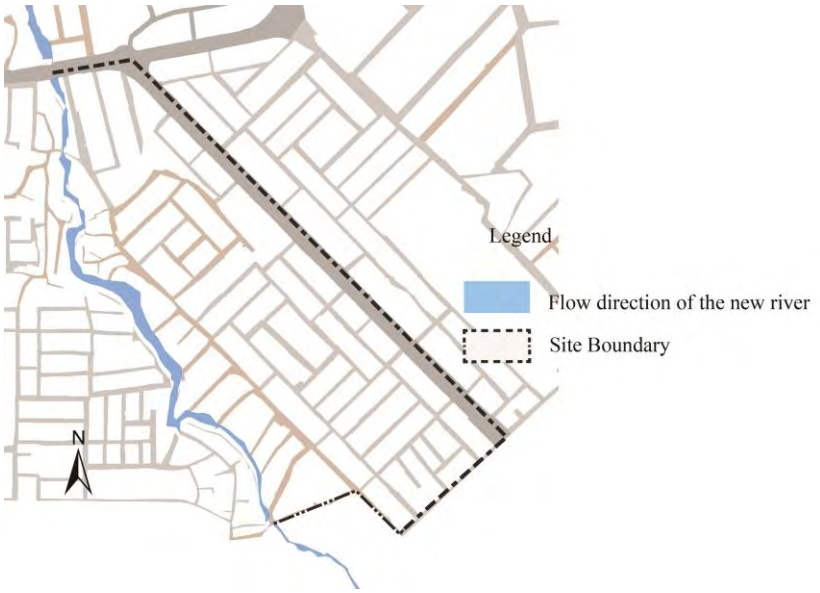


Figure 5.7: New Finicha River

5.5 Greenway

In the case study area, there is no greenway. But in certain places of the river, there are foot paths. There are also bridges .The bridges connect the case area with the neighborhood. In addition, there is a road along the river.

Figure 5.8: Local road along Finicha River

5.6 Connection between Yerer's Settlers and 'Finicha River'

In the early days, there were healthy connection between Yerer's settlers and the river. For instance, People were used to sit and relax along the river .The river was also used for drinking water, taking bath and washing clothes. Besides, the river was used for irrigation, active and passive recreations. It was also a place for plants and animals. On the contrary, nowadays, the river and the surrounding areas are becoming places for settlements and dumping waste materials. But the residents that are living along the river explained that the sound of the river is music for them, and they enjoy it.

CHAPTER SIX

ANALYISIS AND Data INTERPRITATION

6.1 Introduction

This section presents the analysis of the different data gathered from the field. Based on the following analytical framework, the data presented in chapter five will be assessed and evaluated.

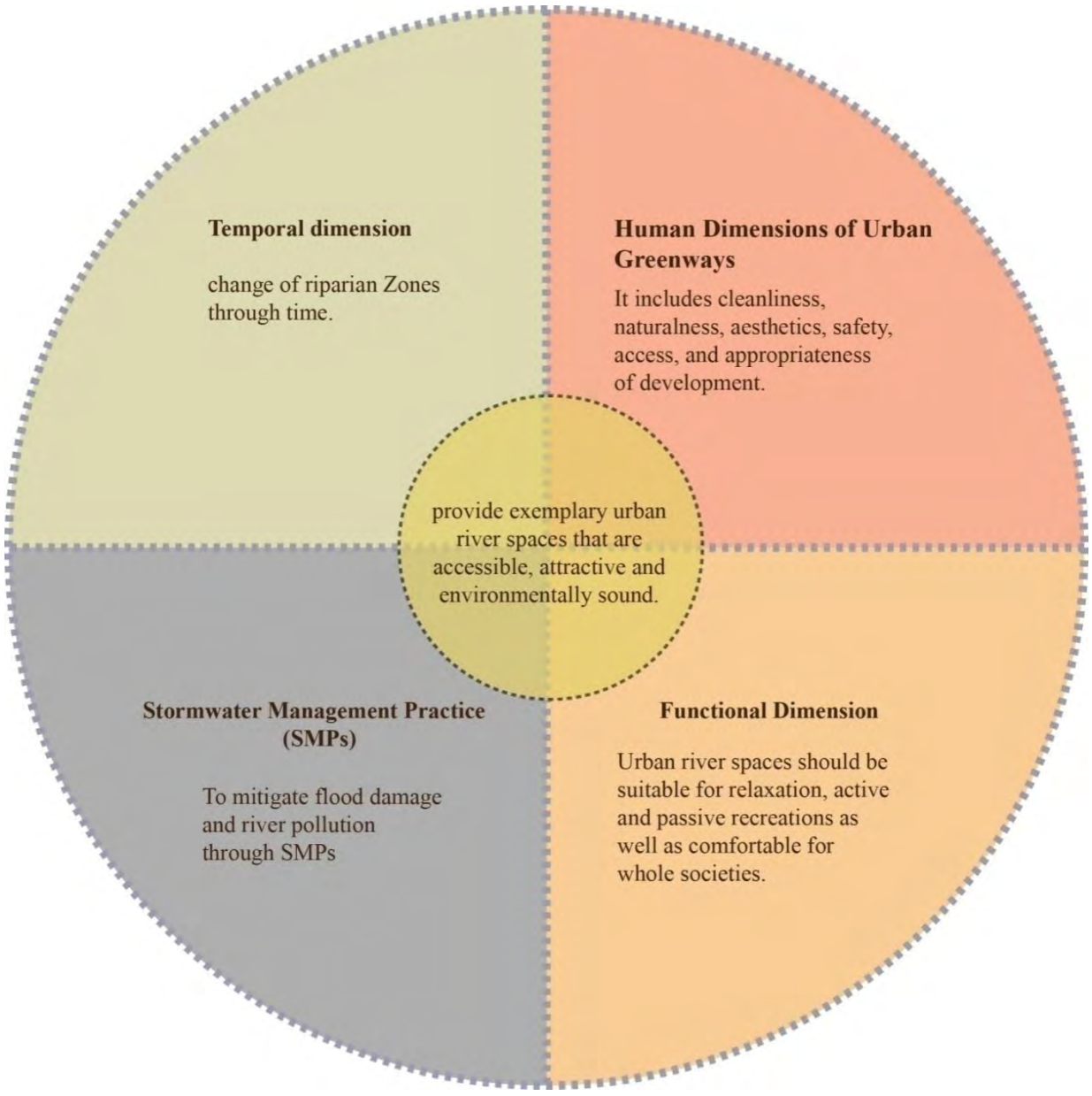


Figure 6.1: Analytical framework

6.2 Yerer's Riparian Zone

Riparian zone of Yerer will be analyzed using temporal dimension of urban design. According to Carmona et al. (2003), temporal dimension dealt with urban space and time. Here the researcher uses the dimension to analyze the riparian zone of the study area.

Carmona et al. (2003) explained that urban environments are continuously and unavoidably changing. For instance, in Addis Ababa, the statuses of riparian areas are constantly changing over time. For example, in the case area, as it is mentioned above, there was dense vegetation type along Finicha River. However the riparian zone highly degraded through time (see figure).

According to the aforementioned explanation, the factors for shrinking of riparian zone are the population growth, informal settlements as well as dumping of liquid and solid and liquid waste through time. (see table)

Table 6.1: Population Status

Year	2007	2015
Population	27,122	42,000

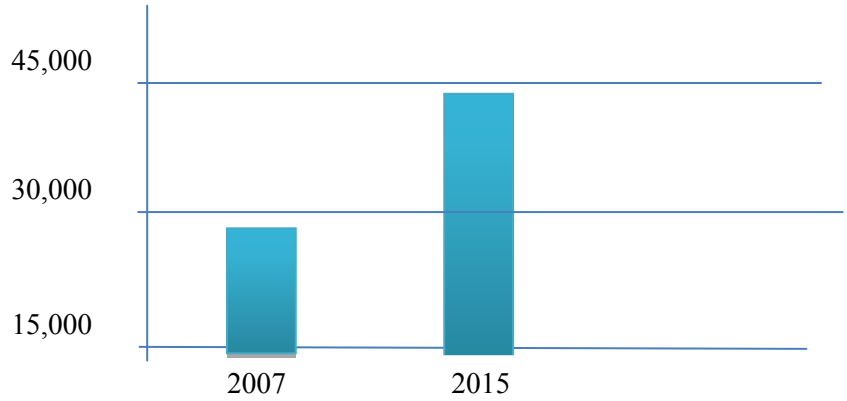


Figure 6.2: Population growth through time

In the case area, the numbers of illegal houses are more than legal houses. (see table 6.1.) As it is illustrated in figure, the illegal houses are situated around the river.

Figure 6.3: Ownership Map

Table 6.2: Number of Legal and illegal houses in Percent (%)

Type of ownership	**Number of houses**	**Number of houses in percent (%)**
Legal houses	928	41
Illegal houses	1,350	59
Total population	2,278	100

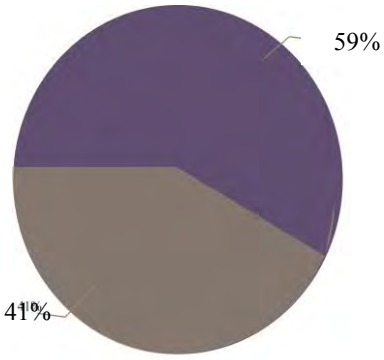


Figure 6.4: number of legal and illegal houses in percent

Carmona et al. (2003) mentioned that many spaces are used intensively for certain periods. On other time it becomes empty or would have only few activities. In the case area, in the past, due to the existence of riparian zone, Finicha River and the riverside were used intensively for different activities. On the contrary, the riparian zone has been replaced by settlements. Currently, the riparian zone is being used only for dumping trashes.

Tabel 6.3 :Effects and impacts of Yerer's Riparian Zone

2000E.C to now	Loss of riparian habitat; Lack of active and passive recreations; the dwellers are dumping solid and liqui wastes on the riparian zone; the river has highly degraded water quality; Flood hazards Gully erosion;
1980E.C. - 1990E.C.	The communities wash their clothes and take bath in Finicha River; the residents had used the river for watering floriculture .that is located at river edge; Children and youths used to swim in the river; Residents began to dump solid and liquid waste around the river.
1980E.C.- During the time of Empress Zewditu	Active and passive recreation around Finicha River; Existence of Finicha riparian habitat; water quality of Finicha River was not degraded

Figure 6.5: The study area in 2009

Figure 6.6: The study area in 2015

In the early days

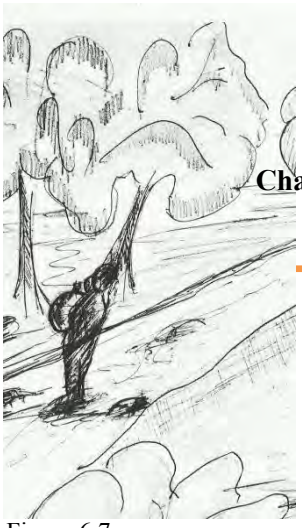


Figure 6.7: crossing‘Finicha river ‘on foot

Change through time

Now

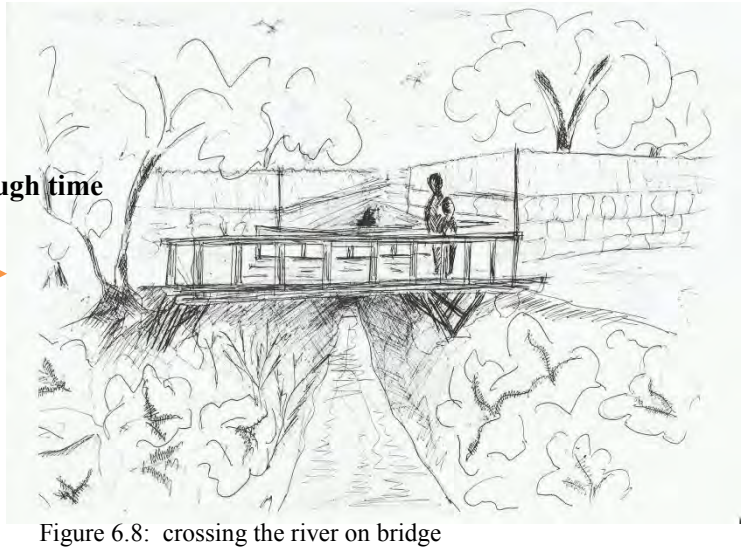


Figure 6.8: crossing the river on bridge

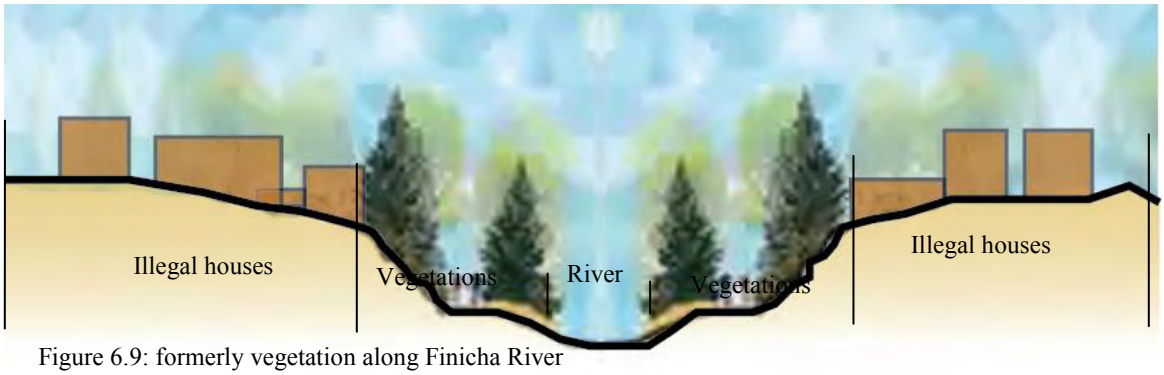


Figure 6.9: formerly vegetation along Finicha River

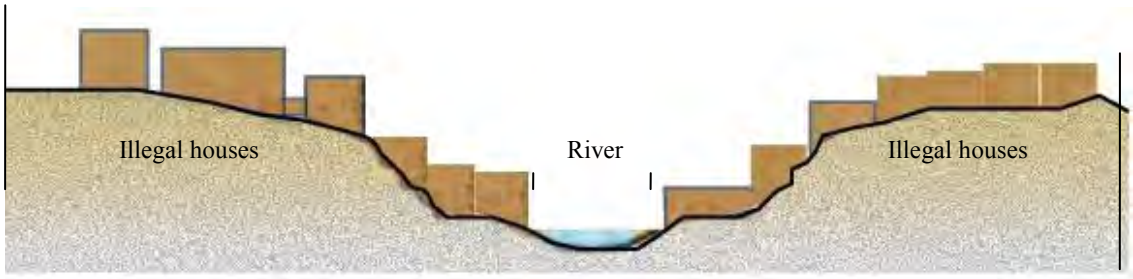


Figure 6.10: now a days: illegal houses built at the edges of Finicha River

6.3 Water Qualities of Finicha Rivers

According to Randolph (2004, p. 456-488), Watson et al. (2003, p.7.5-5) and Daniels et al. (2003, p.413), it is important to use STPs to mitigate water pollution. This is because; such practices are effective in removing pollutants before they leave the site and at least enter to rivers.

Using STPs, the researcher will analyze the case area and the management of solid and liquid wastes by considering how the case area's residents deal with them before entering to Finicha River.

6.3.1 Existing Building Uses

As it is illustrated in the land use map, in the case and planning areas, there are residences, mixed Uses, commerce, social Services, light industries and open Spaces. Additionally, there are large scale industries in the planning area. The researcher will analyze the case area's land uses using STPs.

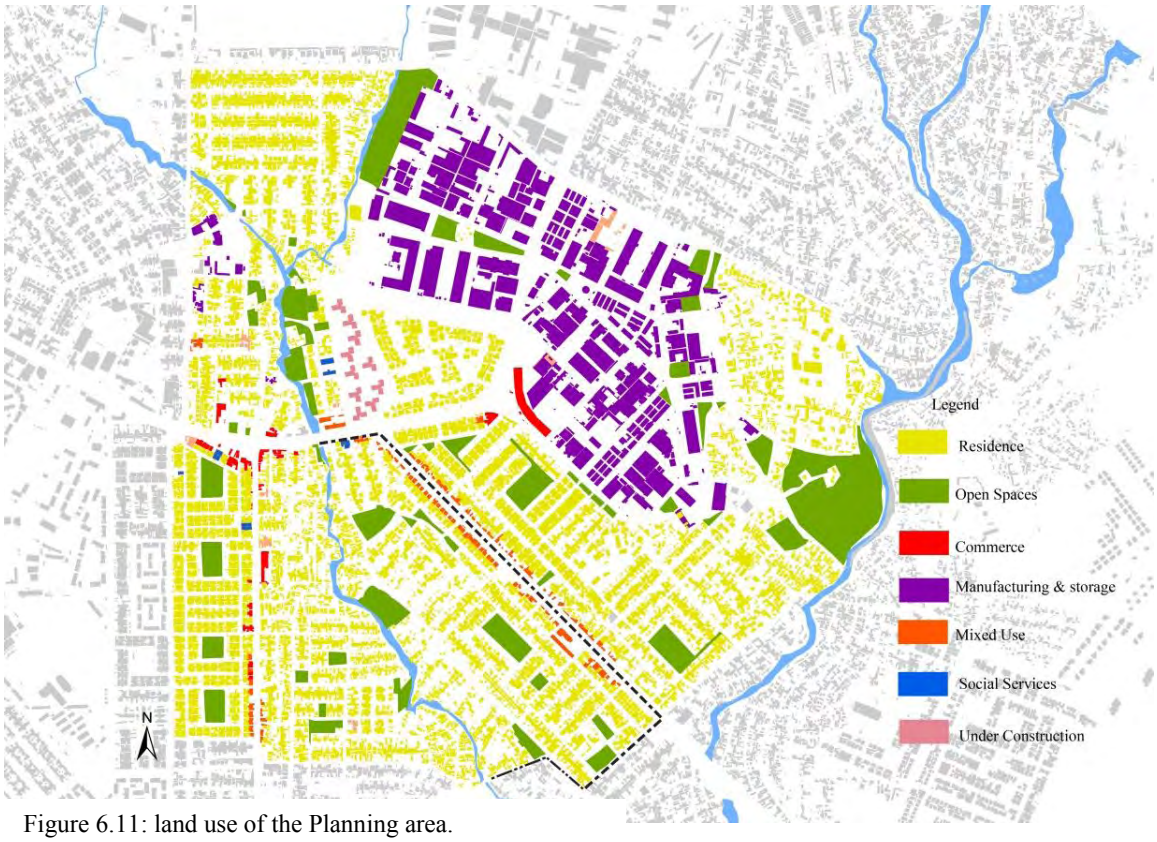


Figure 6.11: land use of the Planning area.

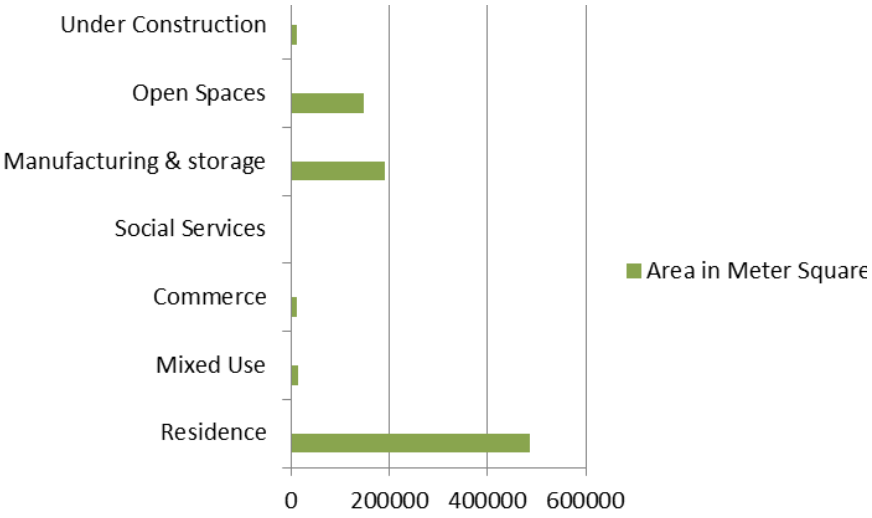


Figure 6.12: land use the planning area, area in meter square

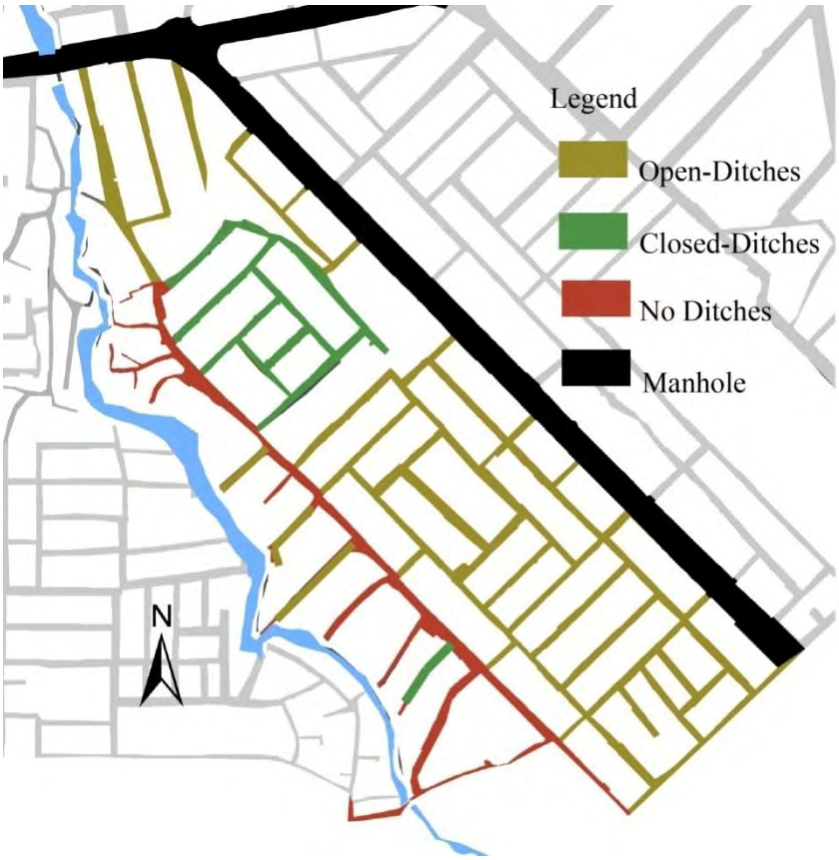
Figure 6.13: land use of the action area

In the case area, there are cooperative and illegal houses. About 12 % of the houses have plants adjacent to their fence as it can be observed from site survey. The residents have planted trees, flowers and grasses along their fences in order to beautify their surroundings as mentioned by the communities and gardener. Though planting species along the fences have potential to treat runoff before entering Finicha River, it was not meant to reduce pollutants.

Figure 6.14: vegetation along fence of the residential houses

6.3.2 Existing Road

In the case area, along the road, there are no open channel systems such as dry swales, wet swales and bioswales or any other treatments mechanisms. There are only closed and open ditches that are made of concrete. As a result, the ditches do not treat runoff before reaching into Finicha River. Additionally, through the drainage systems, all the dirty materials would be washed away , and enter to the river without any treatments.



