

DECLARATION

I, 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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This thesis is submitted to the Ethiopian institute of Architecture, Building Construction and City Development (EiABC) and to the School of Graduate Studies of Addis Ababa University in the Partial fulfillment of the requirements for the degree of Masters of Science in Landscape Architecture.

Title of the Thesis:

POTENTIALS OF HOUSEHOLD ORGANIC SOLID WASTE FOR URBAN AGRICULTURE IN CONDOMINIUM HOUSING AREA:

THE CASE OF “BASHA WOLDE-CHILOT” CONDOMINIUM, ADDIS ABABA

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ABSTRACT

Open spaces near communal housing areas are among one of the urban agricultural components for the urban environment, but the soil in these open spaces has been affected by different types of waste. The purpose of this study is to evaluate the potential of organic solid waste (OSW) on the households to restore the disturbed soil, contribute to urban agriculture and provide recommendations to prevent environmental pollution caused by OSW. Like many developing countries, Addis Ababa generates a significant amount of OSW with substantial contributions from households. The generated OSW, which is being sent to the landfill sites have been burning the ground, unpleasant odors, environmental pollution, groundwater pollution, vegetation damage, affect biodiversity (Justyna & Pitchayan, 2016).

Condominium housing in Addis Ababa consists a large number of households (depend on the design starting from G+2 -G+12) with small plots that tend to generate a large amount of OSW. The “Basha Wolde-Chilot” condominium site that is chosen for this thesis for the reason that it contains three types of Solid Waste Management (SWM) system (vertical trash Shute , free stand metal garbage, and Trash bag(madabria) at their home), condominiums that are the same typology, manageable block number, and near to the Riverside. The survey was applied to ten building that is determined by Taro Yamane’s sampling method. Before the survey, the researcher provided colored trash bags (“madaberia”) for residents in organic,plastic and other types waste categories followed by an awareness session on waste separation. Afterward, the researcher conducted a field investigation, on-site waste characterization and measured the waste at the block in two different collection days.

According to “Basha Wolde-Chilot” waste characterization, the average waste consists of 84.1% organic, 3.4 % plastic and 12.5% other materials. From this figure, the most substantial amount is organic solid waste that could be recycled and generate compost. The “Basha Wolde-Chilot” site generates 87,048 kg of organic solid waste every year and send it to the landfill that contributes to the pollution of the environment quality deterioration, worsening of groundwater quality, poor air quality from emitted gases and noxious odors, and worsening climate change impact. From this figure, we can understand that by failing to process waste, the site loses 10,881 kg compost every year. But this 10,881kg compost has the potential of restoring the disturbed soil and providing fertilizer for 28,307m² vegetation production,5,348m² for attractive, aromatic and medicinal plant and for than 200 tree and shrubs for the “Basha Wolde-Chilot” condominium site community.

In conclusion, if the organic solid waste gets separated at the source (providing garbage Shute), recycled, composted and merge to the condominiums green space, it will provide significant input for the environment as well as for the residents. The application of compost may vary according to the users need.

Keywords: Household organic solid waste, compost, soil fertility, urban agriculture

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ACRONYMS

AACG - Addis Ababa City Government

EPA – Environmental Protection Agency

FAO – Food and Agriculture Organization

GHG - Greenhouse gas

GI - Green infrastructure

HHSW - Household solid Waste

IGNIS - Income generation & climate protection by valorizing municipal solid wastes in a sustainable way in emerging mega-cities

ISWM - Integrated Solid Waste Management

MSW – Municipal Solid Waste

NGO – Non Governmental Organization

OSW- Organic Solid Waste

SW –Solid Waste

SWDS - Solid Waste Disposal Site

SWM - Solid waste management

SWRDPO - Solid Waste Recycling and Disposal Project Office

UA – Urban agriculture

UF- Urban farming

UN – United Nation

UNFCCC – United Nations Framework Convention on Climate Change

UN-Habitat - United Nations Human Settlements Program

WB- World Bank

CHAPTER 1 – INTRODUCTION

1.1. BACKGROUND OF THE STUDY

Throughout the world, waste generation rates are rising. According to (Hoornweg and Bhada-Tata, 2012), the worlds' cities generated 1.3 billion tons of solid waste per year, amounting to a footprint of 1.2 kilograms per person per day. (World Bank, 2018) report states that municipal waste generation is expected to rise to 2.2 billion tones by 2025 a result of rapid population growth and urbanization.

Open dumping or uncontrolled landfill sites are commonly found in low-income countries (Pharino 2017) suffering several problems (Issam.et al., 2010) the major causes of environmental quality deterioration, particularly of worsening of groundwater quality, poor air quality from emitted gases and noxious odors, and worsening climate change impact (Amornchai and Chanathip,2015).

As being a city of a developing country, Addis Ababa also faces challenges in solid waste management (Issam. et al., 2010).The solid waste dump to the landfill site at Koshe is one case. Due to rapid urbanization and population growth of Addis Ababa, the amount of solid waste has increase.

(Tesema,2010) states the amount of daily waste generation in 2010 from Addis Ababa was 1,125 tons, of which about 900 tons were collected and dumped at Repi Solid Waste Disposal Site (SWDS). The most significant contributor was households, accounting for about 76%, with the other 24% coming from institutions, hotels, industries, and street sweeping (Addis Ababa City Administration and the Federal Democratic Republic of Ethiopia, 2012) with solid composition Organic 60%, Recyclables 15 %, others 25% (Addis Ababa city government, 2010).

A large amount of waste was the organic solid waste; Composting keeps the organic wastes out of landfills (Weitz et al., 2002). Composting is a simple process where optimization efforts are used to increase the rate of decomposition (thereby reducing costs), minimize nuisance potential, and produce a clean and readily marketable finished product (Daniel et al.,2000).

If the number of households increases the waste generation rate also increase (Scarlat. et al., 2013). In Addis Ababa, densifying residential areas currently practicing by the government is condominiums.

Condominium houses have different programs (10-90, 20-80, 1nd 40-60). In this area, lots of residences live in a small plot, which has 2-12 floors and each floor contains 4-6 residential units depends on the types of program and design. To collect waste in multi-story building, provide opening on each floors and connect with vertical trash chute. The residence simply dump their waste according to provided opening and collect with garbage container at the bottom (Clare et al., 2017)