Open-Ditch

Closed-Ditch

No Ditch

Opened-Ditch

Opened-Ditch

Figure 6.15: drainage systems

The following figures illustrate the management of solid and liquid waste by the residents.

Figue 6.16: Solid wastes on drainage system

Figure 6.17: Liquid wastes discharged through Open-Ditch

Figure 6.18: Liquid wastes discharged on the road

Figure 6.19:Toilet directly linked with Finicha River

The wastes from different systems enter into Finicha River

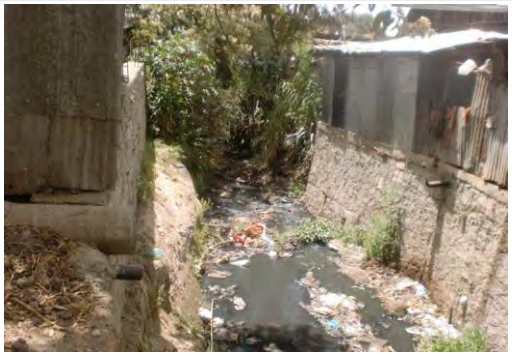


Figure 6.20: Finicha River

6.3.3 Existing Parking areas

In the case area, the local and main roads are used for on street parking. Besides, there are two off-street parking that are situated in future park and Alemayehu building.

As it is illustrated in the figures, there are no trees or any other plants on the parking lots. For this reason, during the rainy seasons, oil materials that are washed from the cars may flow into the draiang system, and enter into Finicha River.

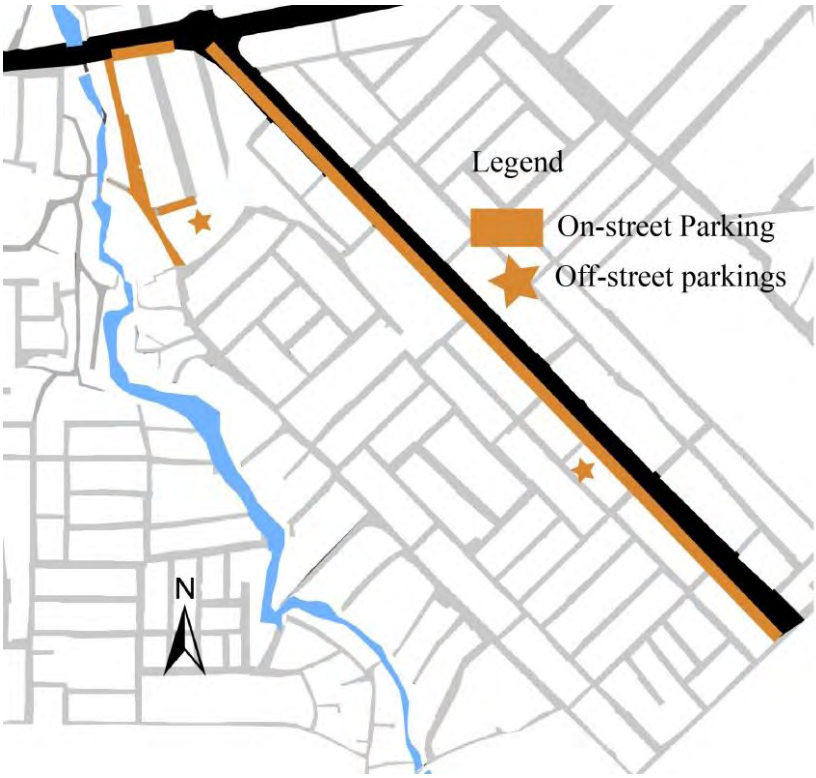


Figure 6.21: Parking spaces

Figure 6.21a: parking along the collector Street

Figure 6.21b parking along the local street

Figure: 6.21c: parking area along Local Street

Figure 6. 21 d: parking area along sub Areterial street (SAS)

Figure 6.21e: parking lot in Future Park

Figure: 6.21f parking lot in Alemayehu building

6.3.4 Existing Open Spaces

In the planning and case areas, there are open spaces that are defined by cooperative houses. These spaces are called community gardens. The community gardens, which are found in the planning area, are used for parking purposes and store houses, to put materials of the 'edirs'.

In the case study area, there are ten open spaces. Four of the open space 1, 2, 3 and 8 are covered with vegetation. Therefore, they have their own contributions in reducing runoff and water pollution of the

area. On the other hand, one of the open spaces (open space 9) is becoming a commercial site for selling sand and stone, in which it is decreasing vegetation cover. Due to this, during the rainy seasons, the solid wastes from this open space would be washed away into the drainage systems and enter Finicha River.

The open spaces 4, 5, 6 and 7 are not handled well as they are covered with unattended trees and grasses including trashes as illustrated in the figures. For this reason, they are not aesthetically attractive.

Figure 6.22: open spaces

Figure 6.22a: open space 2

Figure 6.22b: open space 3

Figure 6.22c: open space 5

Figure 6.22d: open space 4

Figure 6.22e: open space 1

Figure 6.22: open spaces

Figure 6.22f: open spaces 6

Figure 6.22g: open spaces 7

Open space 1

It is called Future Park. The open space has two manmade Water features: one of the water features is fountain that is situated around the gate and the second water feature is found inside the park. The second one flows on excavated stone. Besides, it has aesthetically attractive vegetation such as grasses, shrubs, flowers, etc. The walkways are paved with tiles. As a result, the rain waters can percolate into the ground as the pathways are permeable. Additionally, waste materials can also be captured by the vegetations.

Figure 6.22h: open spaces 8

Figure 6.22i: open spaces 9

Figure 6.22a$_1$: Fountain at the gate of Future Park

Figure 6.22a$_2$: water feature that fall on the excavated stone

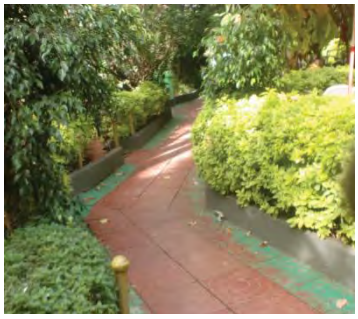


Figure 6.22$_3$: in the future park walkways are paved with porous pavements.

6.3.5 Analysis of the case area's Land uses Using SMPs

Residential Subdivision Development

In the study area, there are cooperative and illegal houses.

Existing status of the housing conditions: Good

Building Height: G+0- G+3

Plot size: range from 123 m2-219 m2

Private garden: the houses that are located around Future Park and an open space, where tele. pole is situated, have private gardens

Detention and infiltration: it mitigates flood hazards (Hoyer et al. ,2011). Detention and infiltration measures comprise porous pavement and green roofs. In the study area, there are no green roofs in the cooperative houses. But some of the residential buildings have plants grown in pots located at their balconies (see fig.).

Figure 6.23: Absence of green roof

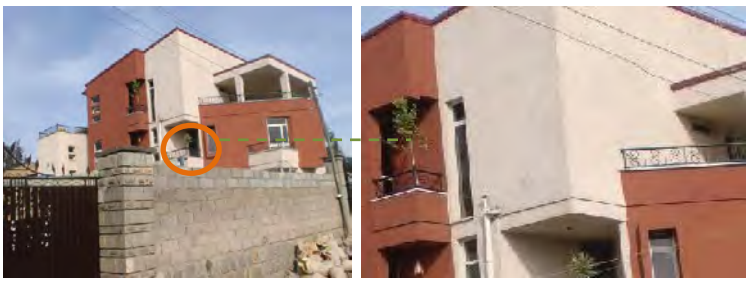


Figure 6.24: Flower at the balcony

Most of the surfaces of the compounds of the cooperative houses and mixed use buildings are paved with concrete. For this reason, rainwater does not percolate into the ground. In contrast to this, some of the surfaces of the compounds are paved with cobble stone and grass.

Figure 6.25: Surface of the residential compound

Figure 6.26: Surface of residential compound paved with tiles

Mixed Use Buildings

In the case area, the mixed use buildings have no detention and infiltration system

Figure 6.27: Lack of green roof, Alemayhu Building

Figure 6.28: Surface of the mixed use compound paved with concrete

Social services

In the study area, there are one school and clinic. The detention and infiltration of them is explained below.

Name: Fana School.

Pavement : Surface of the compound is paved with concert and soil.

Green roof: it has no green roof

Vegetation cover: the school has trees and shrubs along the fence. Additionally, it has an acacia tree in the middle of the compound.

Figure 6.29: Fana School

Figure 6.29b: surface of the compound

Figure6. 29a: Acacia tree; Fana school

Name: Seyoum Special Eye Clinic.

Pavement: Surface of the compound is paved with concert

Green roof: it has no green roof

Vegetation cover: it has no natural elements the compound.

Figure6. 30: Seyoum Eye Clinic

6.3.6 Pollutants of Finicha River

As it is mentioned above, Finicha River is polluted. The major pollutants that have impacts for the degradation of the river quality will be explained below. The pollutants would have negative effects on the river quality if they are above the standard level. The Ethiopian standard for pollutants that are discharged into inland waters is described below.

According to the laboratory test, the amount of Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), dissolved solids, inorganic chemicals and disease-causing microorganisms are found in excess amount in Finicha river except PH (see table 5.4). The aforementioned pollutant effects to aquatic biodiversity will be explained as follows.

In Finicha River, dissolved solids such as phosphate (26.8 mg/l) and nitrate (11.2 mg/l) are found. The dissolved solids are excess in amount . Due to this, they have affected aquatic organisms by disturbing the water balance that is found in the organisms' cells.

In Finicha River, there are heavy metals such as lead, mercury, chromium, cadmium and Arsenic as it is observed in the laboratory test. These metals are inorganic chemicals that have negative impacts on the growth of aquatic animals.

In the river, there is 35/100ml amount of Fecal Coliforms (see table 5.4). This is because; sewerage lines are directly linked to the river. Additionally, the residents are using the river as toilet. As a result, disease-causing microorganisms such as bacteria, viruses and protozoans can breed in the river as water features provide suitable space for reproduction of the microorganisms.

The acidity and alkalinity of water features are measured by PH. Most aquatic animals prefer PH value that range between 6 and 9. In the Finicha River PH value is 6.9. Therefore, such PH value is suitable to aquatic life. However, due to excess amount of the above-mentioned pollutants there are no aquatic plants and animals in Finicha River.

6.4 Flood

According to Farr (2008), Watson et al (2003), Daniel et al., (2003) and Randolph (2004), the Stormwater Management Practices (SMPs) reduce flood risks. These SMPs include rainwater harvesting, detention and infiltration (rooftop retention and permeable paving), conveyance and open channels, stormwater ponds, and wetlands. In the next section, the researcher will analyze the case area and flood mitigation approach used by the residents using SMPs.

6.4.1 Figure ground

Figure 6.31: Figure ground for the planning area.

$$BAR = \frac{\text{Built}}{\text{Total area}} = \frac{1{,}215022}{2{,}269{,}525}$$

BAR= 0.5

Unbuilt= 1,554,744 meter square

Built= 714,781meter square

Unbuilt: decrease runoff

Built= increase runoff

Implication

This figure ground map shows that the relationship between the built up area and void spaces. This map also implies that the buildings are arranged in gird iron form except the buildings, which are found along Finicha River. It has well-defined open spaces that can contribute to water sensitive urban design by enhancing water permeability on surface of the earth.

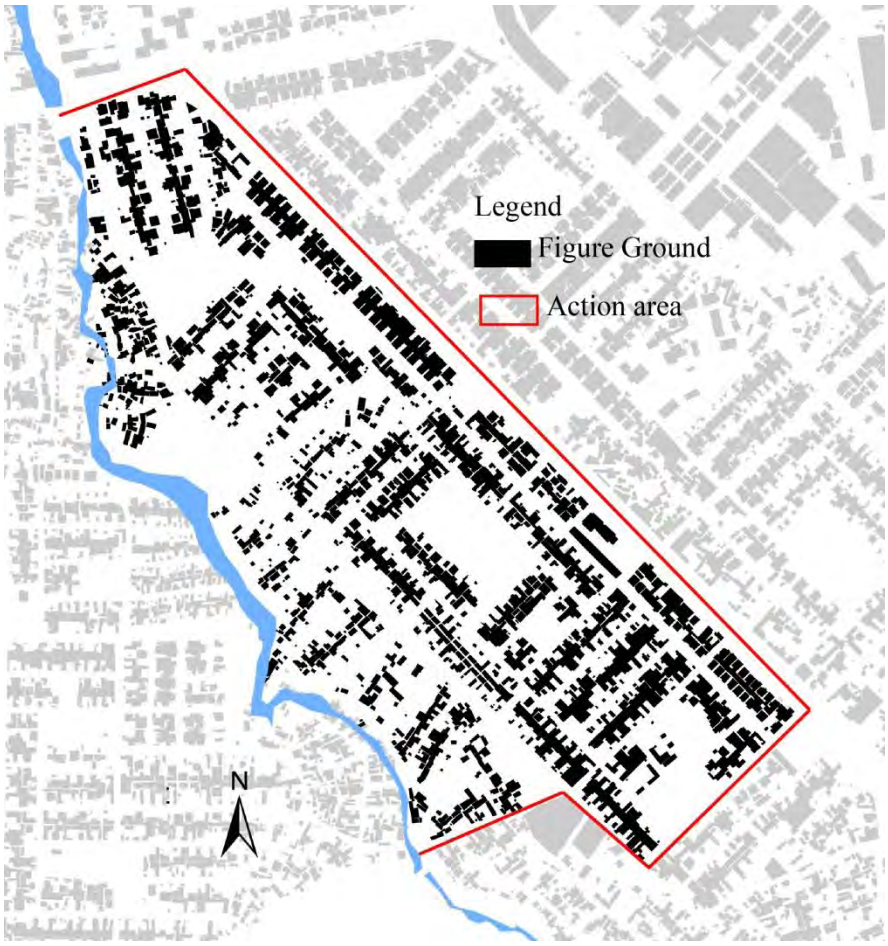


Figure 6.32: Figure ground of the action area

Figure: 6.32a: Urban form: Grid iron & open spaces that are defined by building

Implication

In the case area, built up areas increase runoff. As a result, flood and soil erosion around Finicha River have taken place. Even the un-built up areas of the site have its own effect for decreasing infiltration rate, as they are not covered with vegetation.

6.4.2 Existing Road Material

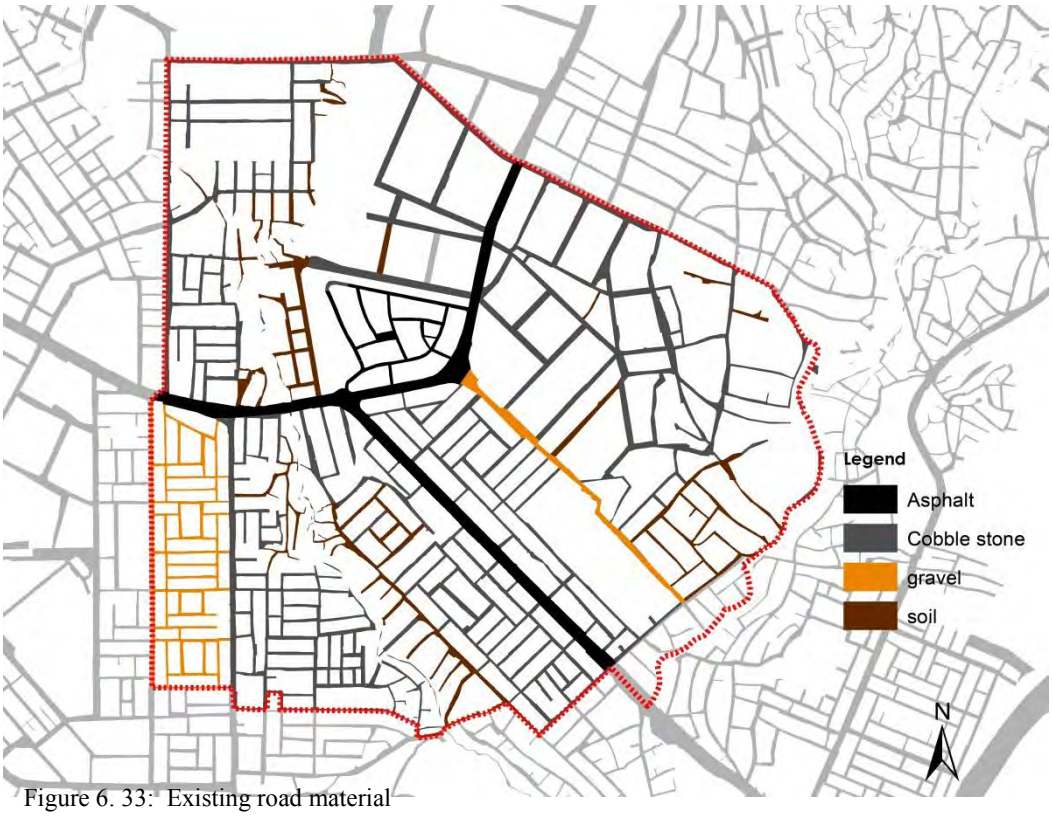


Figure 6. 33: Existing road material

Table 6.4: Area of Road material

Road Pavements	Area in Meter square	Area in Percent
Asphalt	85863.94069080000	17
Gravel Surface	44477.40187650000	9
Cobble stone	294929.95668300000	59
Native Soil Surface	74970.13350600000	15
Total	**500241.43275630000**	**100**

Implication

The existing road constructed from asphalt, coble stone, gravel and soil. The main roads (SAS and PAS) are made of Asphalt. 59%, which is more than 50% of the road is paved with cobble stone. So, it has its own contribution in reducing run off.

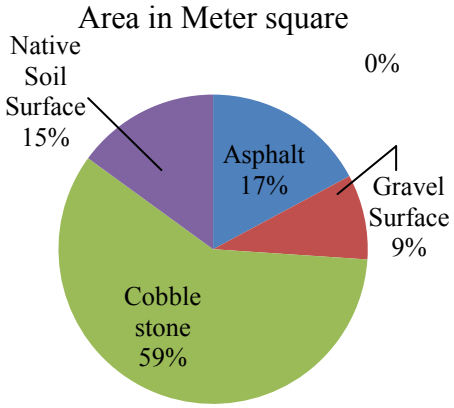


Figure 6. 34: Area of Road Pavement

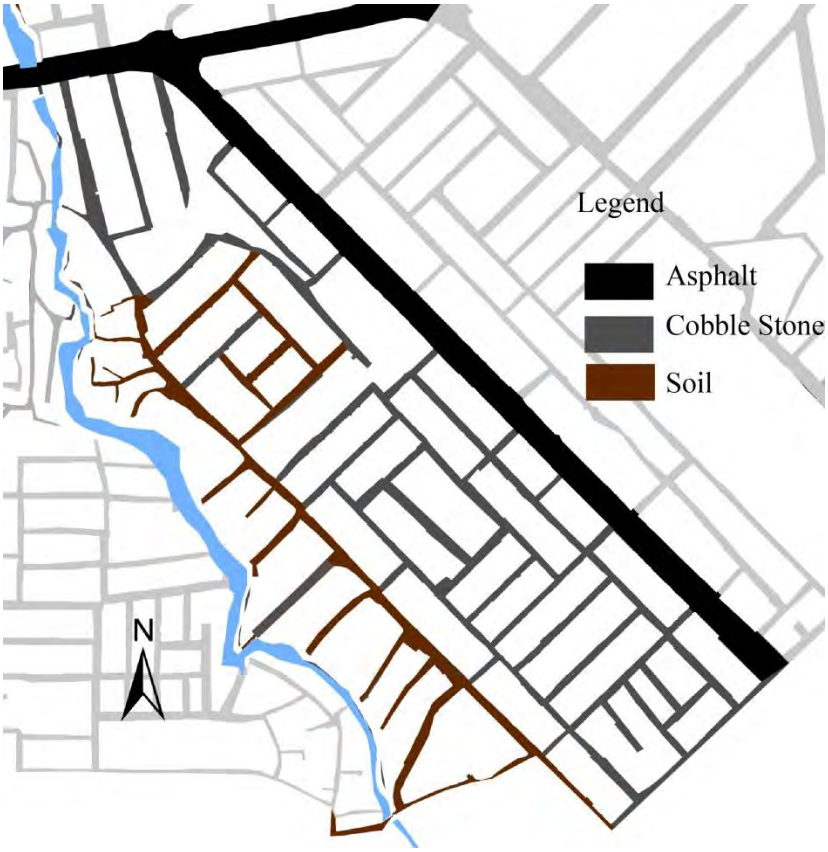


Figure6. 35 road pavement of the action area

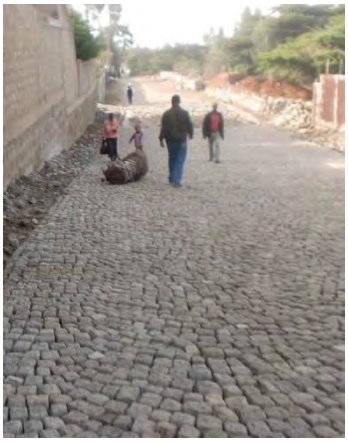


Figure 6. 35a: local road Paved with cobble stone

Figure 6.35b local road Paved with soil

Figure 6.35c: the main road Paved with Asphalt

Table 6.5 : summary of runoff calculation for the planning area's road

Road Material	**Runoff Volume in Liter/ average year**
Asphalt	79,480,012
Gravel	26, 639,499
Soil surface	32, 656, 932
Cobble stone	192, 707,262

6.4.3 Existing Land Use

This map illustrates the existing land uses of the planning area .It are dominantly occupied by residential houses. The residences have high runoff volume. (See table 6.2)

Table 6.6: land use of the planning area

Land use	Area in M^2	Area in %
Residence	485389	56
Mixed Use	13569	2
Commerce	11435	1.3
Social Services	2465	0.4
Manufacturing & storage	191193	22
Open Spaces	148819	17
Under Construction	10729	1.3
Total	863600	100

6.4.3.1 Runoff Volume Calculation for the Planning area's Land Uses

Table 6.7: summary of runoff calculation for the planning area

Land use	Runoff Volume in Liter/ average year
Residences	317,153,173
Mixed Uses	11,082,481
Commerce	8,716,901
Manufacturing Storages	166,567,342
Open Spaces	48,619,167

6.4.3.2 Runoff Calculation for the case area's Land Uses

Open Space 5

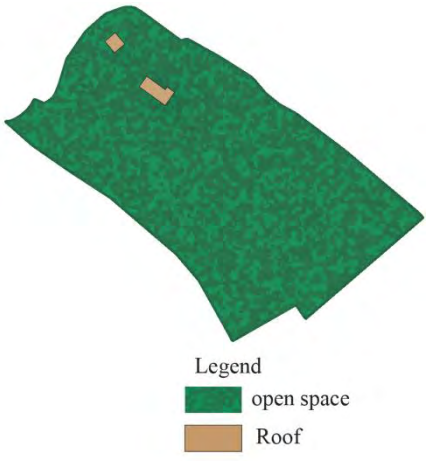


Figure: 6. 36: site plan of open space 5

Figure: 6. 37: vegetation in open space 5

Permeable

Runoff volume for open space = Total area of the open space * Annual rainfall* runoff coefficients

= 6,473m2* 1089 mm * 0.25

=1,762,274 liters/average year

Impermeable

Run off volume for roofs= total area of the roof * annual rainfall* runoff coefficient

= 63m2 * 1089mm* 0.75

=51455 liters/average year

Total runoff volume of the open space= Permeable Surface+ Impermeable surface

=1,762,274 liters/average year +51455 liters/average year

= 1,813,729liters/average year

Open Space 7

Permeable surface

Runoff volume for grass = Total area grass * Annual rainfall* runoff coefficients

= 434m2* 1089 mm * 0.7

=330,838 liters/average year

Semi-permeable surface

Run off volume for sandy loam soil= total area of the soil * annual rainfall* runoff coefficient

= 549m2 *1089 mm* 0.25

=149,465 liters/average year

Impermeable Surface

Run off volume for roofs= total area of the roof * annual rainfall* runoff coefficient

= 91m2 * 1089mm* 0.75

=74,324 liters/average year

Total runoff volume of the open space= Permeable + Semi permeable + Impermeable surface

=330,838 liters/average year +149,465 liters/average year+74,324 liters/average year

= 554,627 liters/average year

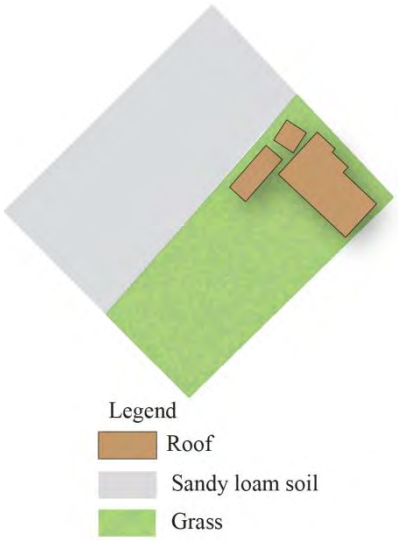


Figure: 6. 38: site plan of open space 7

Figure: 6. 39: sandy loam soil and scarce grass

Open Space 9

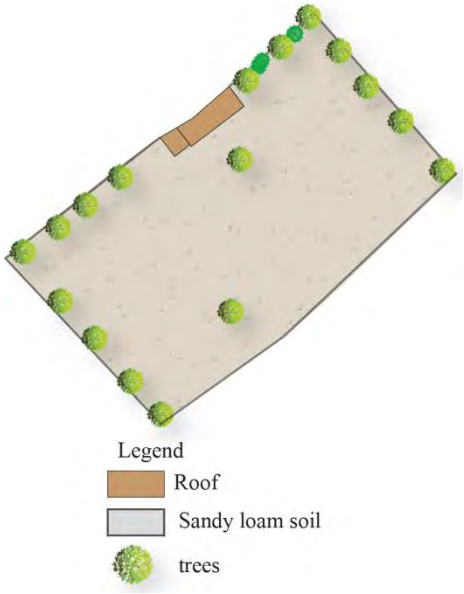


Figure: 6. 40: site plan of open space 9

Figure: 6. 41: open space 7; a commercial site for selling sand and stone

Permeable Surface

Runoff volume for private garden = Total area private garden * Annual rainfall* runoff coefficients

= 421m2* 1089 mm * 0.3

=137,541 liters/average year

Semi-permeable surface

Run off volume for sandy loam soil= total area of the soil * annual rainfall* runoff coefficient

= 1976m2 *1089 mm* 0.25

=537,966 liters/average year

Impermeable Surface

Run off volume for roofs= total area of the roof * annual rainfall* runoff coefficient

= 54m2 * 1089mm* 0.75

=44,105 liters/average year

Total runoff volume of the open space = Permeable + Semi -permeable + Impermeable surface

=137,541 liters/average year + 537,966 liters/average year + 44,105 liters/average year

=719,612 liters/average year

Residence one

It has semi-permeable and impermeable surface.

Semi-permeable Surface

Runoff volume for tile= total area of tile* annual rainfall* runoff coefficient

= 77m2 *1089 mm* 0.6

=50,312 liters/average year

Impermeable Surface

Run off volume for roofs= total area of the roof * annual rainfall* runoff coefficient

= 111m2 * 1089mm* 0.75

=liters/average year

Total runoff volume of the residence= Semi permeable+ Impermeable

=50,312 liters/average year + 90,659 liters/average year

= 140,971 liters/average year

Therefore total runoff volume of the residence is 140,971 liter/ average year.

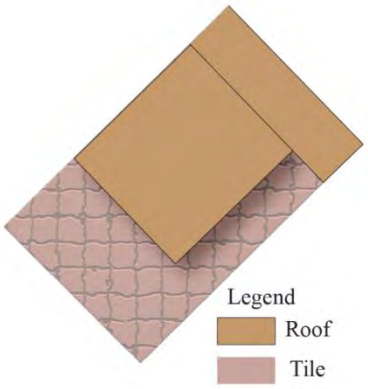


Figure 6.42: site plan of residence one

Residence two

Impermeable surface

Run off volume for concrete = total area of the concrete * annual rainfall* runoff coefficient

= 106 m2 * 1089mm* 0.9

=103,891 liters/average year

Run off volume for roofs= total area of the roof * annual rainfall* runoff coefficient

= 4,214 m2 * 1089mm* 0.75

=3,441,785 liters/average year

Total runoff volume of the residence= sum of the impermeable surface

=103,891 liters/average year + 3,441,785 liters/average year

=3,545,676 liters/average year

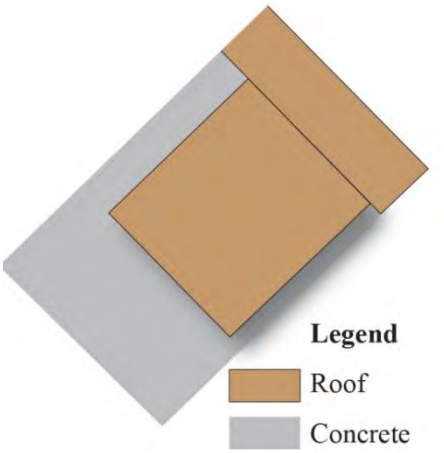


Figure 6.43: site plan of residence two

Light Industry

Light industry (garage)

Impermeable surface

Run off volume for roofs= total area of the roof * annual rainfall* runoff coefficient

= 112m2 * 1089mm* 0.75

=91,476 liters/average year

Semi permeable

Run off volume for Sandy loam soil = total area of the soil * annual rainfall* runoff coefficient

= 307 * 1089mm * 0.2

= 66,865 liters/average year

Total runoff volume of the garage= permeable surface +

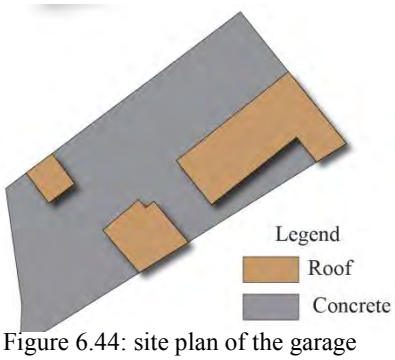


Figure 6.44: site plan of the garage

impermeable surface

= 91,476 liters/average year +66,865 liters/average year

=158,341 liters/average year

Social Services

Fana School

Permeable

Runoff volume for private garden = Total area private garden * Annual rainfall* runoff coefficients

= 220m2* 1089 mm * 0.3

=71,874 liters/average year

Semi permeable

Run off volume for Sandy loam soil = total area of cobble stone* annual rainfall* runoff coefficient

= 664m2 *1089 mm* 0.2

=144,619 liters/average year

Impermeable

Run off volume for roofs= total area of the roof * annual rainfall* runoff coefficient

= 392m2 * 1089mm* 0.75

=320,166 liters/average year

Run off volume for concrete = total area of the concrete * annual rainfall* runoff coefficient

= 120 m2 * 1089mm* 0.9

=117,612 liters/average year

Total runoff volume of the school= Permeable + Semi permeable + Impermeable

= 71,874 liters/average year + 144,619 liters/average year + 437,778 liters/average year

Total runoff volume of the school= 654,271 liters/average year

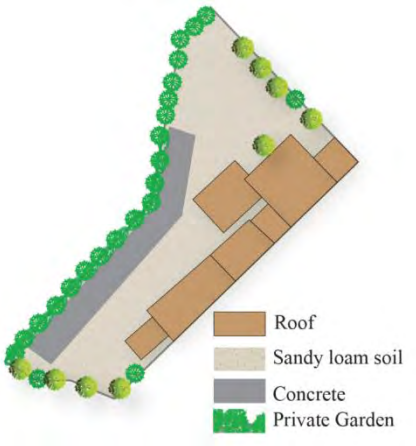


Figure 6.45: site plan of Fana School

Seyoum Special Eye Clinic

Impermeable Surface

Run off volume for roofs= total area of the roof * annual rainfall* runoff coefficient

= 145m2 * 1089mm* 0.75

=118,429 liters/average year

Run off volume for concrete = total area of the concrete * annual rainfall* runoff coefficient

= 103m2 * 1089mm* 0.9

=100,950 liters/average year

Total runoff volume of the clinic = 118,429 liters/average year + 100,950 liters/average year

= 219,379 liters/average year

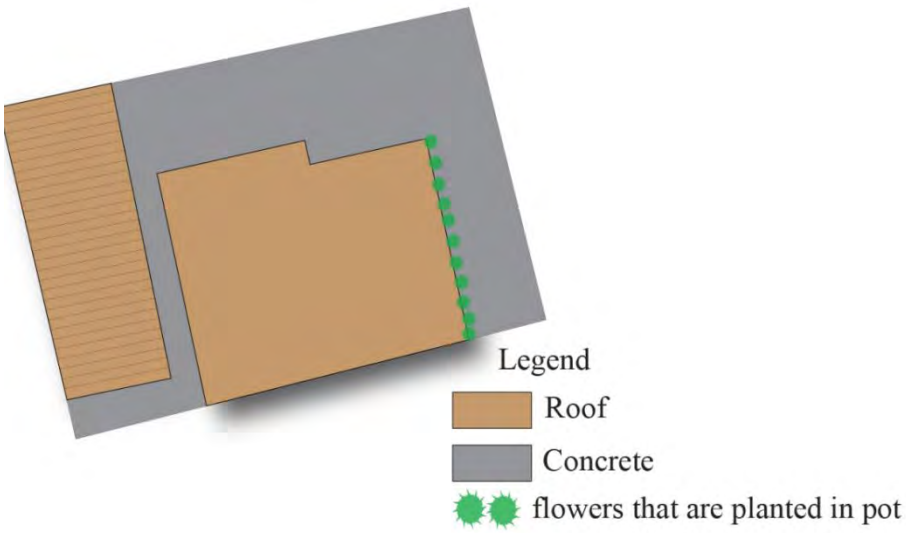


Figure 6. 46: site plan of Seyoum Special Eye Clinic

Mixed Use Building

Permeable

Runoff volume for private garden = Total area private garden * Annual rainfall* runoff coefficients

= 0.7m2* 1089 mm * 0.3

=229 liters/average year

Impermeable

Run off volume for roofs= total area of the roof * annual rainfall* runoff coefficient

= 202m2 * 1089mm* 0.75

=164,983 liters/average year

Run off volume for concrete = total area of the concrete * annual rainfall* runoff coefficient

= 74m2 * 1089mm* 0.9

= 72,527 liters/average year

Total runoff volume of the mixed use building = Permeable + impermeable + Impermeable surface

=229 liters/average year + 164,983 l/average year + 72,527 liters/average year

= 237,739 liters/average year

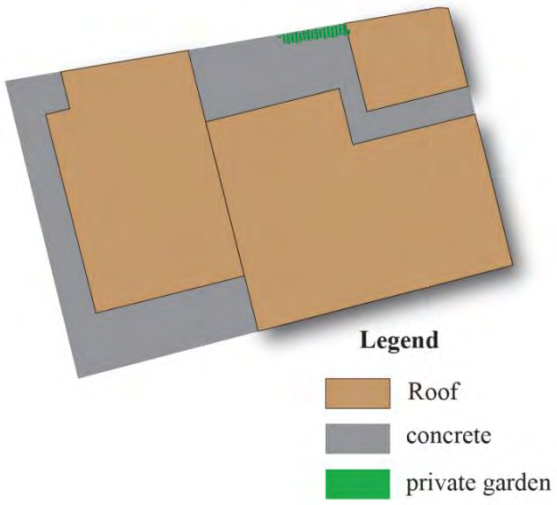


Figure 6. 47 site plan of mixed use building

As it is illustrated above, the runoff volume for the case area's open spaces residence, social services, mixed use building, light industry were calculated.

Rainwater harvesting: in the case area, the **residents do not have r**ainwater harvesting reservoirs. But, during the rain seasons, some of the residents use rainwater for household activities such as washing clothes and Utensils. Additionally, the mixed use buildings, social services and light industries do not have rainwater harvesting tanks.

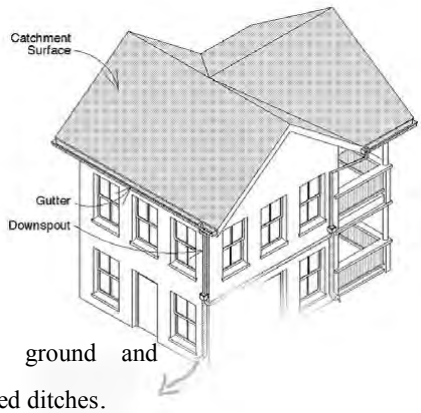


Figure 6.48: General characteristics of the existing building in managing rainwater

Water flow into the ground and commute to open or closed ditches.

6.5 Greenway

In the case study area, as discussed earlier, there is no greenway. Nevertheless in some areas of the river, there are foot paths that directly end into the river. According to the interview made with the residents, the pathways are created by people who enter the river to collect steels and other materials. There are three bridges and a road, which is paved with cobble stone along the river. The researcher will analyze case area's pathways, roads and the bridges using human dimension of urban greenways. According to Gobster et al. (2004), cleanliness, naturalness, aesthetics, safety, access, and appropriateness of development are the six interdependent "human dimensions" of greenways.

Cleanliness

The river and its surrounding environment should be clean (Gobster et al., 2004).

On contrary, in the case area, the river and riversides are not clean. For this reason, when someone crosses the bridge, there is a bad smell when crossing the bridge.

Figure 6.49: The river with waste materials

Naturalness

Interactions with natural spaces can provide important restorative opportunities, relaxation, and stress reduction (ibid., 2004).

However, in the study area, 90% of the vegetation along the river is replaced by building/ residential land uses. But there are shrubs and trees near to the river where it is not suitable to live. As a result, when the communities walk over the bridge or the pathways, they do not have interaction with the natural environment. For example, the residents do not relax when they are walking around the river. They just use the bridge to go home or work.

Figure 6.50: vegetation at the edges of the river

Figure 6.51 unsafe bridge

Aesthetics

Natural beauty was important along even most urban stretches of the corridor, buildings, distinctive bridges, and other human creations also played an important role in people's aesthetic appreciation of the riverscape (ibid., 2004). In contrast to this, as it is mentioned above, Finicha River has no aesthetic value. This is because the river space became a place where liquid and solid waste are gathered/dumped. (the river spaces are full of trash and other dirty materials). Therefore, the residents walk through the bridge not to appreciate the nature but to go to their home or to dump trash.

Figure 6.52: dumping solid waste into the river

Safety

It is an important dimension in the perception of urban environments (ibid., 2004). Gobster et al. (2004) explained that there are two different aspects of safety: **physical safety** such as children falling into the river; health concerns about direct physical contact with polluted water, etc. **Personal safety** includes the river as a place for drinking and drug use, and as habitat for the homeless.

Figure 6.53: path that lead to the river

In the case area, there are three bridges. One of the bridges is constructed with concert, and the rest of them are built with wood. The bridges has constructed by the residents without the help of the Woreda Administration as it can be understood from the interview conducted with the residents. The bridges are unsafe as it is not well constructed .Additionally, children who are playing around the river, and those who enter the river using the foot path are exposed to waterborne diseases. As result of these, the area is physically unsafe. Additionally, the river has become a place for criminal activities. Due to this, there is no personal safety around the river.

Figure 6.54: crossing the unsafe bridge

Access

It is an increasingly important topic with regard to the human dimensions of urban greenway. In central cities, though natural experiences or activities are taking place, development is reducing natural access in suburban and fringe areas. There are two types of access. These are physical and visual access. Physical access to the river through public open space, boat and canoe launches, and riverfront trails. Visual access includes views to rivers are often blocked by fences and weedy growth.

Figure 6.55 visually inaccessible

In the case area, there are physical accesses into the river since it has pathways that lead into the river. However, it is not recommended to use the footway as the river is dirty and aesthetically unattractive. Besides, some part of the river is not visually permeable as vegetation grown on it. On the contrary, other part of the river is visually accessible since as there are no vegetation.

Figure 6.56: polluted river

Appropriateness of development

It deals with appropriate use and development of greenways so that both the ecosystems and the experiences for which they are valued can be sustained. New development should be appropriate to the context of river settings. In the wilder sections of the greenway corridor, new recreational developments should respect the natural qualities of the environment.

In the study area, the official of the Woreda mentioned that new bridge will be constructed that serve the movement of both pedestrians and those who have cars. As a result, the bridge block view of the river. In addition to these, there is a road along the river. It can be greenway. However, it is constructed in the riparian zone.

Figure 6.57: road along the river

6.6 Connection between Yerer's Settelers and 'Finicha River'

In this section, the researcher will assess and evaluate the interaction between Yerer's settlers and Finicha River by using functional dimension of urban design.

Comfort

- Length of time people stay around the river
- Environmental dimensions: relief from sun, wind, etc.
- Physical dimensions: sufficient seating, lighting, etc.
- social and psychological dimension: a sense of security
- Quality of design and management

In case area, the early days, people stay along the river and riverside for longer time since the river was clean, and it is used to have dense vegetation that protect the users from wind and sun as the elders of the case area mentioned.

However, nowadays, the settlers do not stay on Finicha river space. This is because the vegetation is replaced by settlements and the river is polluted as it is mentioned above. In addition, the communities do not pay attention for the cleanness of the river; expect the residents that are living along the river.

Relaxation

The following elements will enable any person to relax:

- Natural elements -trees, greenery, water bodies and the like
- a place that separate from vehicular traffic
- visual permeability

In the past, there were aquatic and territorial plants and animals around Finicha River. In addition the communities used to have both visual and physical access to the river. As result of this, the dwellers sit and relax on the river space. On the contrary, today Finicha River has become a place where trashes are dumping. For this reason, the river is not suitable for relaxation.

Active engagement

It involves direct experience with a place and the people within it. It includes sport such as: Walking, Jogging, Cycling, etc.

In the early days, the communities of the case area were used to swim, wash their clothes. Additionally, during New Year, the residents used to take early bath in the river. As a result, there were active engagements around the river. Nowadays, the residents use the river for dumping wastes. Due to this, Finicha River is not used for active recreations, except certain children are playing along the river.

Passive engagement

It includes watching people, without being involved in the activity (Carmona M. et al, 2003)

In former time, there were passive engagements that women of the case area sat along the river bank, talked to each other when they went to fetch water.

Figure 6.58 Active and passive engagements around Fincha River

CHAPTER SEVEN

FINDING, CONCLUSION AND RECOMMENDATIONS

7.1 Findings

Here the findings of the study area will be presented.

The riparian zone of the case area has reduced in size through time. For in stance, in the past, there was dense vegetation along the river. But, nowadays, the riparian zone is used for unintended purposes such as squatter settlements, toilets and dumping waste materials. The major factors for the shrinking of the case area's riparian zone along the river banks are summarized as follows.

- ***Population growth*** : as the population of the case area increased, the riparian zone decreased in size;
- ***Informal settlements along Fincha River***: the riverbank is occupied by illegal settlers;
- ***Solid and liquid waste:*** the river and riverside have become dumping site for solid and liquid wastes;
- ***Lack of awareness regarding the benefits of reparian zones*** among the case area's residents, woreda and subcity;
- ***Absence of trained man-power related to riverside development (*** landscape architects, urban designers, environmentalist and the like***)*** in the concerned bodies such as WBGB, BBGB,WEPA,BEPA

- Due to the shrinking of the case area riparian zone, gully erosion and loss of biodiversity have resulted.
- The land uses of the case area have contributed to the pollution of the river as they discharge their liquid and solid wastes into the river without any treatment.
- The following are factors that aggravate flood damage and Pollution of Finicha River
    - **Absences of SMPs**: in the case area, SMPs are not incorporated within the existing diverse settings such as buildings, roadsides, parking lots and open spaces. However, some of the houses have vegetation adjacent to their fence. The residents plant shrubs, grasses, trees and flowers and consequently such practices have positive effect on the cleanness of the surrounding area, and in mitigating flood damage. Additionally, the local roads are paved with cobble stones and have opened job opportunities for the residents.
    - **Lack of awareness** regarding the benefits of river. Rivers' significance is not fully understood by the dwellers and the concerned bodies as the community still disposes its household wastes into the rivers.

- **Lack of coordination** between the residents and the concerned bodies (Woreda Administration, BBGR and BEPA).

- Major pollutants such as Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), dissolved solids, inorganic chemicals and disease-causing microorganisms have contributed to the degradation of the river quality as they are found in excess amount.
- The pollution of Fincha River has resulted in social, economic and ecological crisis in addition to health problems caused by water borne diseases.
- Flood has damaged the infrastructure, economy and ecology.
- In order to mitigate flood risks, the community residing around the river has diverted the river's flow. The residents have also dug the stony grounds and constructed gabion along the river to reduce flood damage. In addition, the community has piled up sacks filled with soil and placed them in rows along the river to reduce gully erosion.
- In the study area, there are no greenways. However, in some areas of the river, there are foot paths that directly lead up to the river.
- Unlike the earlier days, currently, the residents do not stay longer in the case area's riverside because it has become a place for settlements as well as a waste dumping places. For this reason, Fincha River is not the recreational area where the residents relax around either actively or passively.

7.2 Conclusion

During the time of empress Zewditu Finicha River was used to be a place for aquatic and terrestrial habitat. In addition, in early days, the communities were used to relax along Finicha River. There was also passive and active engagement along the river. For instance, the case area's women were used to fetch water, sat and relax along Fincha River. Moreover, during New Year, the communities were used to take baptized in the river. Nowadays, the river was neglected as it became a place for criminal activities and disposal of solid and liquid wastes. Furthermore, the communities were used to plant and sell flowers. However, due to flood and pollution of the river, they stopped such commercial activity. The children, who were playing along the river, were exposed to water-borne diseases as the river is polluted.

In the past, during rainy season, the water flew to the adjacent area and has caused serious damage to properties. For this reason, to mitigate flood, the community change the flow direction of the river. Additionally, the residents that are living along the river reinforced their fence with stone at the base, and corrugated iron above it. The residents have dug the rocky/ stony grounds. Furthermore, they construct gabion along the river.

Beside, in the study area, there is no rain water harvesting system. But some of the residents use rainwater for household activities such as washing clothes and utensil. There are also no green roofs or any other SMPs in the study area expect the communities have the habit to plant vegetation adjacent to their fences.

In order to achieve the aforementioned finding, the data gathered from the field were interpreted using temporal dimension, SMPs, human dimension of urban greenway and functional dimension. The theories were relevant to come up with findings. Based on the findings, recommendation and site specific design strategies will be explained below.