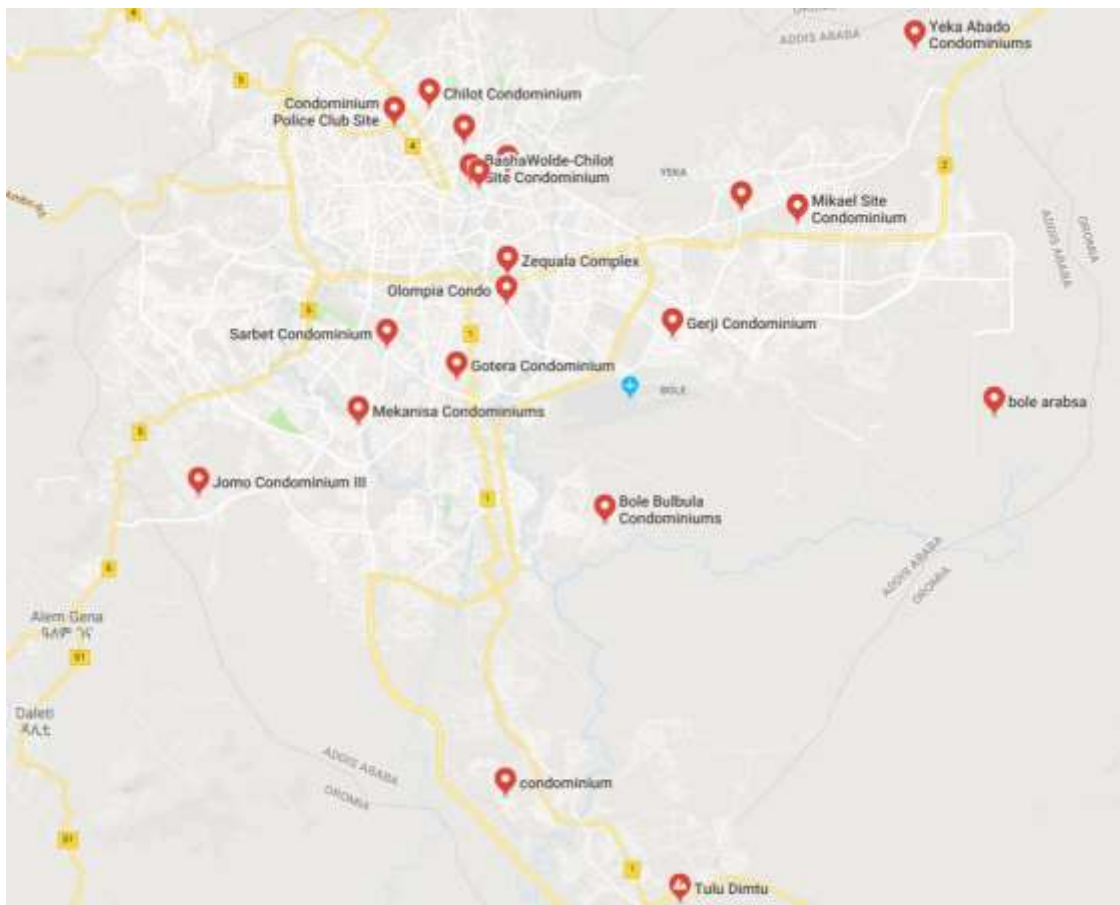


Fig.1.1: Condominium sites in Addis Ababa, (Source: Google map, 2018)

In low-income countries, although there is a waste with high organic composition, the practice of composting is rarely carried out (Pharino, 2017). Composting is a suitable method for maintaining the fertility of the soil (Anastasiou et al., 2014) and benefits in the

restoration of disturbed soils in urban area (Bilal *et al.*, 2016). Linking urban MSW management through recycling of urban waste into compost is the right way to create sustainable cities (Vazquez *et al.*, 2002).

1.2. PROBLEM STATEMENT

Even though Green infrastructure (GI) have vital role for the city as well as the society, the current Addis Ababa is missing GI due to many factors. One of the significant component of GI is urban farming and to implement urban farming in a city, condominium site have higher potential. (Ministry of urban development and housing, 2016) stated that the open space around the communal housing areas as one of the green infrastructure components. The government provides green area for different purpose in neighborhood condominium design. Currently condominium open/green area have been affected by different types of waste that has also been causing health problem, cause air pollution, affect ecosystems, and affects ground water. The relation between the residence of the condominium and their environment must have positive attachment.

“Basha Wolde-Chilot” condominium is one of the condominium site in Addis Ababa around “Arat Killo” area. This condominium site has large open/green space that includes a river buffer next to it. Nonetheless the open/green area was not developed yet and the link between the community and the open/green space is inadequate. Among the many reasons the soil is one. These soil is:

- Disturbed by construction materials
- Disturbed by waste
- Poor soil conditions





Fig.1.2: The current soil conditions at “Basha Wolde-Chilot” condominium (Source: Author, 2018)

In some area to solve this problem, the communities bought red soil (fertile soil), animal and chicken manure to amend the disturbed soil and started plantation including urban agriculture.



Fig.1.3: Urban agriculture in “Basha Wolde-Chilot” condominium (Source: Author, 2018)

In other direction, the households generate a large amount of organic waste and dump it to the landfill site. This organic waste has the potential as composting keeps the organic wastes out of landfills (Keith et al., 2002), reduces the impact on the environment and benefits to people by giving fertilizer (C40 Cities Climate Leadership Group, 2016). Good quality compost can be made from organic household wastes in urban areas and be used to grow healthy vegetables in gardens at home environment (Sue and Hailu, 2011). But in the

“Basha Wolde-Chilot” condominium open/green space and the organic solid waste generate from the household has no link.