7.3 Recommendation

The following recommendations are suggested based on the research findings:

- The existing houses that are constructed along Finicha River should be replaced by the riparian forests.
- Variable- width riparian strip is recommended. Therefore riparian buffer of Finicha River should be 20 meters in one sides of the river in order to attenuate flood hazards and protect water quality of Finicha River (see fig. 7.1).
- The proposed riparian forests along Finicha River should contain mix of trees, herbaceous plants, shrubs and grasses. Such mixes of vegetation have the capacity to trap wide range of pollutants before entering into Finicha Rivers.
- Training and seminars that provide awareness regarding the benefits of riparian zone should be given to the case area's residents, woreda and subcity.

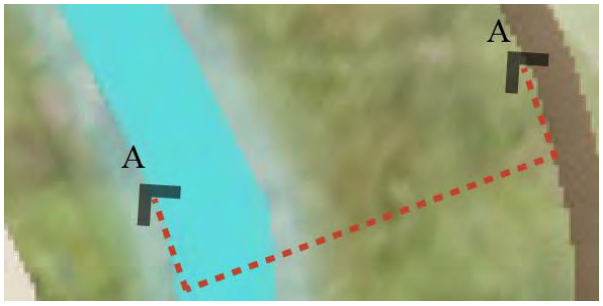


Figure 7.1a: Section A-A

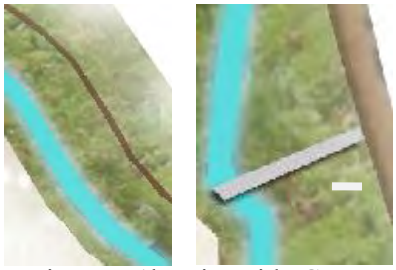


Figure 7.1b: Riverside Greenway

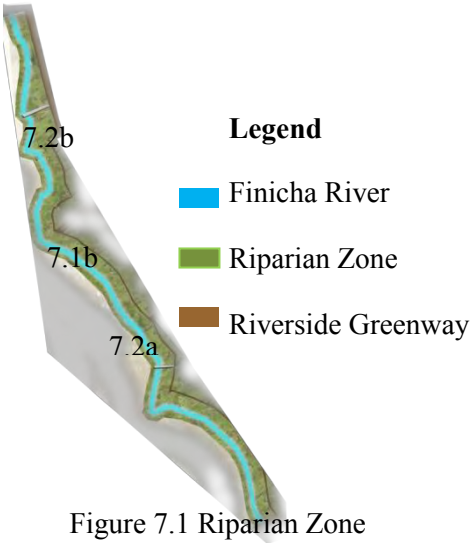


Figure 7.1 Riparian Zone

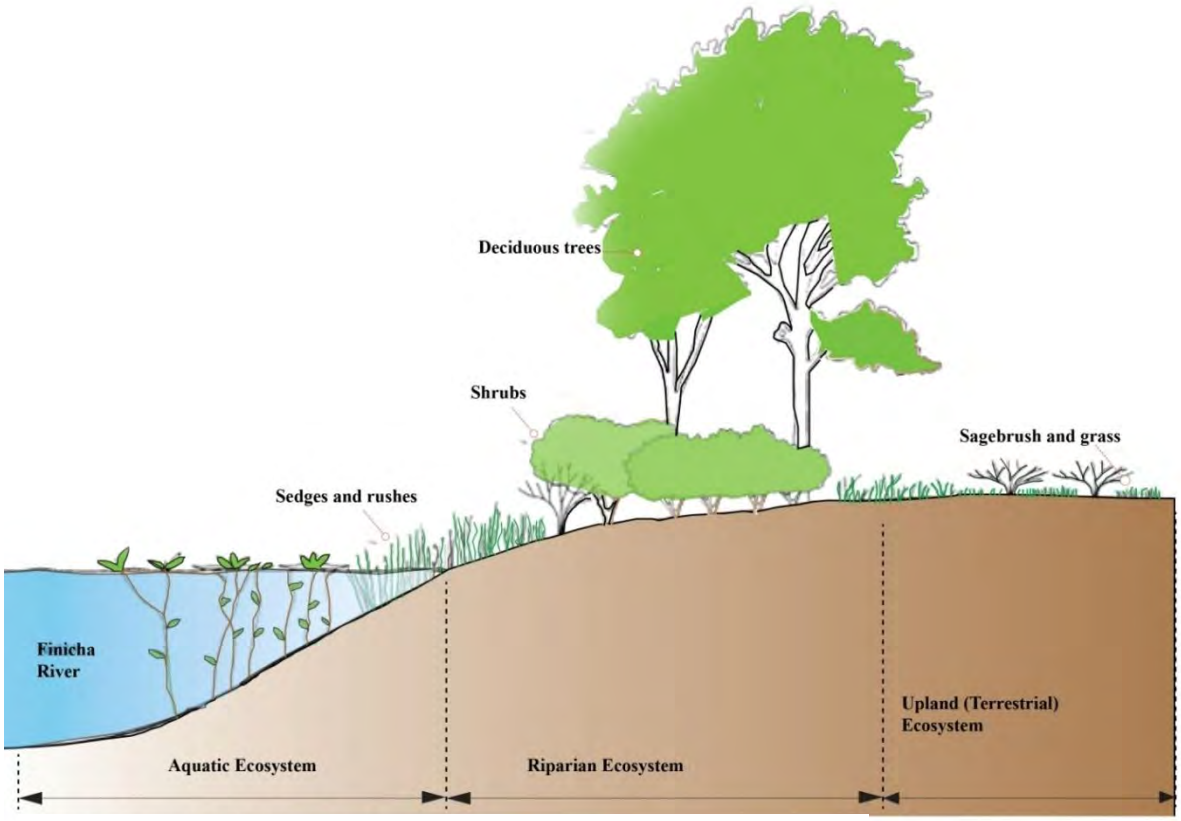


Figure 7.1c: Type of vegetation along Finicha River

Figure 7.1d: Riparian forests along Fincha River

The recommended greenway for the case area is urban riverside greenway, with a view to protect Finicha River and the surrounding area from further damage. Additionally, the construction of greenways along the riparian buffer would help to give emphasis to the neglected Finicha River. The greenway is linear open space that helps the residents to have active and passive recreation.

Figure 7.2: Riverside Greenway

Figure 7.2a: Proposed riverside Greenway around open space 5

Figure 7.2b: riverside Greenway adjacent to buildings

Strong bridges should be constructed for safety and easy passage between the neighborhoods.

Figure 7.3: Proposed bridge

- In order to mitigate pollution of Finicha River and flood damage, it is recommended to use SMPs in each land uses such as residential, mixed, social and light industries open spaces and parking lots. Such practices help to remove major pollutants such as COD, BOD, dissolved solids (phosphate and nitrate), and heavy metals (lead, mercury, chromium, cadmium and Arsenic) before entering into Finicha River and decrease runoff speed.
- To reduce flood damage in the case area, there should be rainwater harvesting system in each land use of the case area. Additionally, the compound of each land use should be paved with porous pavers in order to reduce the speed of runoff, and also treat rainwater before it infiltrates into the ground.

Figure 7.4: Proposed land use map

- The compounds of the study area's residential, industrial, social services and mixed use buildings should be paved with permeable pavements, and have private gardens. This makes the permeable pavements and vegetations to treat the rain water before entering into the ground or is stored in water tank.
    - In order to eliminate the amount of fecal coliforms found in Finicha River, it is recommended to build septic tanks in each household.
    - To avoid excess amount of COD and BOD that exist in Finicha river, it is advisable to give training about reuse of grey water (household wastes) to the communities of the study area. In addition, the woreda administration should penalize those who have directly connected their toilet to the river, as well as those who discharged solid and liquid wastes through the drainage lines.

Residence

Land Use Type: Residence

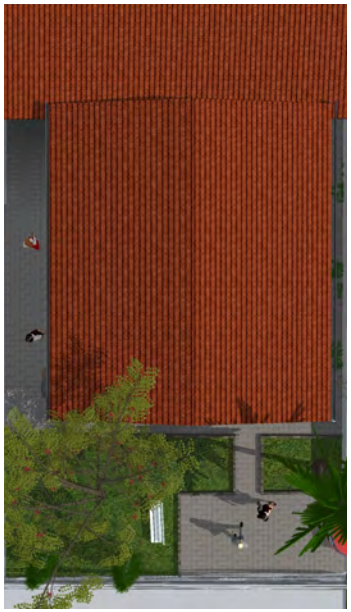
Property Owner: private

Roof area: 4214 meter square

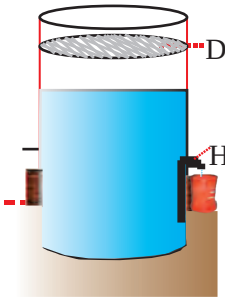
Proposed Permeable pavement: 111 meter sqaure

No impervious surface

Proposed Cistern



roof is coverd with wire mesh inoreder to remove pollutants



percolate into the ground

Clean water that is used for household activities such as to wash clothes and utensil

Flash

Calculating the storage capactiy of cistern by using dry period demand method

Formula:storage of capacity of cistern= household daily demand+ dry season run on average

required

household daily demand=?

given

consumption of water per day = 35 L

35* 5 people= 175L

rainfall max. 27mm= 0.027m

dry season run on average= 120day (October November December January)

Figure 7.5: Sample design for residence

Mixed Use Building

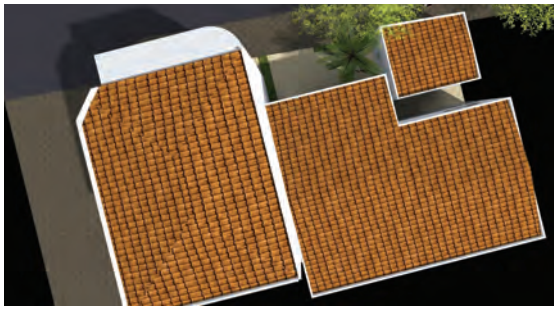
Land Use Type: Mixed Use Building

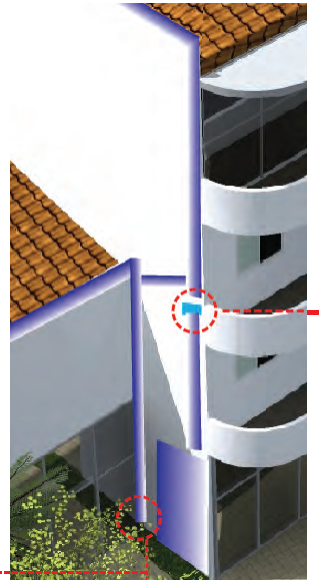
Roof area: 202meter square

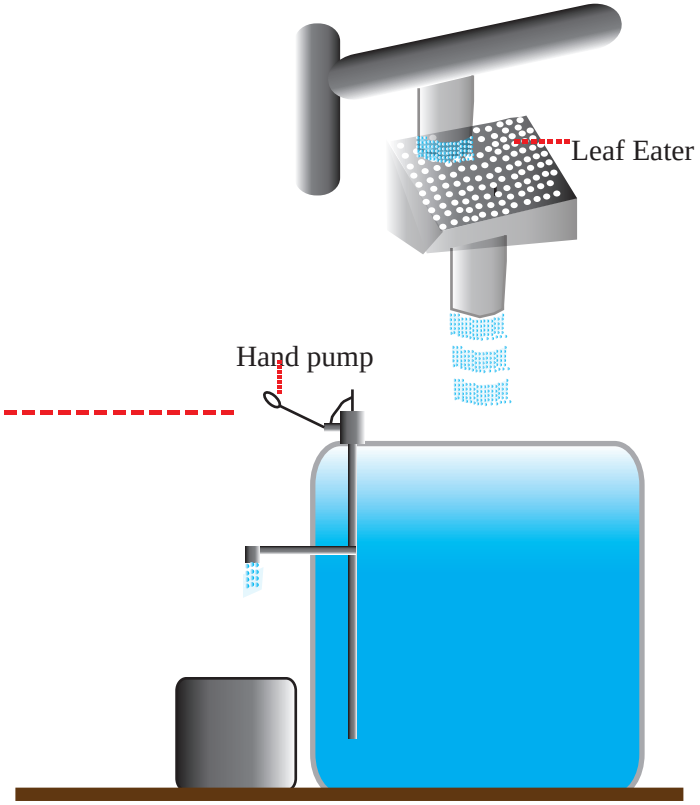
Proposed Permeable pavement: 74meter square

No impermeable surface

Proposed Cistern





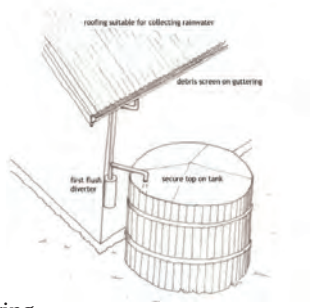


First flush diverter the rainwater fall into permeable surface that is grass

Figure 7.6: Sample design for mixed use building

Social Services

Land Use Type: Fana School
Property Owner: private
Roof area:392 meter square
Proposed Permeable pavement: 1004meter
proposed permeable surfaces
Proposed Cistern

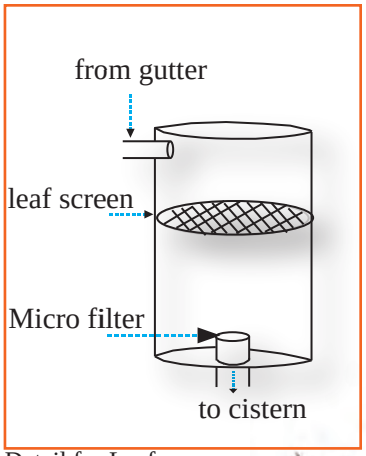


Debris screen on guttering

Figure 7.7:Sample design for social service, Fana School

Social Services-2

Land Use Type: Seyoum Special Eye Clinic
Property Owner: private
Roof area:145 meter square
Proposed Permeable pavement: 103 meter square
No impervious surface
Proposed Cistern

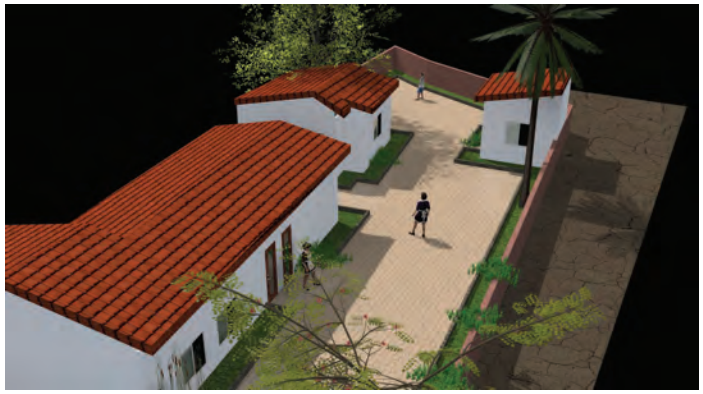


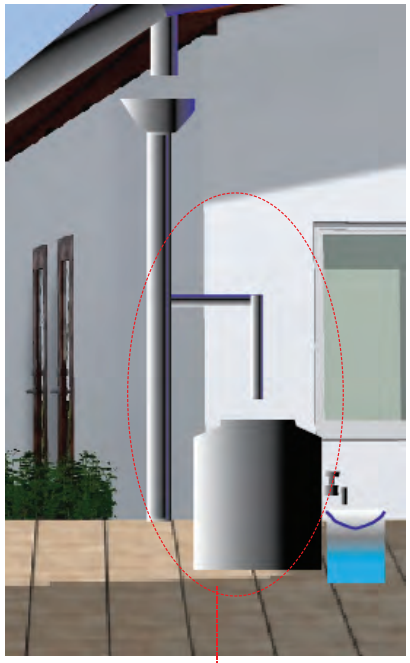
Detail for Leaf screen

first flash
Diverter

Figure 7.8: Sample design for social service, Seyoum Special Eye Clinic

Light industry :Garage





Land Use Type: Garage

Property Owner: private

Roof area: 112 meter square

Proposed Permeable pavement: 307 meter square

porous paver

Proposed Cistern

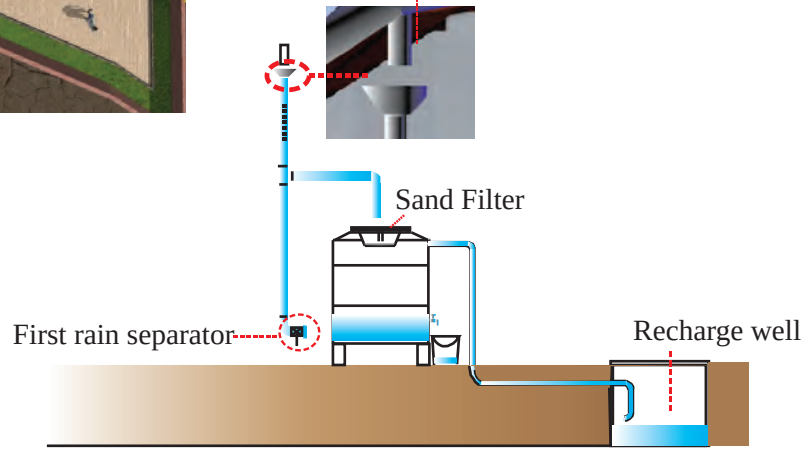
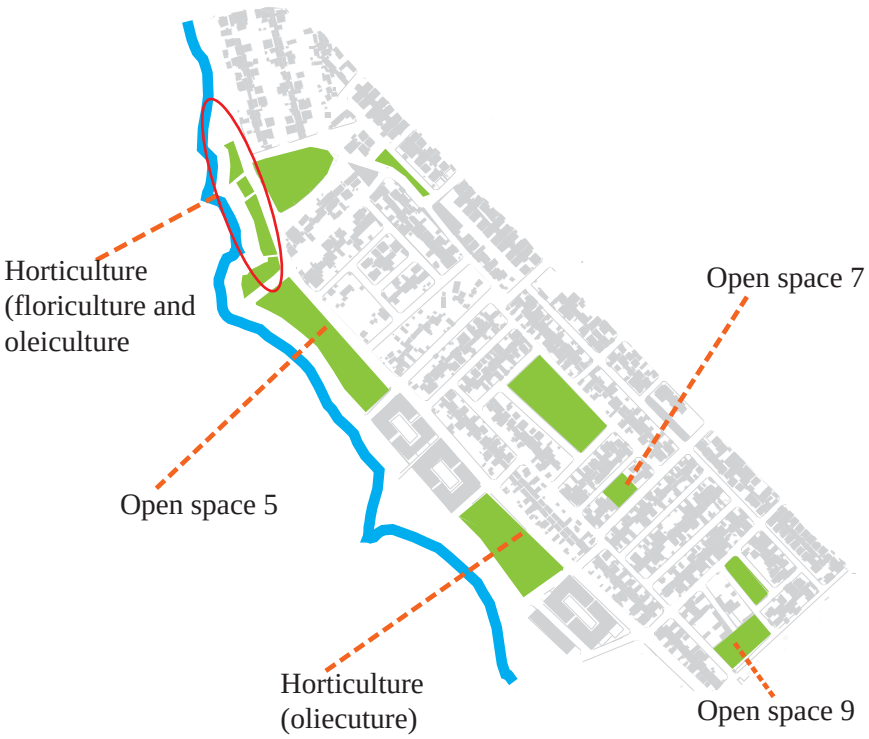


Figure 7.9: Sample design for ligth industry

Proposed Open Spaces



The case area open spaces should include both hard landscape like porous paver and soft landscape such as grass, tree, flower and shrubs. These help to reduce runoff speed and rain water can percolate into the ground. In addition, such landscapes have the potential to remove pollutants at their sources before entering to Finicha River. The following are the proposed open spaces.

Proposed Open space 9

The proposed open space 9 has space for children, elder, youth and meeting place ('edir'house). It has also space to celebrate 'meskel', and other cultural ceremonies and events. Therefore, the proposed open space is multi-purposed recreational center.

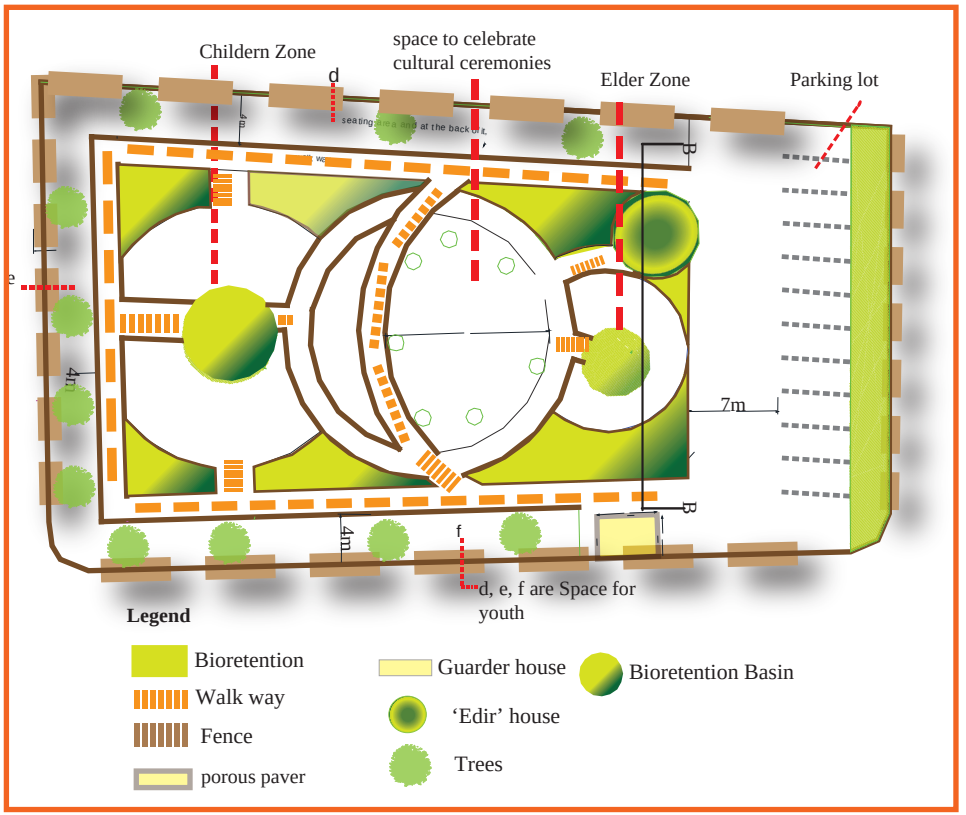


Figure 7.10: proposed open spaces

Top view of the open space

space for childern,

space for old peoples,

space for youth,

Figure 7.11: proposed Open Space 9

The following SMPs will be used in open space 9

a.Bioretention

b. green roof

c. porous paver

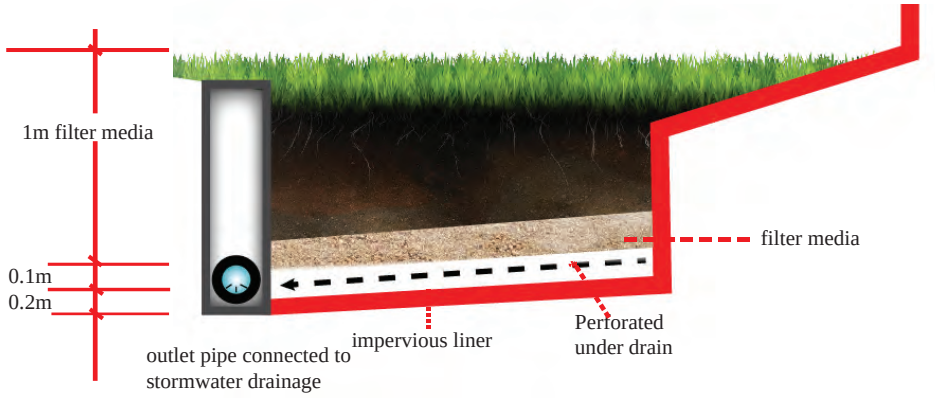
d. Water Tank

Justification

The above to method is applied in the design layout because:

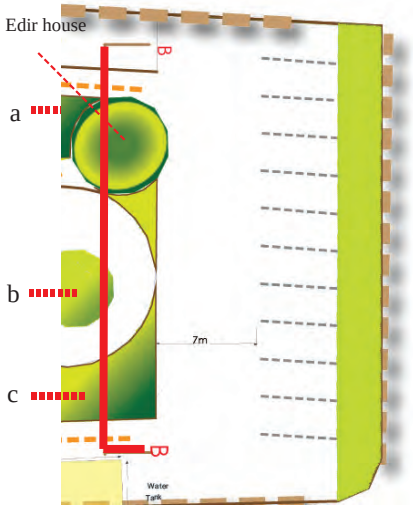
They have slope that range between 0 and 5%

According to the suitability alnaysis, the open space is extermely suitable to apply SMPs.

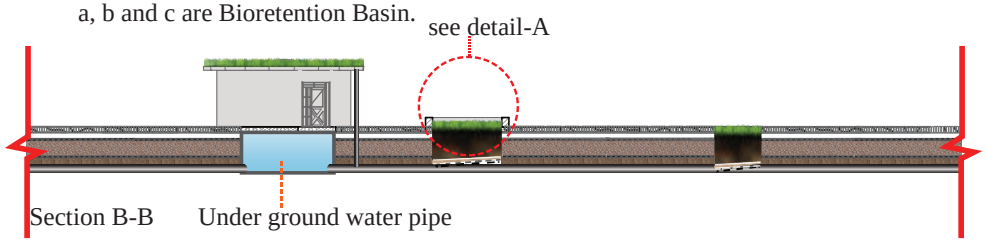


Section for bioretenion basin (Detail-A)

a.Bioretention Basin.

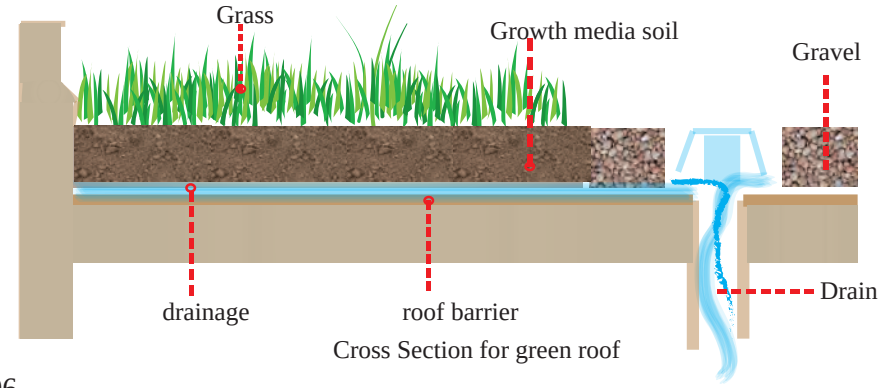


a, b and c are Bioretention Basin.



b. Green roof

'Edir House (green roof)



Cross Section for green roof

Figure 7.12:Bioretention basin and green roof ; proposed open space 9

c.Cisterns

The open space has two types of rain water tank .That is,underground water tank and above ground water tank The water that are inflitriate into cobble stone and bioretention basin. Then they will convey through pipe of cobble stone and bioretention basin . Finally store in to the underground rain water tank.

Figure 7.13: Cisterns and porous paver; open space 9

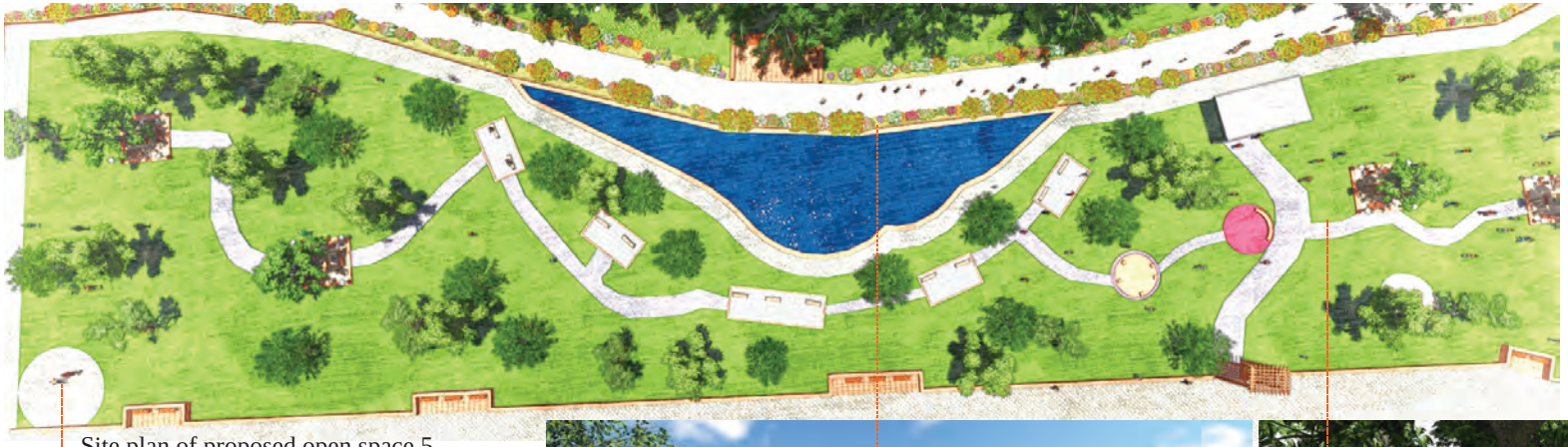
d Porous Paver

In the proposed open space, ground surface of the parking area, walk way paved with cobble stone. Additionally, some part of the space that will be used by elder, chidern and youth is paved with cobble stone.

the walkway is paved with cobble stone

The parking lot paved with cobble stone

Proposed Open spaces 5



Site plan of proposed open space 5

The proposed inflitration basin is effective in removing pollutants such as phosphate, nitrate and heavy metals before enering to Finicha River.

place for exercise; proposed open space 5

Inflitration basin; proposed open space 5

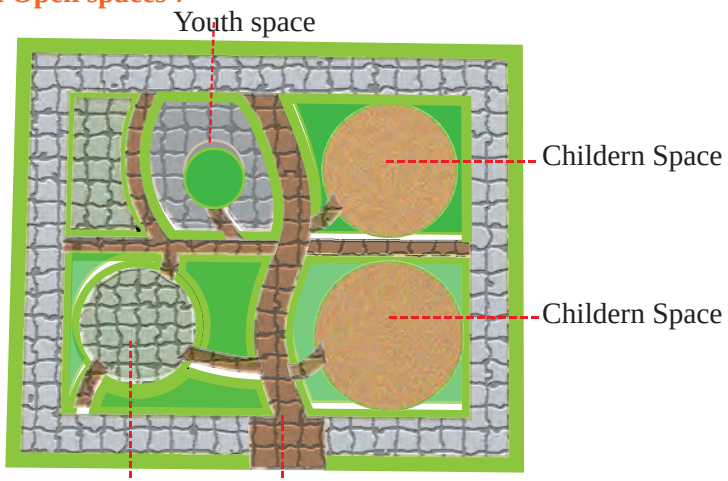
Seating area; proposed open space 5

Top view of proposed open space 5

walkway paved with permeable surface

Figure 7.14: Proposed open space 5

Proposed Open spaces 7



Site plan of open space 7

Top veiw of Open space 7

Childern space

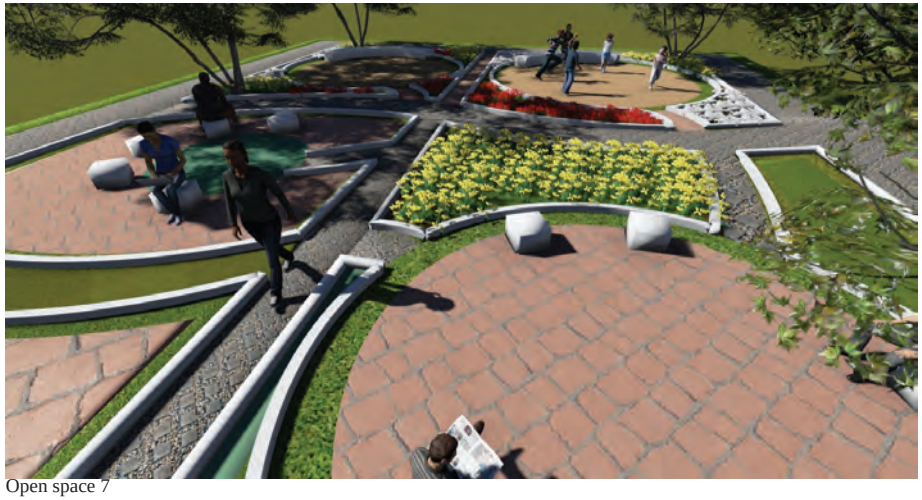
Youth space

Figure 7.15: proposed open space 7

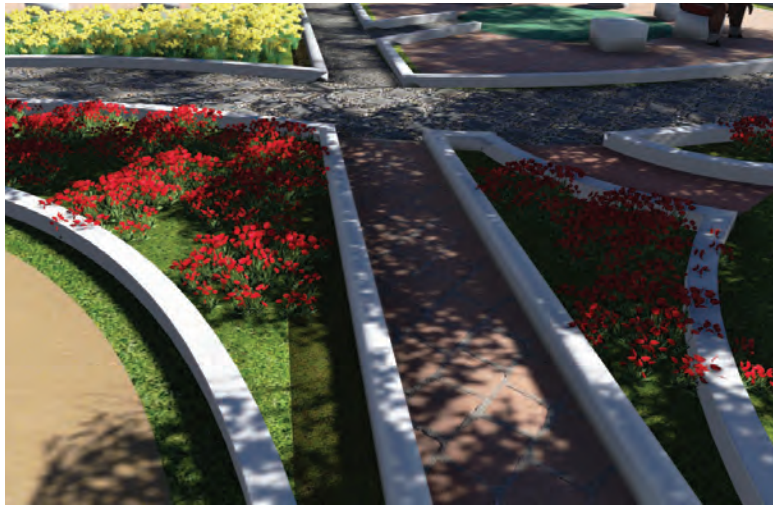
The proposed open space 7 has vegetaion such as flowers, grasses and trees. Additionally, the walkways are paved with permeable surface. For this reason, such vegetaion and permeable surface treat rain water before it pentrates into the ground.

Proposed Open spaces 7

Elder Space



Open space 7



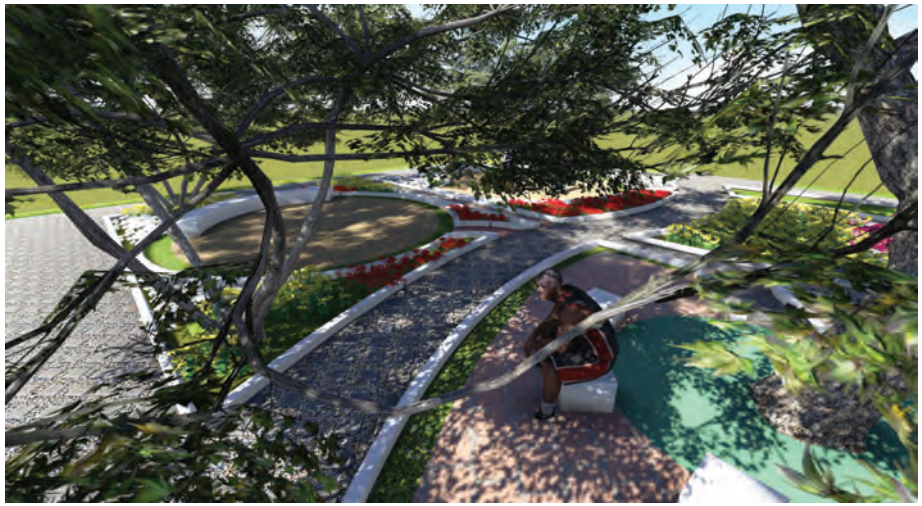
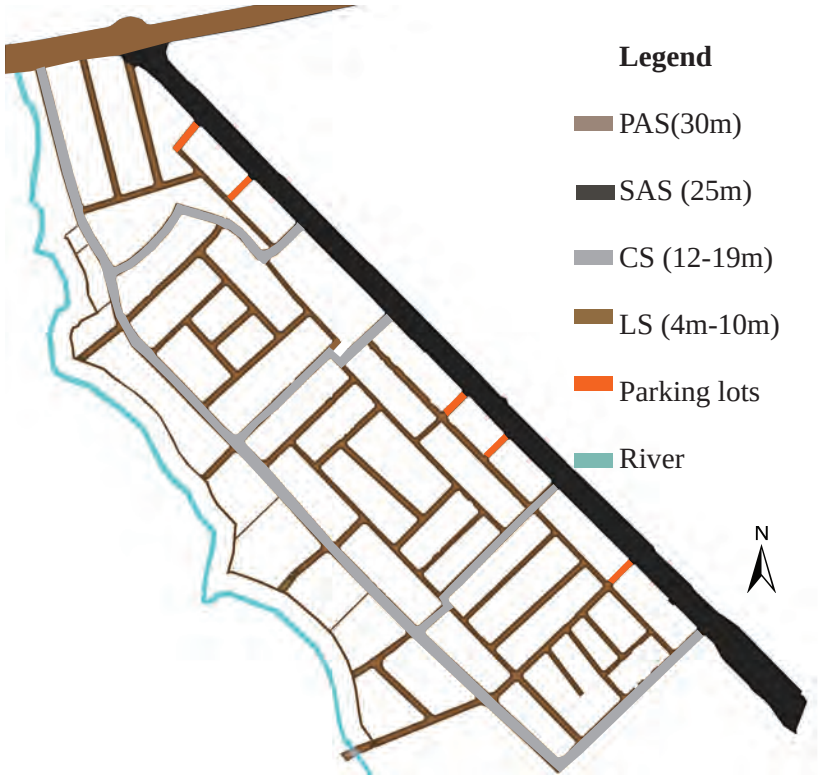


Figure 7.16 paved with permeable surface; proposed open space 7

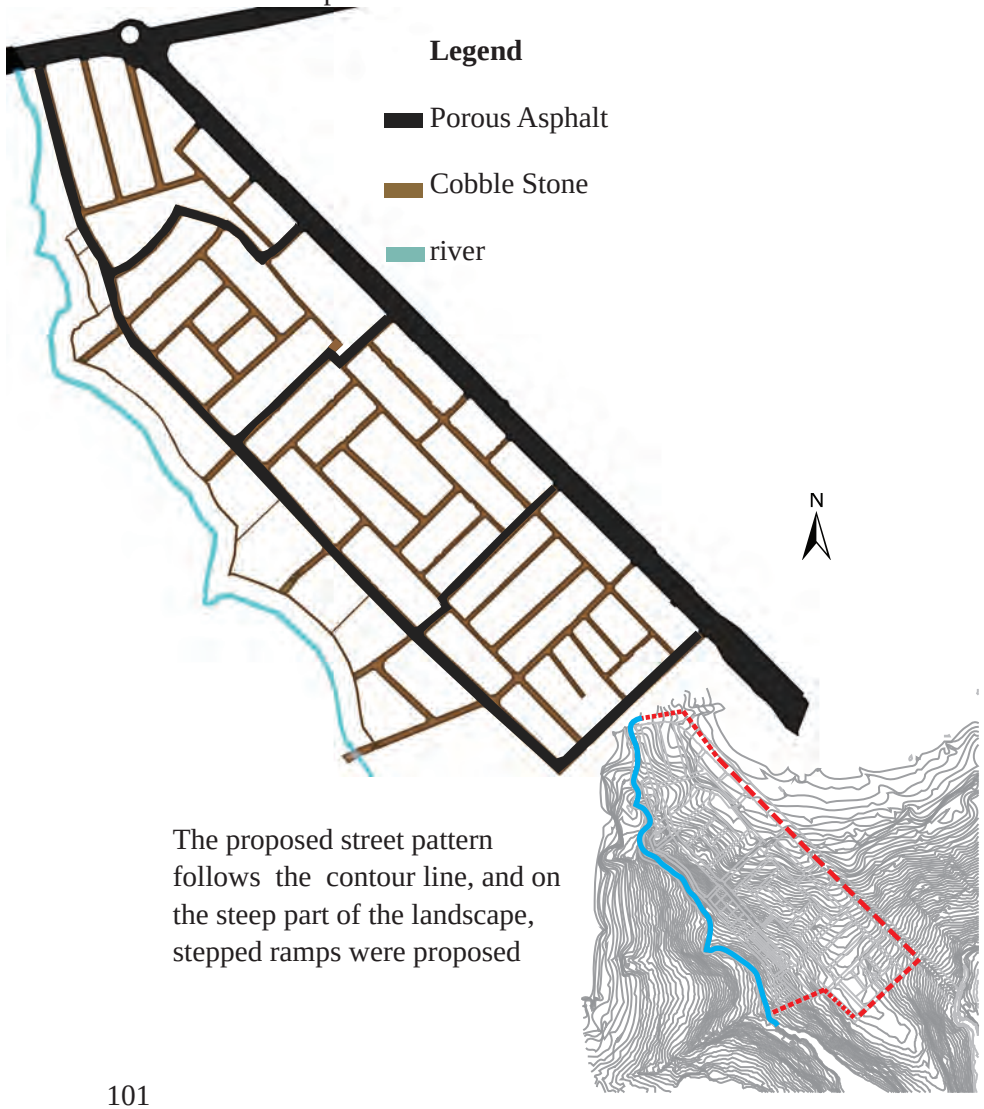
Streetscape development

Proposed Street Network



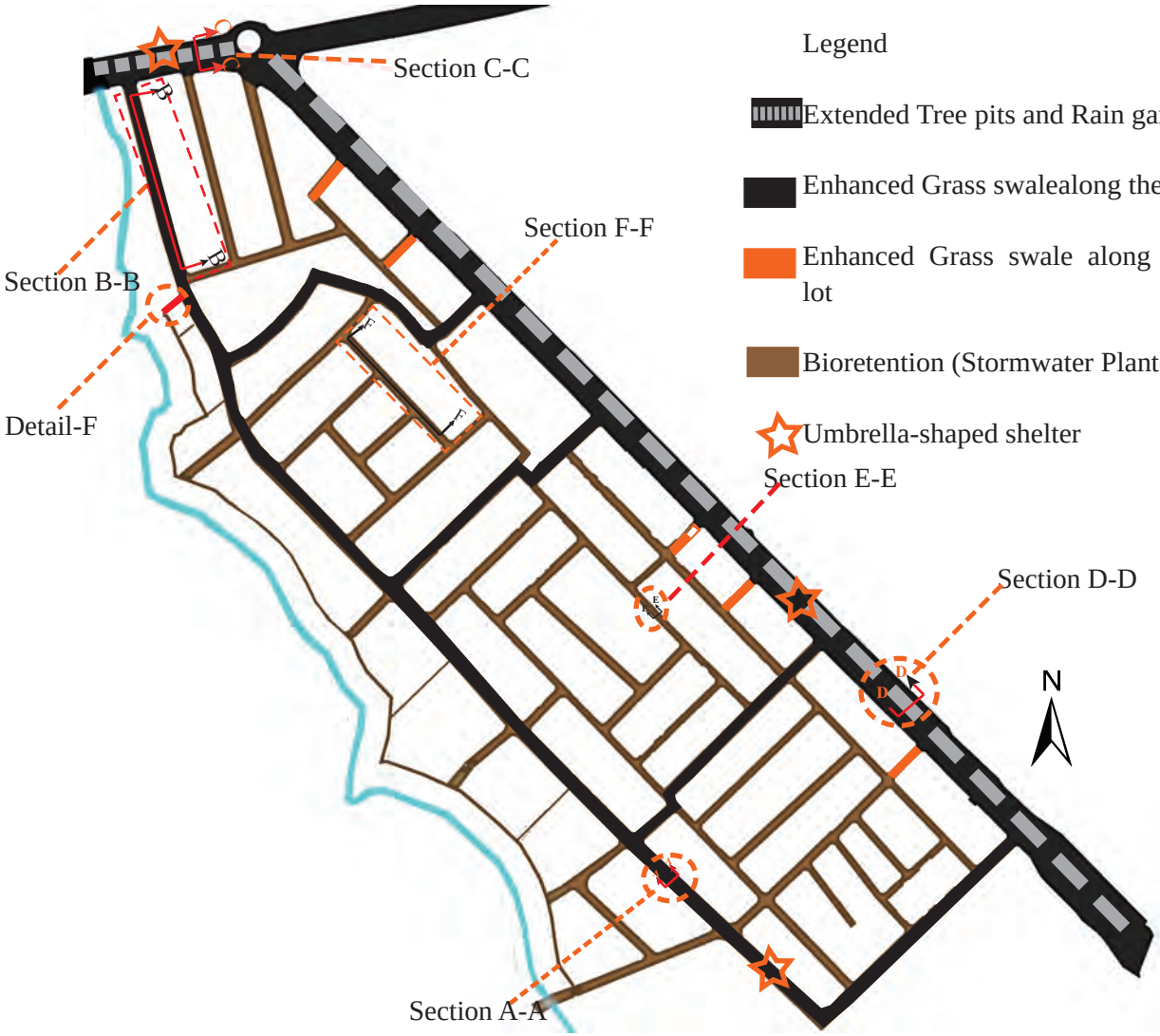
Proposed Street Pavement

To decrease speed of the runoff and treat stormwater, the proposed Principal arterial street (PAS) and the sub arterial street (SAS) should be paved with porous asphalt, and the local street should also be paved with cobble stone.