Sustainable communities are places that people like living in, and want to stay in, neighborhoods with real character and sense of place. These successful places should have well-designed green spaces that people will want to use and respect.

(Commission for Architecture & the Built Environment, 2015)

1.3. HYPOTHESIS

A large amount of municipality solid wastes is generated from households with a high amount of organic solid waste. Changing this organic solid waste into compost and giving it an input for urban farming maintains the fertility and restores the disturbed soil in urban areas.

1.4. OBJECTIVES

1.4.1. General Objective

The general objective of this paper is using household organic solid waste (previously sent to the landfill), transforming it into compost and create a link to the soil for a better landscape values to the community through urban farming.

1.4.2. Specific Objectives

The specific objective of the study is to:

- To investigate the organic solid waste management, organic solid waste generation and percentage of organic solid waste.
- To identify and analyze the potential of organic solid wastes for urban farming.
- To link the potential of organic solid waste to the open/green space through urban farming with proper design.

1.5. RESEARCH QUESTIONS

- What types of organic solid waste management system is used by “Basha Wolde-Chilot” condominium? How much organic solid waste is being generated? What percentage of organic solid waste does the site generates?

- What are the ways to change this organic solid waste and use for urban farming?
And how to use the product for urban farming?
- How can the organic solid waste create new landscape qualities (urban agriculture)?

1.6. SIGNIFICANCE OF THE STUDY

The significance of this study is to enhancing urban municipality organic solid waste management system through recycling organic solid wastes from households into compost and create a sustainable solid waste management system. In addition this study aims to give some direction to policymakers, especially for municipality solid waste management office, the office that works on environmental issue and housing agency in Addis Ababa.

In addition, the study intends to link households to their open/green space. More than hundreds and thousands of household lives in condominium depend on the size of the condominium site. In most of the condominium sites, the household and the open/green space did not have a strong link because of the contaminated soil, and this thesis is hopes to tight the connection by one step.

The green infrastructure in urban areas is becoming destroyed over time. The open /green space in condominiums is one type of green infrastructure for urban area, and this paper will be used as an input for urban green infrastructure

1.7. SCOPE AND LIMITATION OF THE STUDY

1.7.1. Scope

- The thesis focuses on researching household organic solid waste management system and identifying the amount and use for green space in the “Basha Wolde-Chilot” condominium area. The study targets the potential of organic solid waste amount by designing proper space and implementing it into to the green space.
- The focus area of the study is “Basha Wolde-Chilot” condominium around “Arat Kilo”.

1.7.2. Limitation

- Due to time and money, the study is limited to a specific area, the “Basha Wolde-Chilot” condominium which is a representative sample.

- The study will not focus on the economy, family size, and lifestyle of the households.
- The study will not analyze the physical and chemical properties of the household organic solid waste.

CHAPTER 2 - LITERATURE REVIEW

2.1. DEFINITION OF TERMS

Waste is an unavoidable by-product of most human activity (World Bank 1999).

Waste management or **waste disposal** are all the activities and actions required to manage waste from its inception to its final disposal. This includes amongst other things collection, transport, treatment and disposal of waste together with monitoring and regulation. It also encompasses the legal and regulatory framework that relates to waste management encompassing guidance on recycling (Irum et al., 2017).

Municipal Solid Waste (MSW) is generated from households, offices, hotels, shops, schools and other institutions. The major components are food waste, paper, plastic, rags, metal and glass, although demolition and construction debris is often included in collected waste, as are small quantities of hazardous waste, such as electric light bulbs, batteries, automotive parts and discarded medicines and chemicals (World Bank,2012).