The proposed street pattern follows the contour line, and on the steep part of the landscape, stepped ramps were proposed

Figure 7.17: proposed street Network and materials



Legend

Extended Tree pits and Rain garden

Enhanced Grass swalealong the CS

Enhanced Grass swale along parking lot

Bioretention (Stormwater Planters)

Umbrella-shaped shelter

Justification

The SMPs that are applied on the proposed street layout than other SMPs due to the following reason:

1.Enhanced Grass swales

the area has slope between 0% and 8%

2.Forms of Bioretention

2.1.Extended tree Pit

the area has slope betwen 0 and 5%

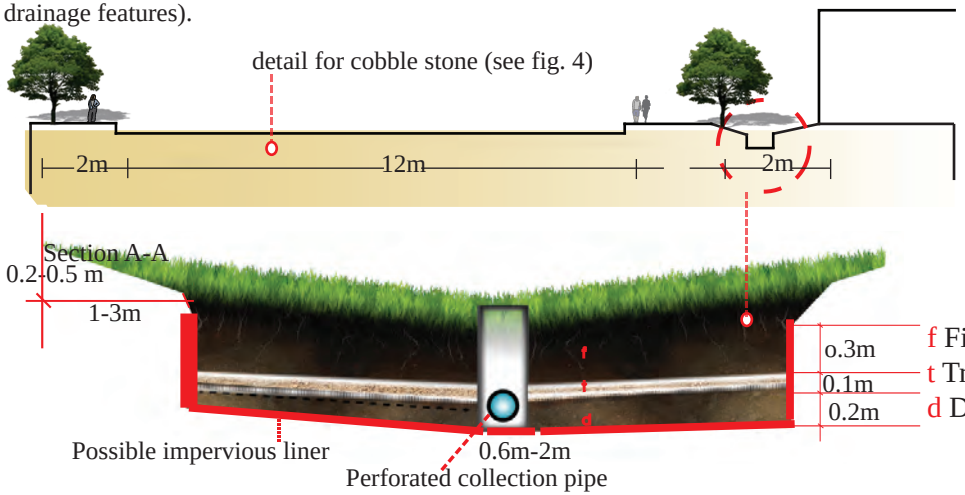
2.2.Storm water Planter

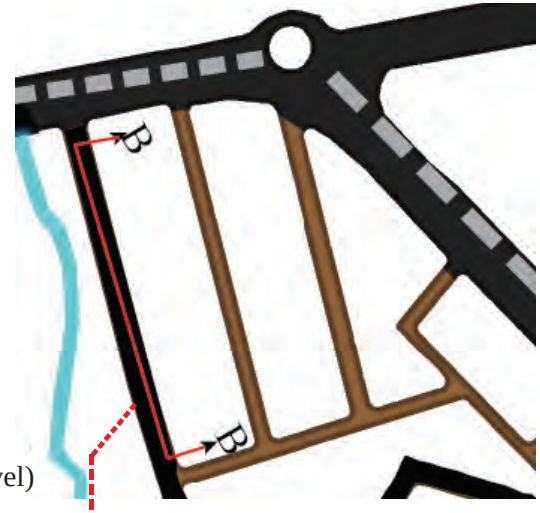
The study area has slope that range between 0 and 5%, and on the project area, there are plants adjancent to buildings. Therefore, in order to keep the site context, Stormwater Planter proposed on the area.

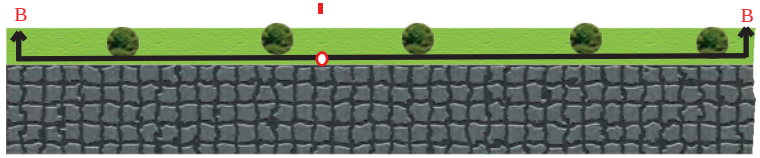
Figure 7.18: Application of Bioretention and Enhanced Grass Swale on the street.

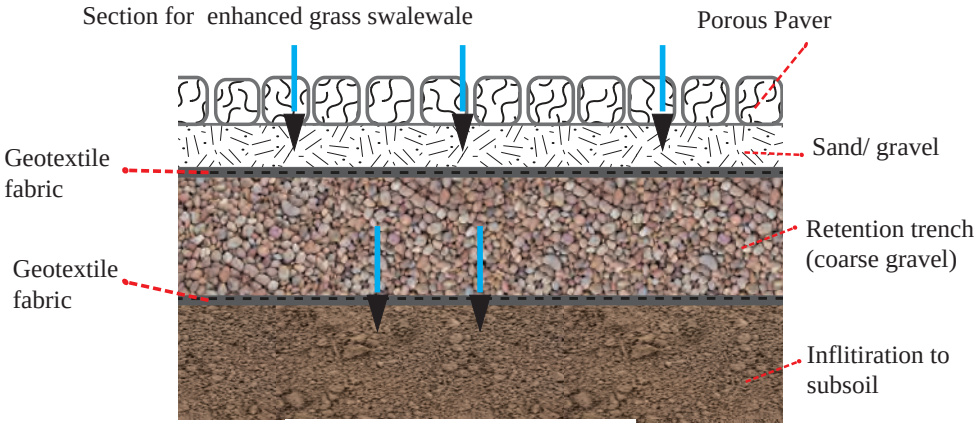
Enhanced Grass swales along collector street

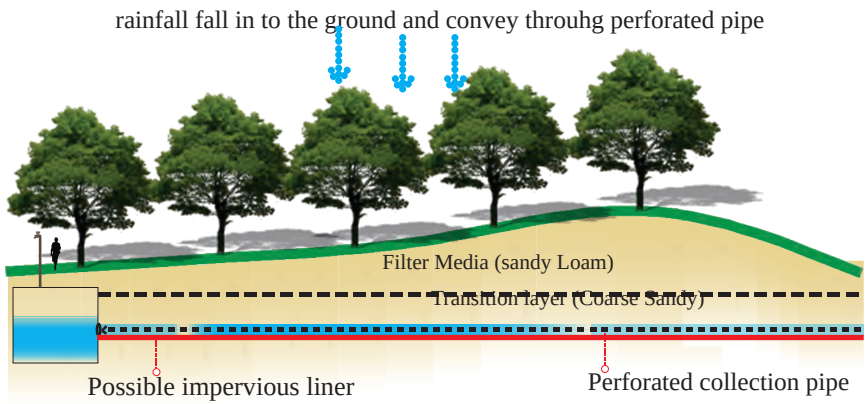
The existing drainage line should be substituted by enhanced grass swales (linear vegetated drainage features).







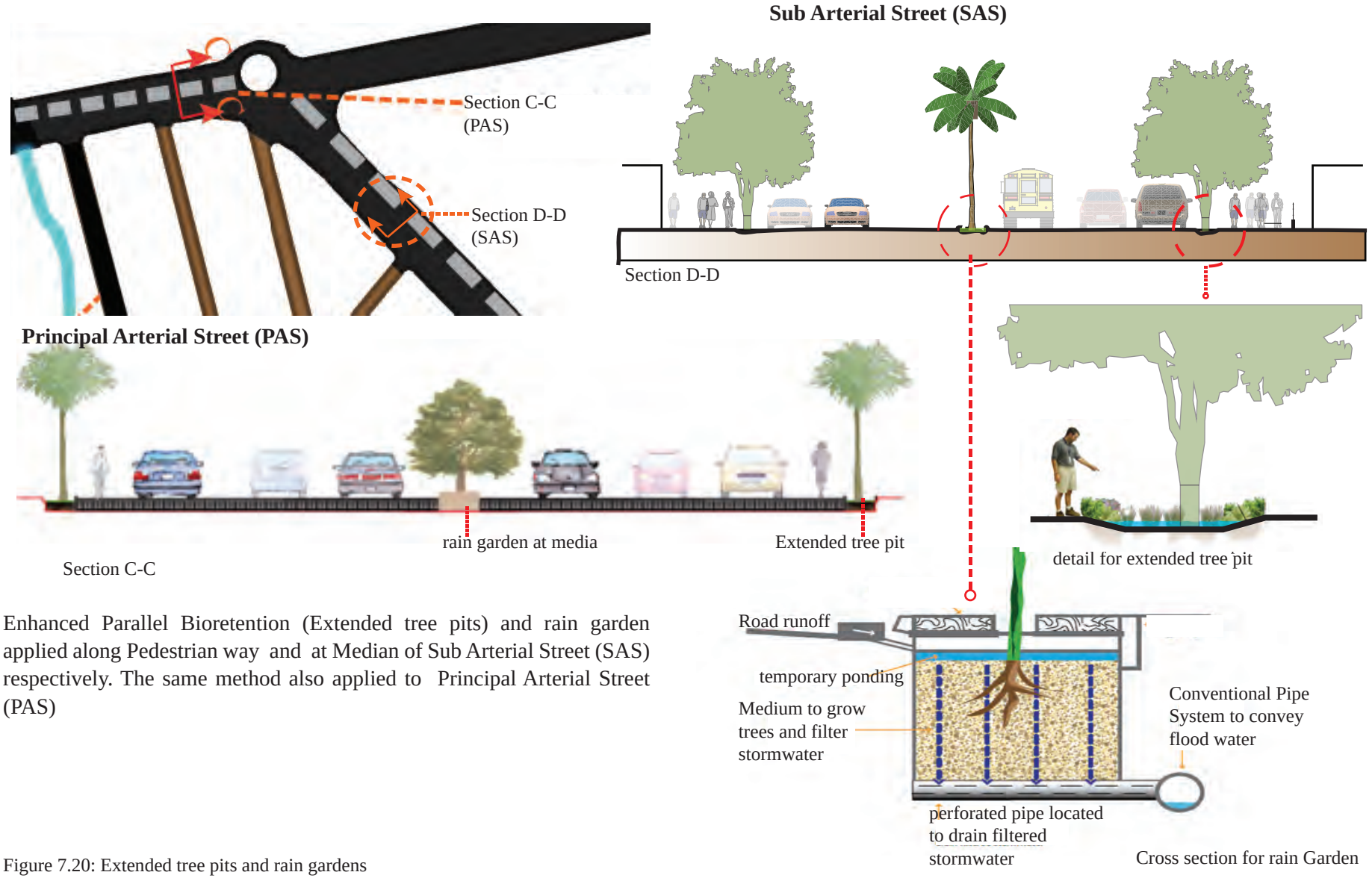




Section B-B: Longitudinal section for enhanced grass swale

Figure 7.19: Section for enhanced grass swale

Extended Tree Pits and rain Gardens

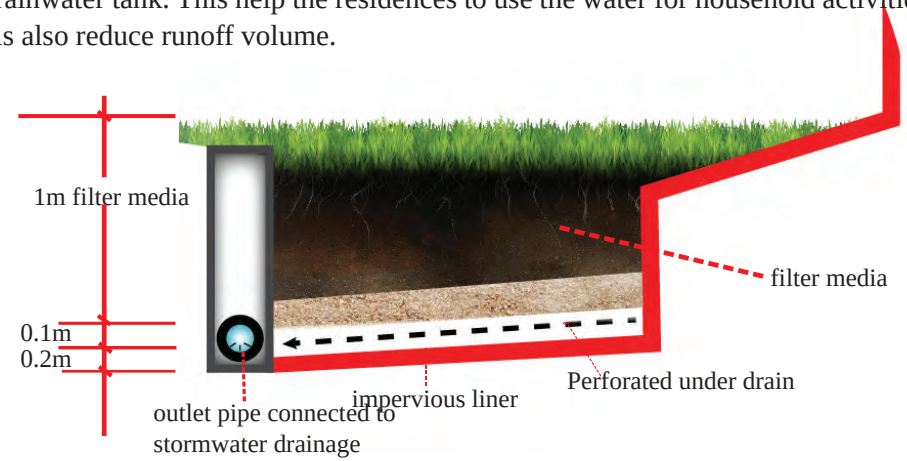


Enhanced Parallel Bioretention (Extended tree pits) and rain garden applied along Pedestrian way and at Median of Sub Arterial Street (SAS) respectively. The same method also applied to Principal Arterial Street (PAS)

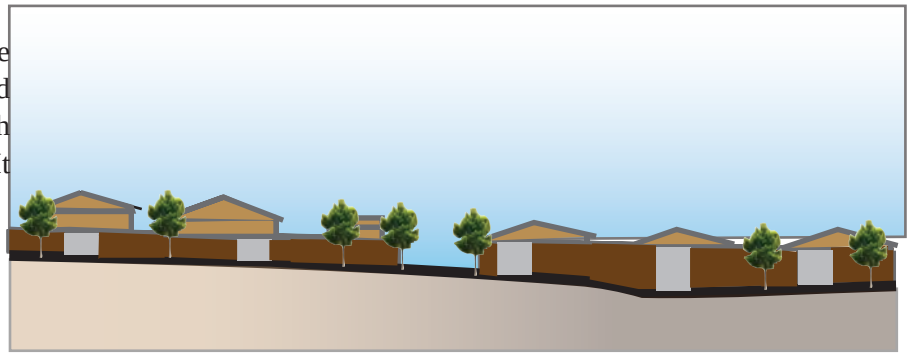
Figure 7.20: Extended tree pits and rain gardens

Bioretention: Stormwater Planters along the local street

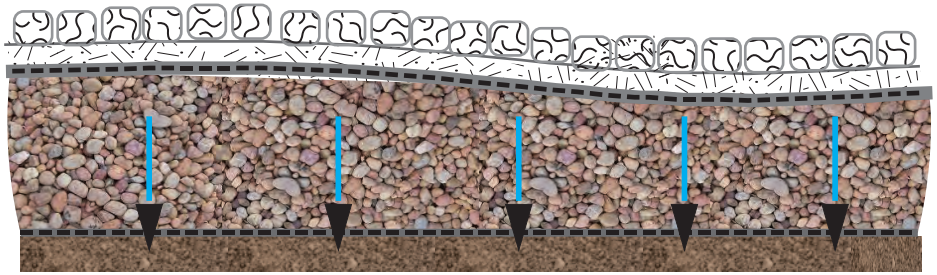
In the project area, there are plants adjacent to the fence of the buildings. Therefore in the proposed design layout change such practice into bioretention basin, and connect the pipe of the cobble stone (pervious pavemen) and biortention basin with rainwater tank. This help the residences to use the water for household activities. It is also reduce runoff volume.



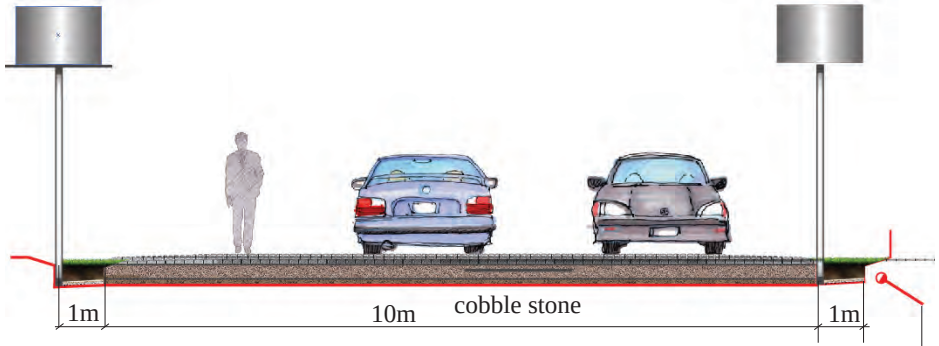
Section for bioretenion basin (detail k)



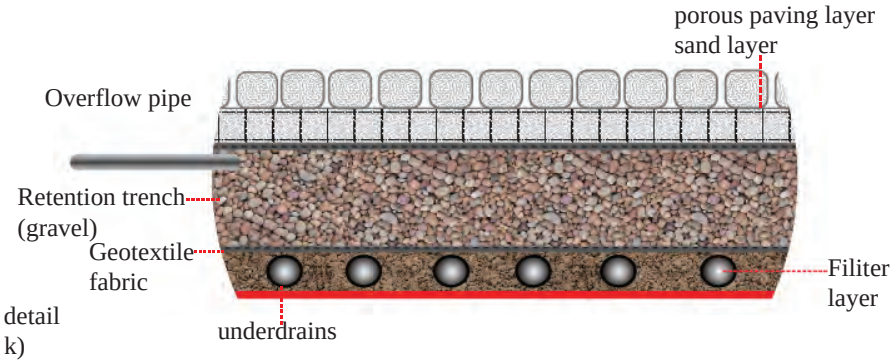
See Figure 5



Detail for cobble stone

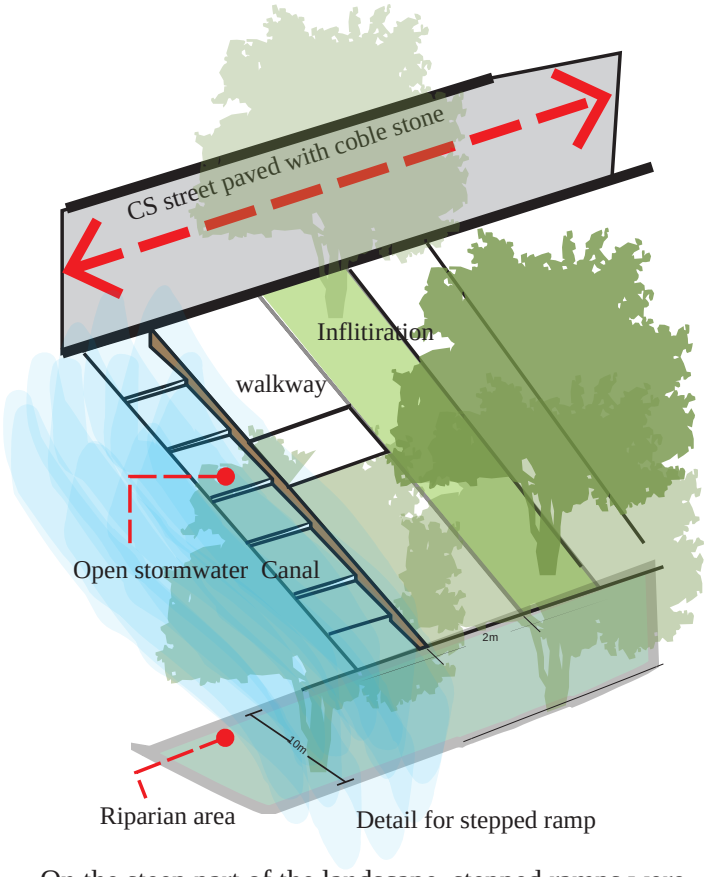


Bioretention detail (refer- detail k)



Cross section for cobble stone

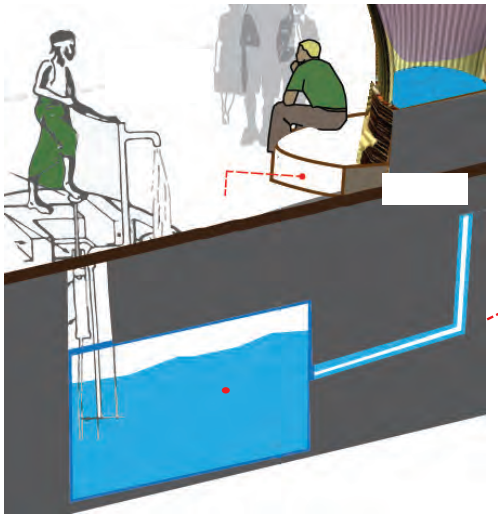
Figure 7.21: Section for enhanced grass swale

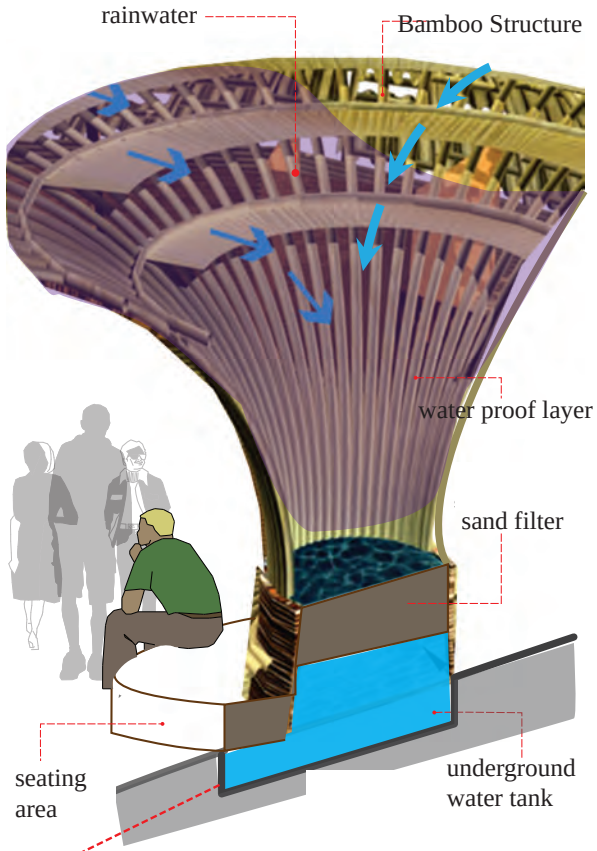


On the steep part of the landscape, stepped ramps were proposed

The Stepped Ramps are used for pedestrian way.

The movement of water on the open stormwater canal creates an inviting environment, especially one of exploration for children.





umbrella- shaped shelter: provide shade at nodal points where people gather.
The shades are used to store rainwater and to water street side trees.It is made of bamboo. It has climber on the umbrella- shaped shelter.

Figure 7.22: Extended tree pits and rain gardens

Parking lots

Parking lots should also be paved with porous pavers and have vegetation cover in order to remove lead and other heavy metals before entering the river.

The local streets that have direct access to the sub arterial street are recommended to be parking spaces. Along the parking areas, there are vegetated swale. This has contribution in reducing run off volume of the street as well as trap pollutants.

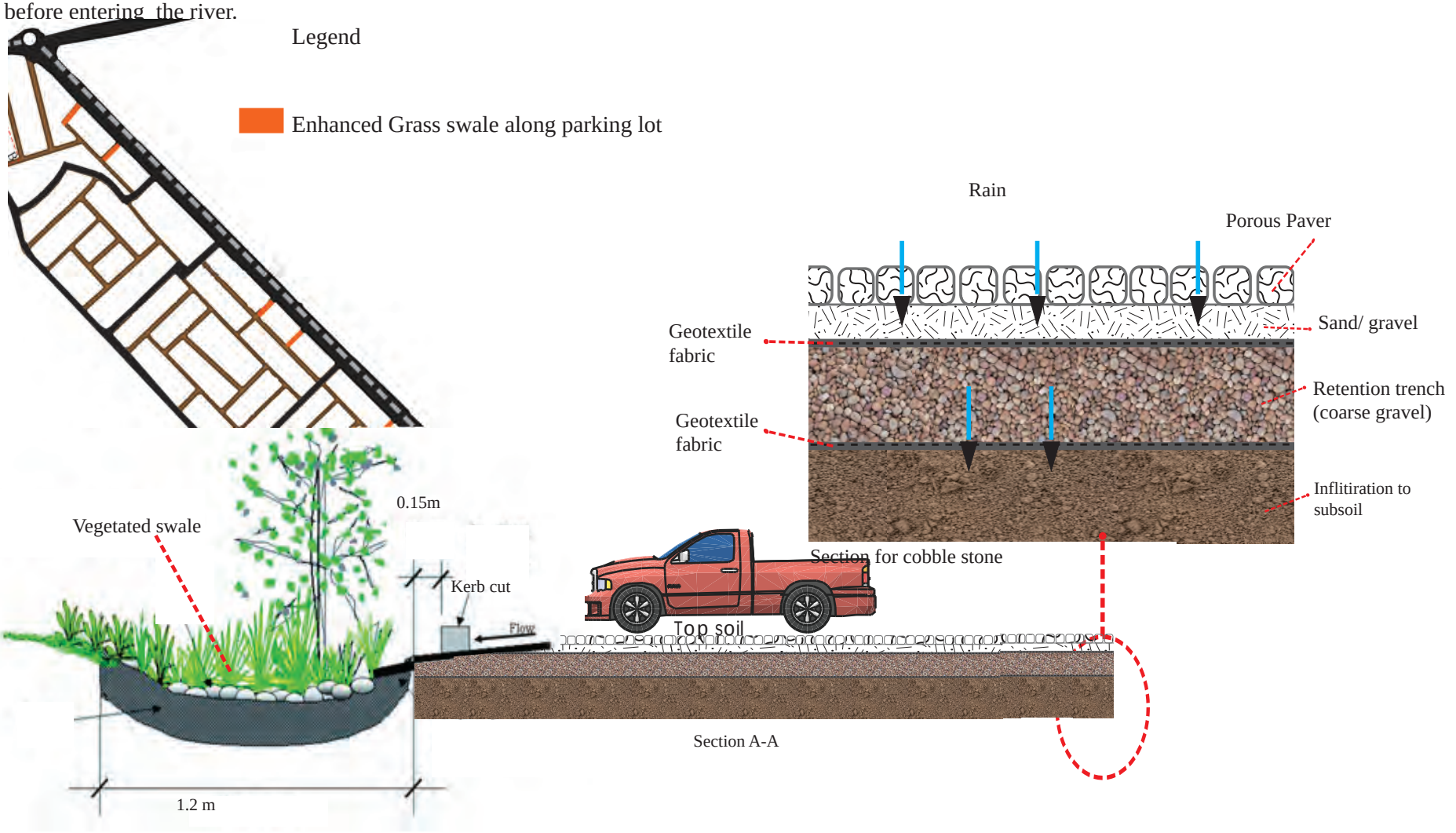


Figure 7.23: Section for parking spaces

The proposed parking type is angular parking

vegetated swale should be proposed at the egde of the parking lot

Top view of the parking lot

Figure 7.24: parking spaces

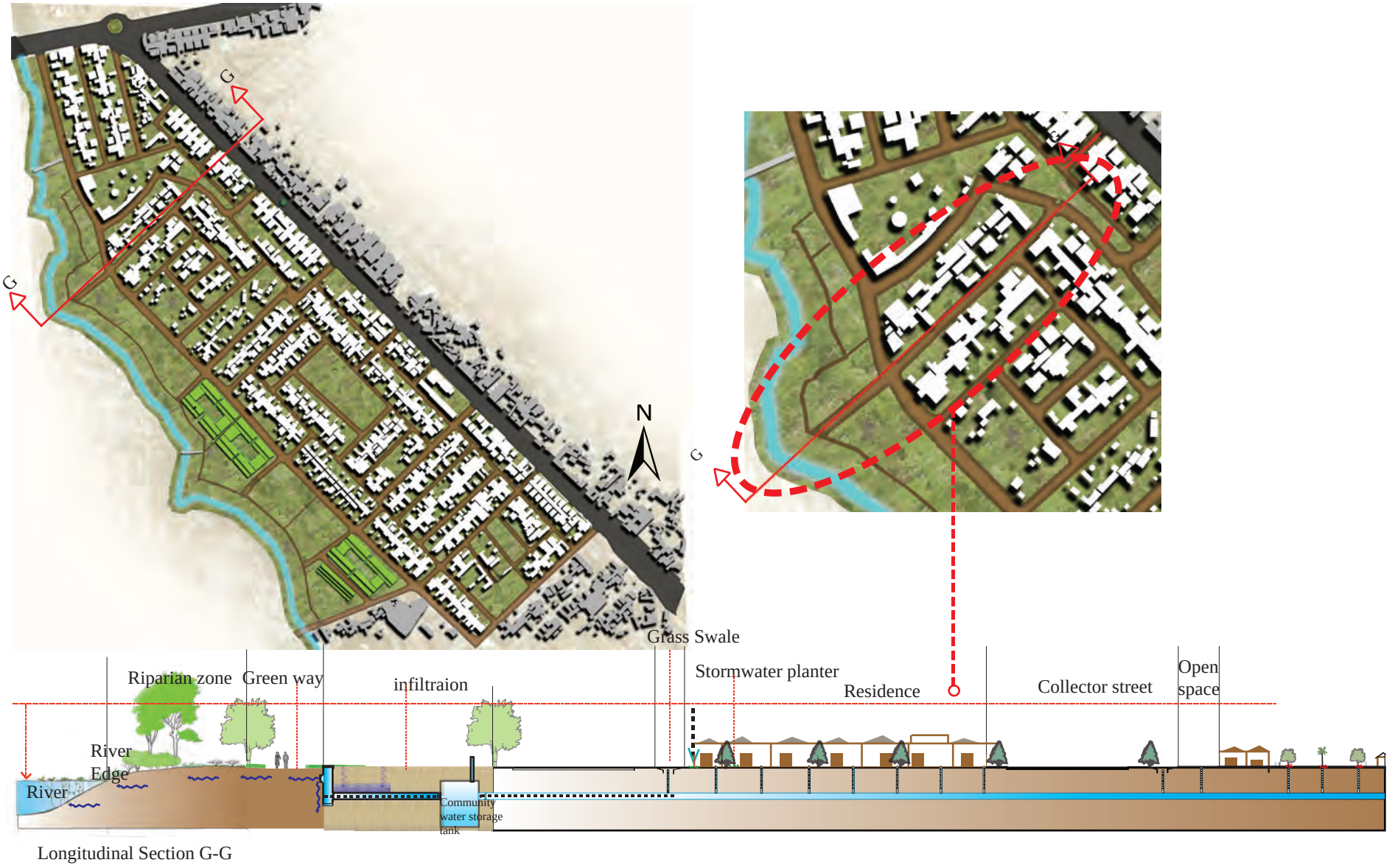
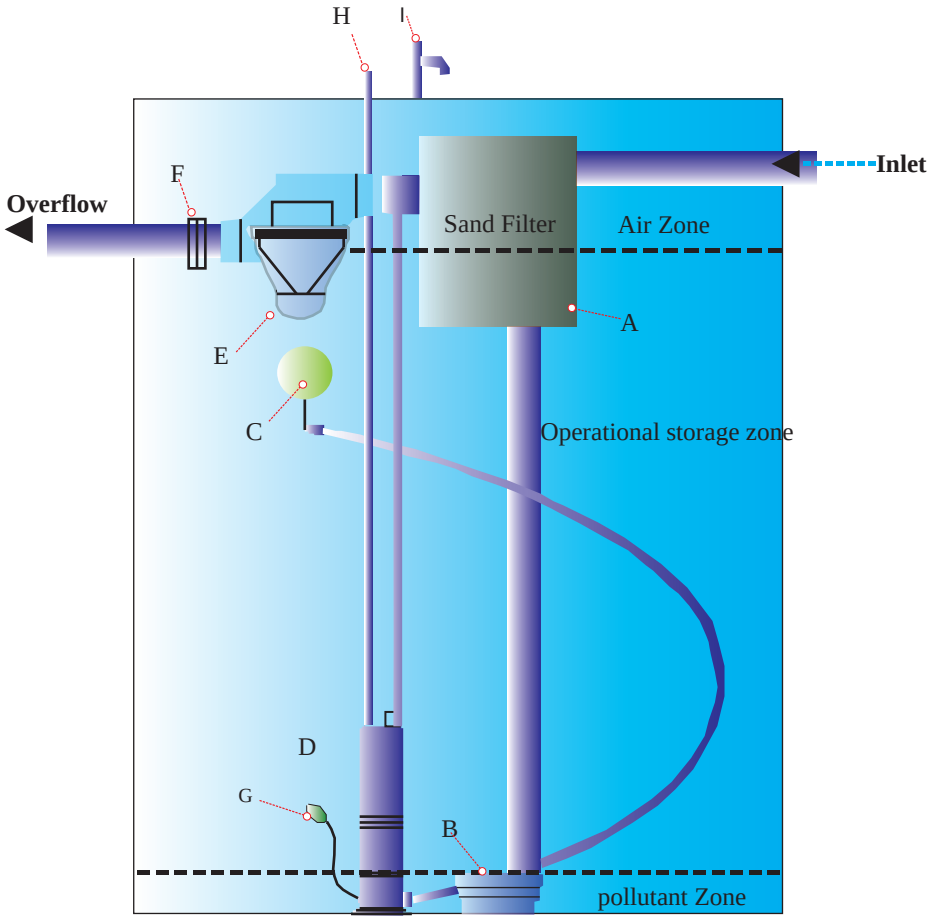


Figure 7.25: Section that show rainwater harvesting neighborhood level



Legend

A Sand Filter
B Calmed inlet
C Floating Pump intake
D Pump
E Overflow Siphon
F Backflow prevention valve
G Water level gauge
H operating pedal
I Water pipe

Figure 7.26: community water storage tank, treatment mechanism

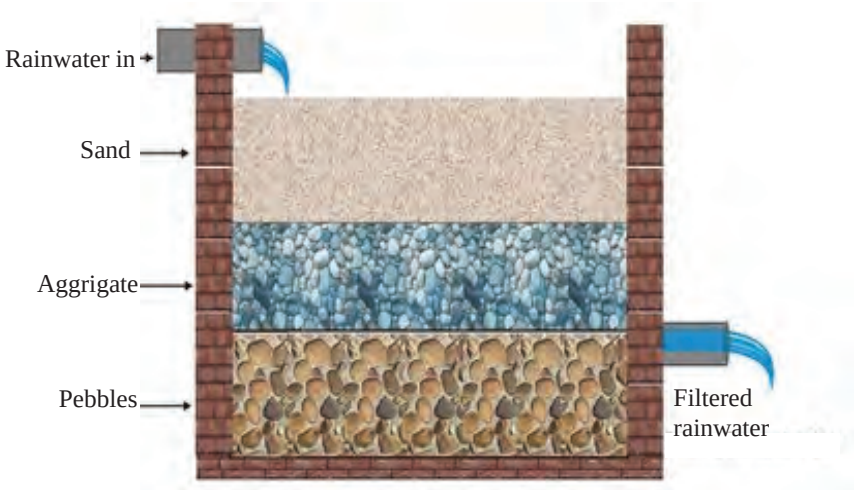
Water Quality Zone

It is advisable to have community water storage tanks . The water tank may have three water quality zone. These are

Air Zone The air zone is maintained through the use of a siphon outlet offset from the obvert of the tank.Overflow siphon can remove any floating films, scum or pollens that may accumulate on the water/air interface. The design of the siphon prevents rodents and mosquitoes entering the tank.

Water Pollutant zone it allows for the settling of any fine materials or suspended solids.

Operational storage zone – The area between the pollutant zone and the air zone is the operational storage zone



In the case area,rain water should be treated as an opportunity rather than a ‘Problem’.

1. Rain water should be collected on the building rooftop

2. Roof water should be conveyed via downpipes.

3. Stormwater should be collected from hard and soft surfaces and controlled through landscape design

4. The collected stormwater should be conveyed through swales

5.It is advisable to hold the water using infiltration basin in order to remove pollutant before entering to Finicha River.

6. the overflow water should be encouraged to infiltrate in to the natural ground where it recharges groundwater.

7. Plants allow evapotranspiration of water back in to the air

8. Controlled outfall into the surrounding drainage system

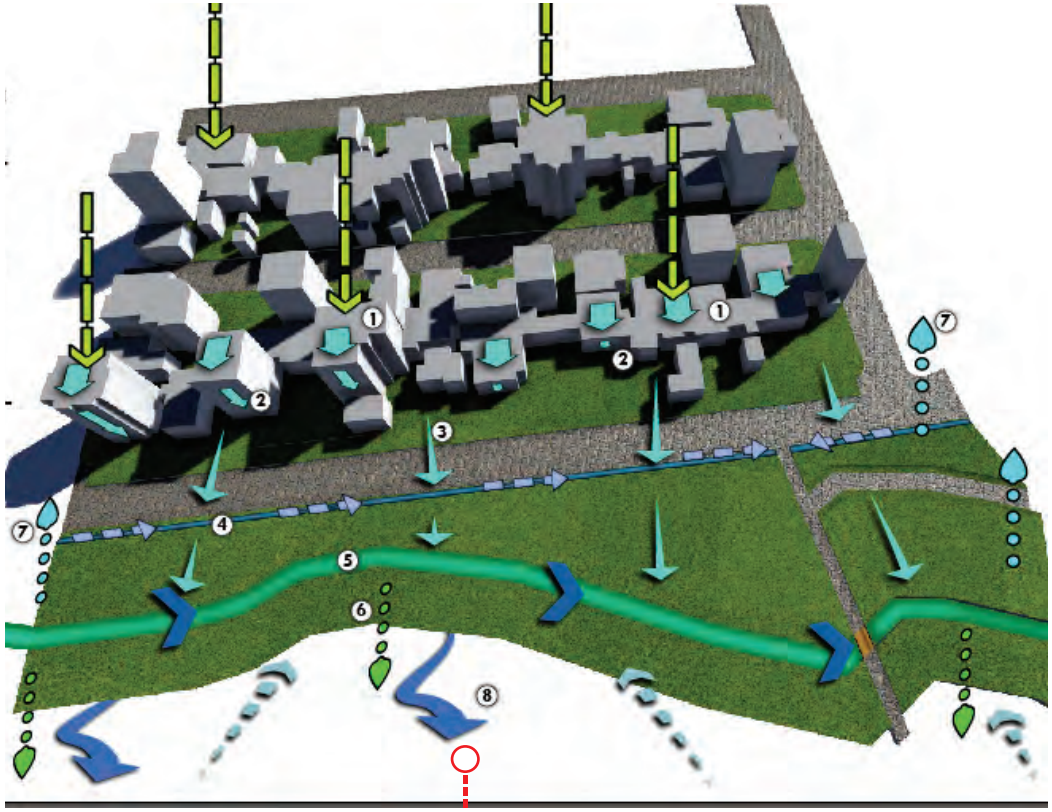


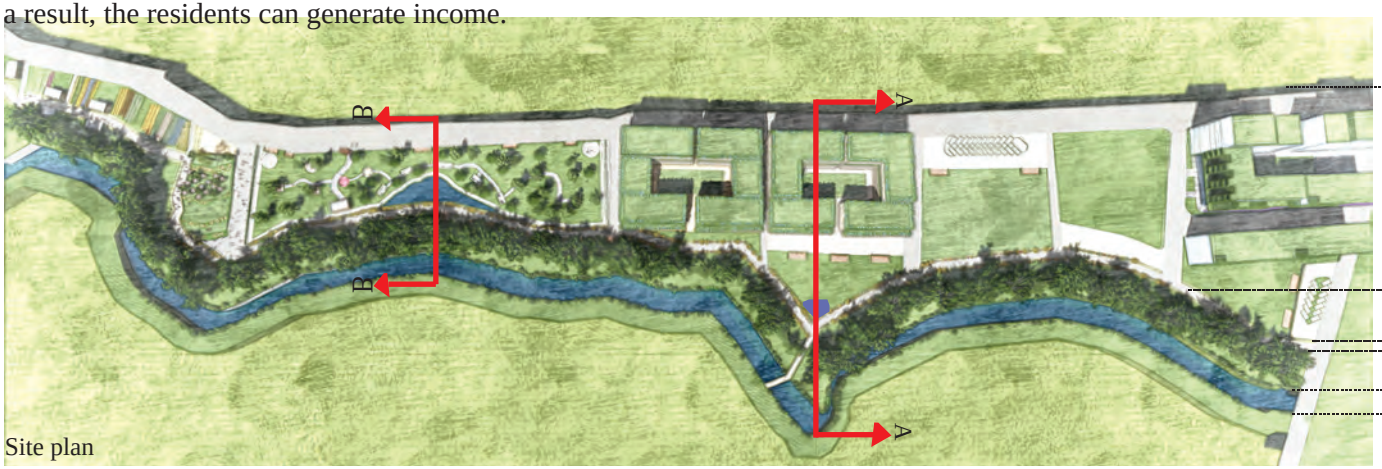
Figure 7.27: SMPs

In order to have healthy connection between the case area's settlers and riversides, lands adjacent to the Finicha River should be grouped into the following three zones:

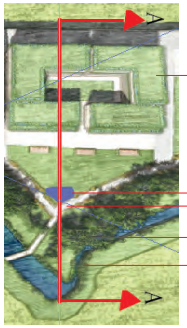
• **Riparian zone** refers to the space between the edge of the river and top of the bank.

• **Urban Greenway Zone** as it is mentioned above, the recommended greenway type is urban riverside greenway

• **Development Zone** The development zone is the area adjacent to the urban greenway zone. In the development zone , there should be floriculture and olieculture as well as mixed buildings. The floriculture and olieculture will create job opportunities for the residents. As a result, the residents can generate income.



Site plan



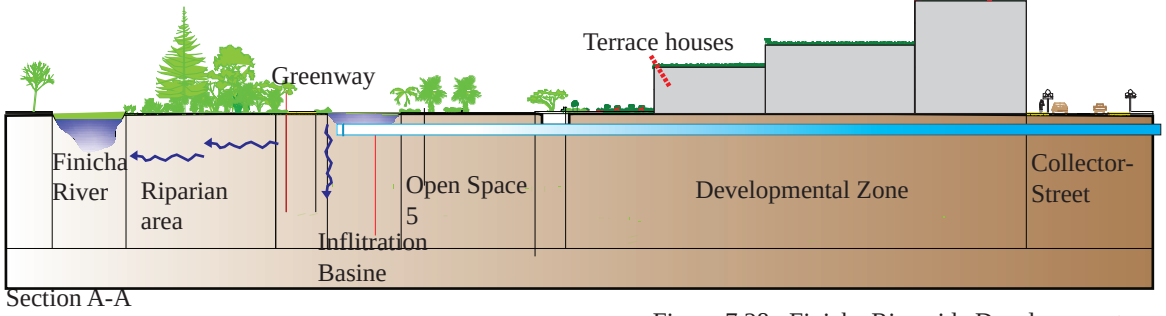
Terrace houses

Inflitration Basin around terrace house

Greenway

Riparian area

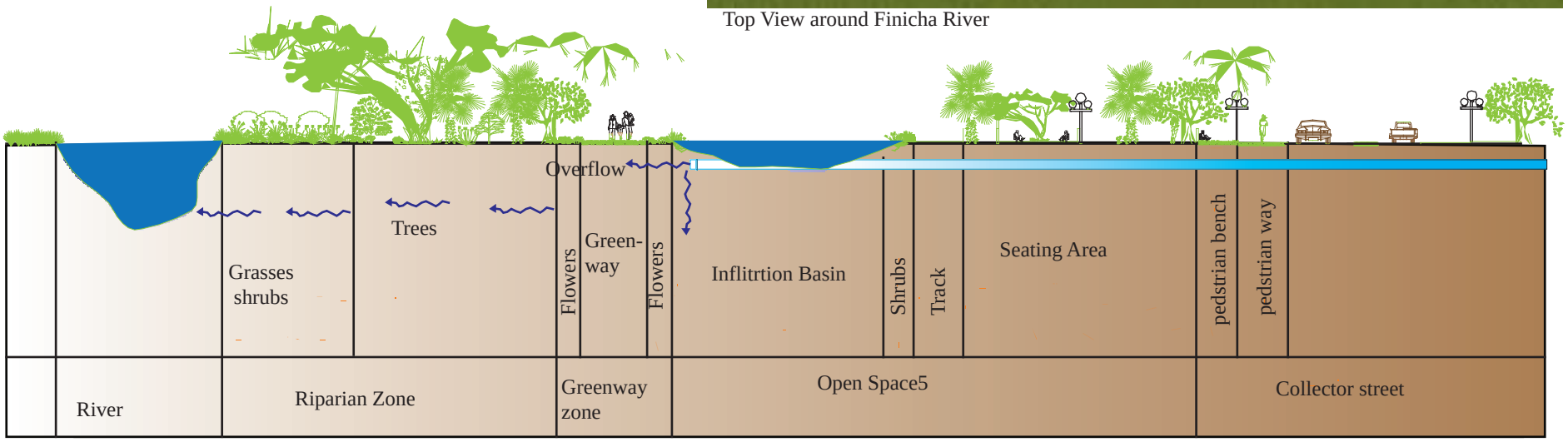
Finicha River



Section A-A

Figure 7.28: Finicha Riverside Developement

Top View around Finicha River



Section B-B

Figure 7.29: proposed open space 5, inflitration basin

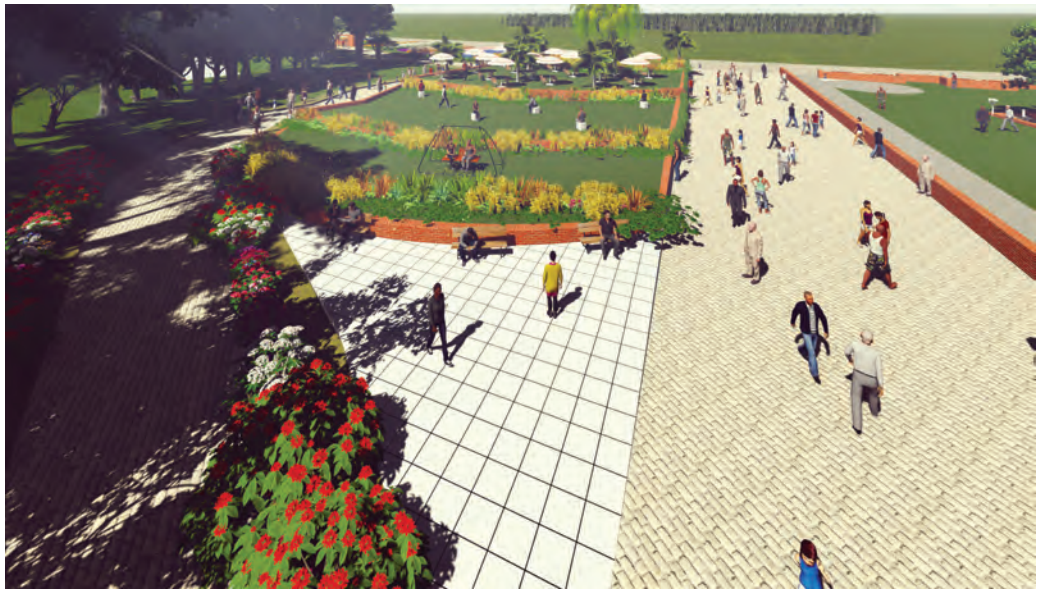
Horticulture: in the case area, two types of horticultures are suggested adjacent to the greenways. These are **floriculture (flower production)** and **olieculture (vegeration)**. Both the floriculture and oliecuture give aesthetic value to the riverside and provide job opportunities to the residents . it is advisable to have shop in the area where floriculture and oliecuture are planted.

Orientation the buildings :the shops and mixed use buildings should face the greenways and Collector Street in order to make the greenways and street active and safe.

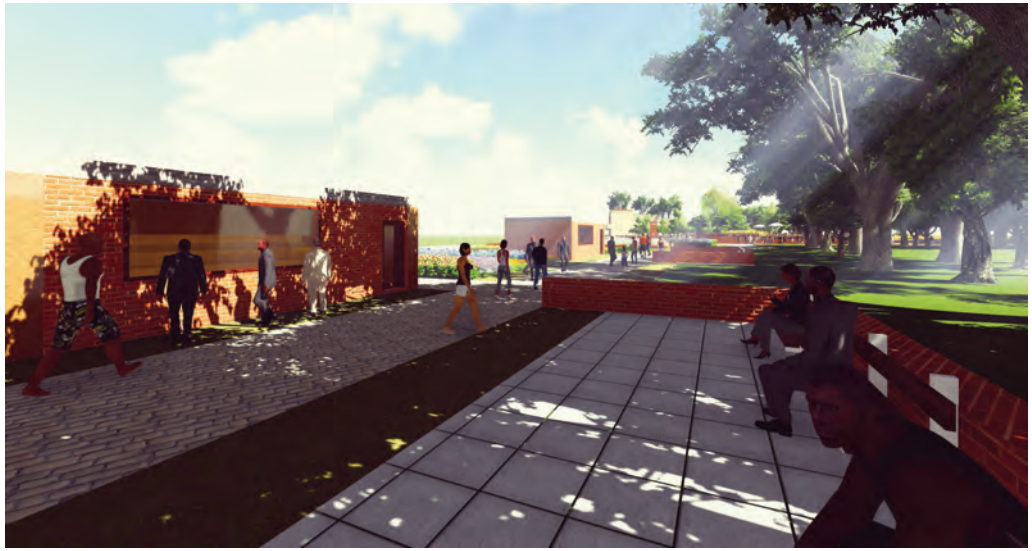
Floriculture

Olieculture

Figure 7.30: Horticulture and recreational area along the greenways



Recreational area



The shops face the greenway inorder to make the greenway safe and active

Floriculture

Recretional area

Floriculture face to ward the greenway

The proposed riparian , greenway and developmental zones help the residents to have both active and passive recreations. Besides, they can improve water quality, mitigate flood damage and help the case area's residents by being sources of income.