Municipal Solid Waste Landfill: A landfill discrete area of land or excavation that receives municipal solid waste (EPA, 2018)

Household solid Waste (HSW): is considered as a type of municipal solid waste and consists mainly of plastics, paper, glass, metal, organics, wood and other (Bader and EL-Sadek, 2015)

Organic waste: is organic material such as food, garden and lawn clippings.it can also include animal and plant based material and degradable carbon such as paper, cardboard and timber (Daniel et al.,2000).

Compost: is organic matter that has been decomposed in a process called composting. This process recycles various organic materials - otherwise regarded as waste products - and produces a soil conditioner (the compost). Compost is rich in nutrients. It is used for example in gardens, landscaping, horticulture, urban agriculture and organic farming (Keith et al., 2002).

Composting :is a simple process where optimization efforts are used to increase the rate of decomposition (thereby reducing costs), minimize nuisance potential, and produce a clean and readily marketable finished product (Daniel et al.,2000).

Urban agriculture: refers to the growing plants for food and other related uses (pollinator encouragement, etc.), within or surrounding cities and towns. Urban Agriculture promotes community development and education, and increases self-reliance, community health, wildlife habitat, environmental awareness and social interaction among residents. It plays a crucial role in achieving food sovereignty and strengthening the local food network of a city (Acre and sentre, 2016).

2.2. MUNICIPAL SOLID WASTE MANAGEMENT

Solid waste is an environmental and also an economic issue confronting entire the world. It is an economic issue since now a day's management of solid waste devours an excessive amount of financial resources by local governments (Irum *et al.*, 2017). Countries to use effective waste management required 20%-50% cost of their municipal budgets (UN-Habitat, 2018)

For cities that attract people for various opportunities ranging from income to services, the increasing population produces an ever-increasing amount of solid waste every day (Ahsan and Zaman , 2014), Compared to those in developed nations, the residents in developing countries, especially the urban poor, are more severely impacted by unsustainably managed waste. Due to the poor collection and inadequate transportation in developing countries, where solid waste management is a matter of least concern (Wajeeha et al., 2016)

Low and Middle-income countries have limited resources for proper solid waste management. In these countries, waste is often disposed of unregulated dumps or openly burned which is a serious health, safety, and environmental hazard. Adding poorly managed waste serves as a breeding ground for disease vectors, methane generation that contributes to global climate and promotes urban violence (Climate and Clean Air Coalition, Korean Green Growth Trust Fund, Global Partnerships on Output-Based Aid, International Solid Waste Association, 2018).

As other low-income country, Addis Ababa sends the wastes to the landfill site and cause an environmental and economic issue.

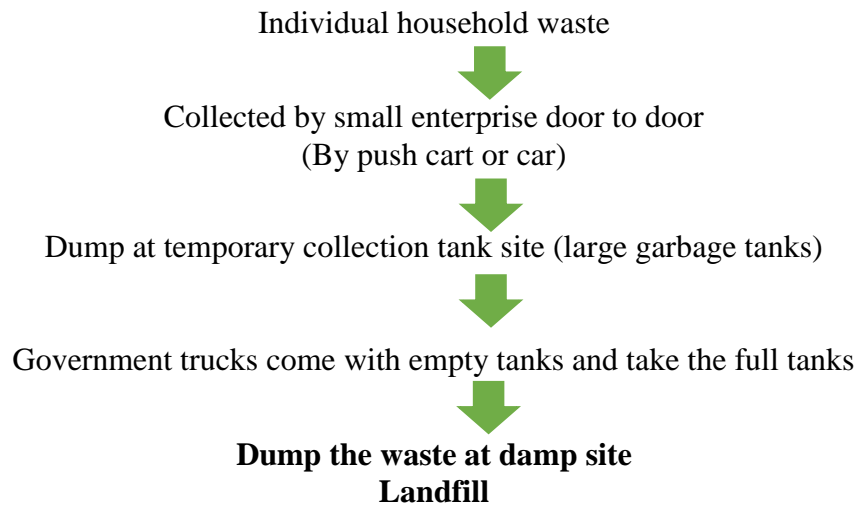


Fig.2.1: Waste management system in Addis Ababa

For cities to be livable and buildings are sustainable waste management is adequate, but this is a challenge for many developing countries. Countries to use effective waste management required 20%-50% cost of their municipal budgets (UN-Habitat, 2018).