Figure 7.31: Horticulture and recreational area along the greenways-2

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APPENDICES

Appendix 1: Interview Questions

Interview: key Informants

1. Type of stakeholder

   first settler □□persons that are live along Finicha river □□

   Local community □□□□other type_____

2. What are the Characteristics of riparian areas at different time?

   _____

   _____

3. What are the main factors that increase flood risk?

   Lack of Awareness □□ lack of coordination □□□ lack of responsibility □

   Other □

   _____

   _____

4. Is SMPs applied in case area to control flood?

   Yes □ No □

5. If there are any SMPs, what are the SMPs used by the residence to mitigate flood?

   Rainwater harvesting □ Detention and infiltration □ Rooftop retention description □

   Permeable paving/ porous pavement □ Conveyance and open channels □ swales □

   Stormwater ponds □ Constructed wetlands □

6. If the aforementioned SMPs is not used by the residents, what is the reason ?

   Lack of Knowledge □□□□Lack of concern/ responsibilities □

   Other □

   _____

   _____

7. What is the reason for the river pollution of case study area?

   Lack of awarness □□□□□□ Lack of coordination □□Other □

8. Is stormwater Management Practices/ stormwater treatments (SMPs) applied in A.A to reduce river pollution? Yes □ No □
9. If there is any stormwater treatments, what is the SMPs used by the residence to mitigate water pollution?

   Bioretention □ Stormwater ponds □ Wet Pond □ Wetlands □ Infiltration systems □

   Filtering systems/ gravel or sand filter, biotops □ Open channel systems/swales □

   Other_____

   _____
10. Are there any urban greenways along riverside?

    Yes □ No □
11. If no what is the reason for lack of greenways along riverside?

    Lack of Knowledge □ Lack of concern/ responsibilities □ Other □

    _____

    _____
12. Is there healthy relationship between the city's settlers and riversides? Yes □ No □
13. If not, what is the reason?

    _____

    _____

    _____
14. If not what are the main reasons that promote you not use the river/ riverside?

    Lack of comfort □ Lack of safety □ Lack of time □ Lack of suitability □

    Lack of facility Poor quality □□Others □

    _____

    _____

    _____
15. What is the status of rivers, flood, water quality, greenways, and usage of the riverside at different years?

    _____

    _____

Interview: Office

1. If there is any, for what purpose does the riparian zone used for?

   Settlement □ waste dumping site □ urban agriculture □ other □

   Other □

   _____

   _____

   _____

2. What are the characteristics of riparian zone in A.A?

   _____

   _____

   _____

3. What are the factors that influence buffer width

   Slope □ Soil type □ Vegetation mix/ type □ Rock □ Man-made structure □

   Other □

   _____

   _____

4. What is the type of buffer?

type	Deciduous	tree shrubs	herbaceous plant	aquatic plant	Forest	□other
	□	□	□	□	□	□
year						

   Other □□_____

5. Which of the erosion type occurred due to Mismanagement of riparian?

   Splash □□□□□Sheet □□□Rill and Gully □□□□□steam channel

6. What is the type of riparian strip that is used in A.A currently?

   Fixed-width riparian strip □ variable-width riparian strips □

   _____

7. If fixed –width riparian strip is used, what is the reason?

Easier to enforce □□ Easier to administer by regulatory agencies □

Other □

8. What is the major factor for shrinking of city's riparian zone?

Lack of Knowledge □ Lack of attention □ Lack of concern/ responsibilities

other □

9. What is the reason for the river pollution of A.A?

Lack of Knowledge □ Lack of Attention□ Lack of concern/ responsibilities □

Other □□_____

10. What are the main factors that increased flood risk in A.A?

11. Is any major taken by the responsible office?

12. If yes, what are the measures taken by the offices?

13. If not, what are the reasons?

    _____

    _____

    _____

14. Are there any SMPs in A.A to mitigate flood/ to reduce water pollution?

    Traditional Flood Control (Dam and Reservoirs) □□

    Modification of Channel by widening, straightening and lining □

    Levees, Floodwalls □

    Innovative Stormwater Management □□Other □

    _____

    _____

15. Are there any SMPs in A.A to reduce water pollution and flood damage?

    Pond □ Wetlands □ Infiltration systems □ Filtering systems Gravel or sand /biotopes□□

    Open channel systems /swales □□□□Bioretention □

16. Are any major taken by the concerned-office to delineate urban greenways along the riparian zone of Addis Ababa? Yes □□□□□□No□□□

17. If yes, what major are taken by responsible office to delineate urban greenways along the riparian zone of Addis Ababa?

    _____

    _____

18. If no what is the reasons?

    _____

19. Is measures taken by concerned bodies taken to create healthy connection between the city's settlers and riversides?

    _____

    _____

20. If no, what is the reasons?

    _____

21. If yes, what are they?

    _____

Appendix 2: Interview Pictures

Interview with former settler, Ato Mamo

Interview with the expert of the woreda

Interview with W/rt Fantu, who is the expert of AAEPA

Interview with Ato Samson,the expert of the AAEPA.

Appendix 3: Laboratory procedures

Step 1: From different parts (at beginning, middle and end) of Finicha River sample water were taken by pails;

Step 2: the sample water were mixed;

Container aid

Step 3: the mixed sample river water were taken to AAEPA by the container aid;

Step 4: The result of the laboratory test is shown in the table below

በአዲስ አበባ ከተማ አስተዳደር
Addis Ababa City Government

የአካባቢ ጥበቃ ባለሥልጣን
Environmental Protection Authority

ቁጥር _____
Ref. No.
ቀን _____
Date

ENVIRONMENTAL LABORATORY VERSION REPORT FORM

Tel: 0116452556 **Res.No.Lab O/89 /07**

P.O.Box: 8968, A.A.

Name & address of sender: Mahlet Tesfaye Hiale

Date of sample arrival: 21/06/07

Date of analysis: 21/06/07- 01/ 07/07

Parameter analyzed	Field number or code
	NTG 2803
PH	6.9
Reactive phosphate(R. po_4^{-3}), mg/l	26.8
Nitrate (No_3), mg/l	11.2
Chemical oxygen demand (COD), mg/l	270
Biological Oxygen Demand (BOD), mg/l	172
Fecal Coliform Colonies (FC)/100ml	35
Chromium (Cr) , µg/1	48.88
Lead (Pb), µg/1	210.9
Cadmium (Cd), µg/1	1.362
Arsenic (As), µg/1	2.89
Mercury (Hg)(µg/1	<0.0001

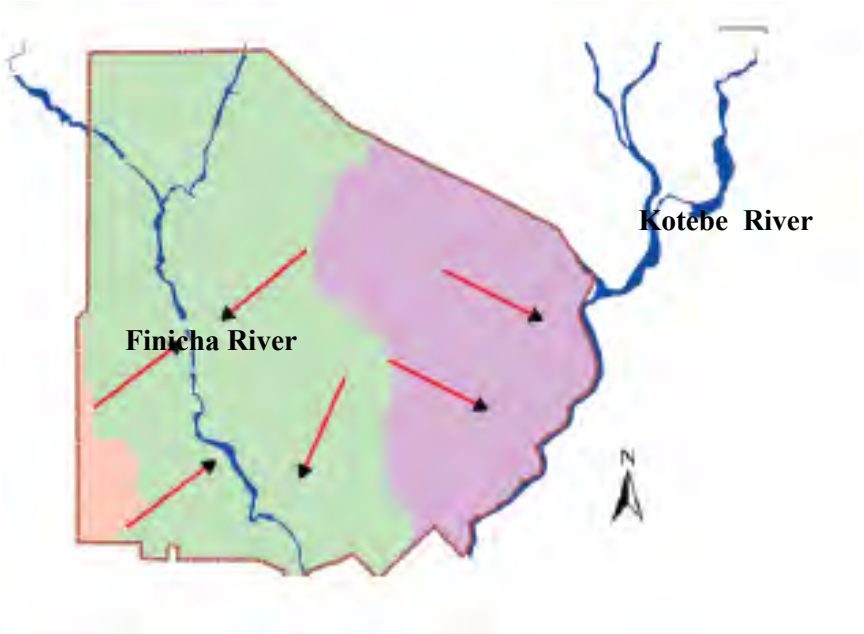
Abebe Alemayehu Fereda
Laboratory Version Leader

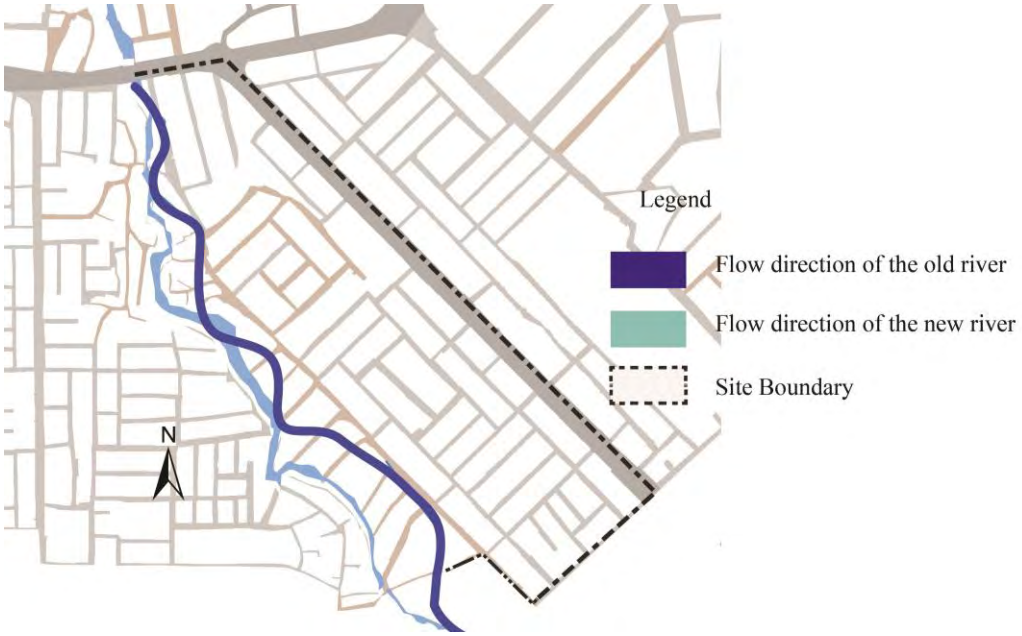
Appendix 4: Spatial Analysis Maps

Watershed map at Macro Scale

Watershed map at Meso scale

Watershed Map at Micro Scale





River flow direction through time

Flood Map

Calculating Runoff Volumes

The runoff coefficient for any given surface depends on what the surface is composed of.

Run off coefficients for asphalt: range 0.85-0.95

Run off coefficients for Gravel Surface: range 0.40-0.80

Run off coefficients for Cobblestone: range 0.60-0.85

Run off coefficients for Native Soil Surface: range 0.30-0.80

Calculating Asphalt runoff

Calculating asphalt runoff

Runoff volume for asphalt = Total area of the asphalt * Annual rainfall* runoff coefficients

= 85864 m2* 1089 mm * 0.85

= 79,480,012 liters/average year

Calculating gravel runoff

A run off volume for road that is made of gravel is calculated as follows:

Runoff volume for gravel = Total area * Annual rainfall* runoff coefficients

= 44477m2* 1089 mm * 0.55*

= **26,639,499 liters/average year**

Calculating Soil Surface runoff

A run off volume for road that is paved with soil is calculated as follows**:**

Runoff volume for Soil = Total area * Annual rainfall* runoff coefficients

= 74970m^2* 1089 mm * 0.40*

= 32, 656,932 liters/average year

Calculating Cobble stone runoff

Runoff volume for cobble stone = Total area * Annual rainfall* runoff coefficients

= 294930 * 1089 mm * 0.6

= **192,707,262 liters/average year**

Runoff volume calculation for the planning area's land uses

Runoff volume is calculated for the planning area. This is because the runoff of the planning area has effect on the case area.

Calculating Residence runoff

Runoff volume for residence = Total residential area * Annual rainfall* runoff coefficients

= 485389m2* 1089 mm * 0.6

=317,153,173 **liters/average year**

Calculating Mixed Use buildings runoff

Runoff volume for Mixed Use building = Total area mixed use building* Annual rainfall* runoff coefficients

= 13569m2* 1089 mm * 0.7

=10,343,649 liters/average year

Calculating Commerce runoff

Runoff volume for Commerce = Total area Commerce * Annual rainfall* runoff coefficients

= 11435* 1089 mm * 0.7

=8,716,901 liters/average year

Calculating Manufacturing & storages runoff

Runoff volume for Manufacturing & storage = Total area Manufacturing & storage *

Annual rainfall* runoff coefficients

= 191193m2* 1089 mm * 0.8

=166,567,342 liters/average year

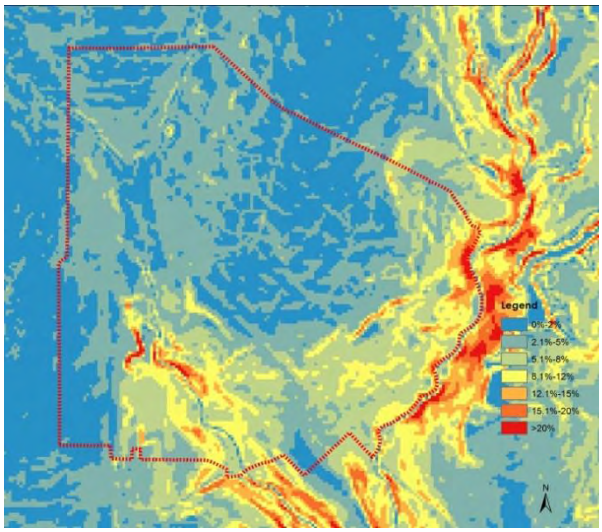
Calculating open spaces runoff

Runoff volume for open spaces = Total area open spaces * Annual rainfall* runoff coefficients

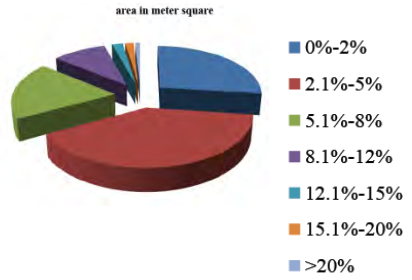
= 148819* 1089 mm * 0.3

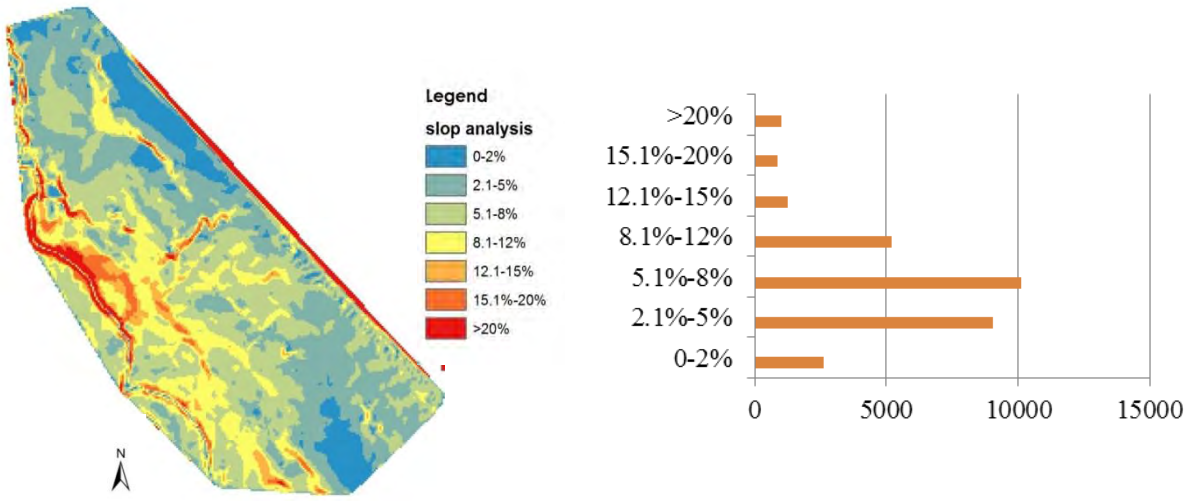
=48,619,167 liters/average year

Slope Map



Planning area



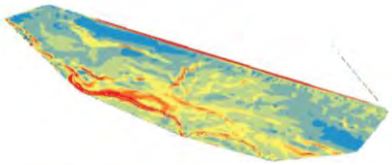


Action area

Implication: the landscape of the project area is dominated by 2.1-5 percent slope and 5.1 % and 8% as can be seen from the chart. The area is suitable for high large scale development (2.1-5%) and for high density residential and commercial development (5.1-8%).

Suitability analysis

Slope

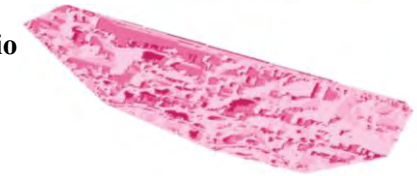


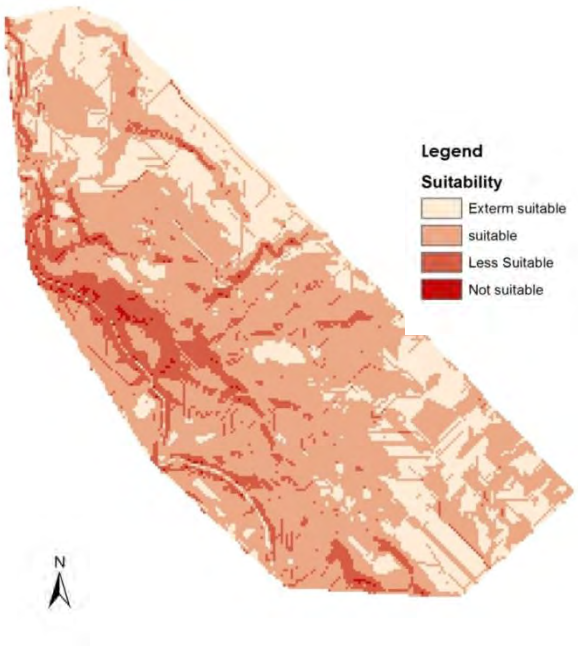
Water table

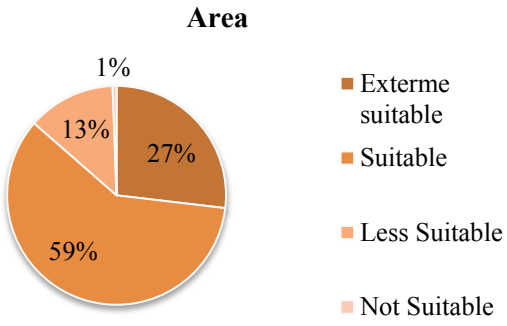
Soil Type

Flow direction

Accumulatio



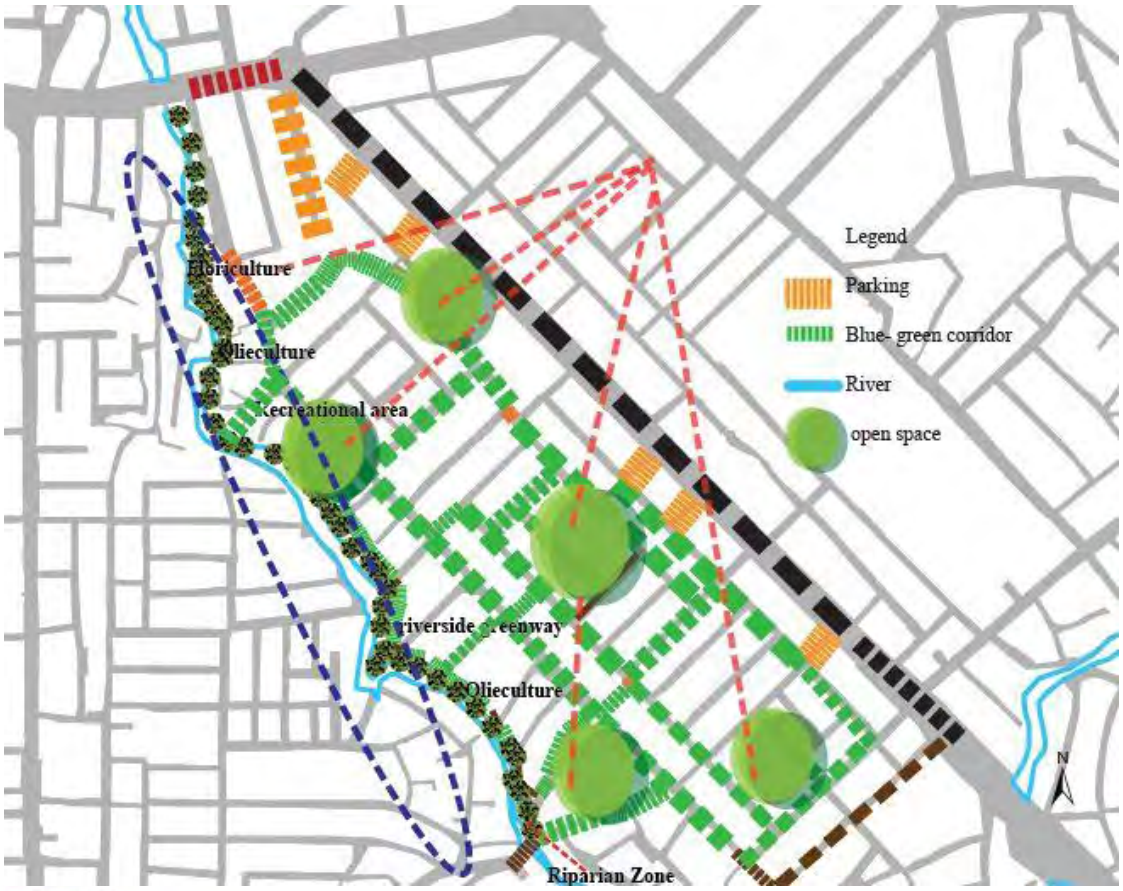


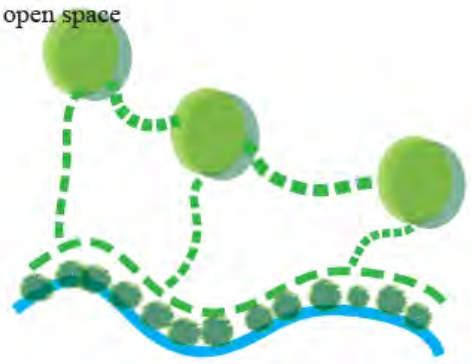


Suitability	Area	Area in %
Extreme suitable	7123	26.8660657
Suitable	15795	59.57454833
Less Suitable	3442	12.98231056
Not Suitable	153	0.577075397
Total	26513	100

Implication: as it can be understood from the maps, the study area is suitable to practice SMPs.

Appendix 5: schematic concept for the proposed Design





Fincha River , greenway and streets are blue-green corridor

Street and greeneway river

the study area's open space are patch that are connected by the corridor