Integrated Solid Waste Management (ISWM) is essential for cities to manage the waste stream effectively. ISWM is a comprehensive waste prevention, recycling, composting, and disposal program. This system effectively considers how to prevent, recycle, and manage solid waste in ways that most effectively protect people and the environment by involving and evaluating specific local needs and conditions, and then selecting and combining the most appropriate waste management activities for those specific conditions (Weitz et al, 2002).

C40 Cities Climate Leadership Group (C40) connects 90 of the world's greatest cities and focus on climate change and this C40 cities are discussed a good waste management system. The proper waste management system is generally those of the priory's action per waste hierarchy.



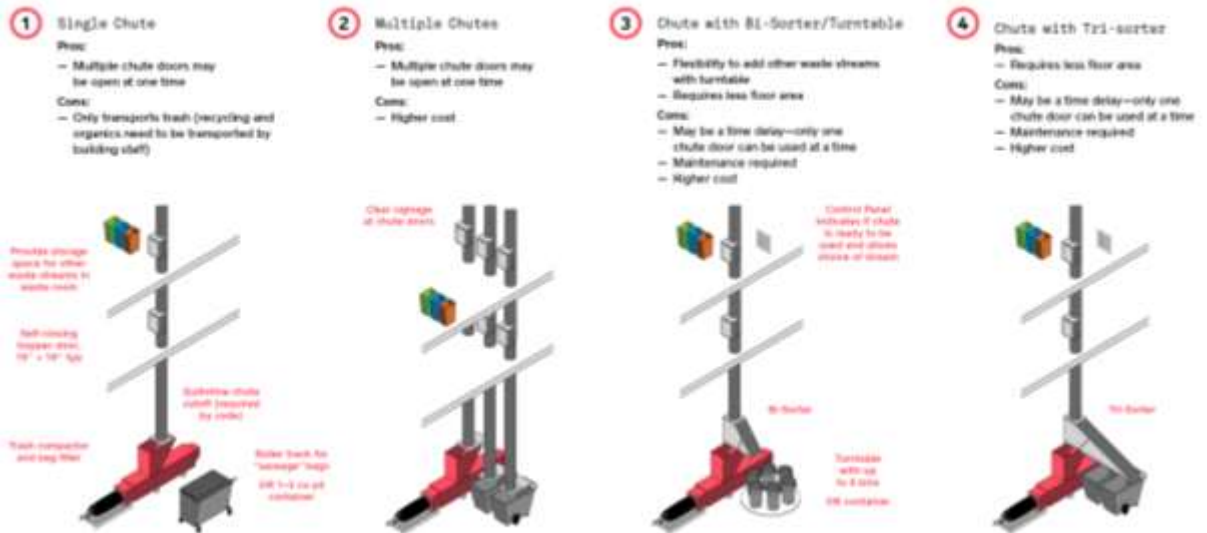
Fig.2.2: Waste Hierarchy, EPA, 2017

This waste hierarchy has several benefits, include GHG emissions reduction, reduction of environmental pollution and energy consumption, resource conservation, jobs creation, and the development of green technologies (C40 Cities Climate Leadership Group, 2015).

2.2.1. Municipal Solid Waste Management in Apartments (High Rise-Low Rise)

Solid waste management is different collection and separation method throughout the world. It also depend on the no of floor. Most of the residential units in urban area are multi-story buildings to accommodate more residence to a small plot of size. To collect waste in multi-story building, provide opening on each floors and connect with vertical trash chute. The residence simply dump their waste in the provided opening and collect with garbage container at the bottom. If this garbage container full, then the trash compactor comes and took it (Clare *et al.*, 2017).

CHUTE OPTIONS



WASTE MANAGEMENT PLAN

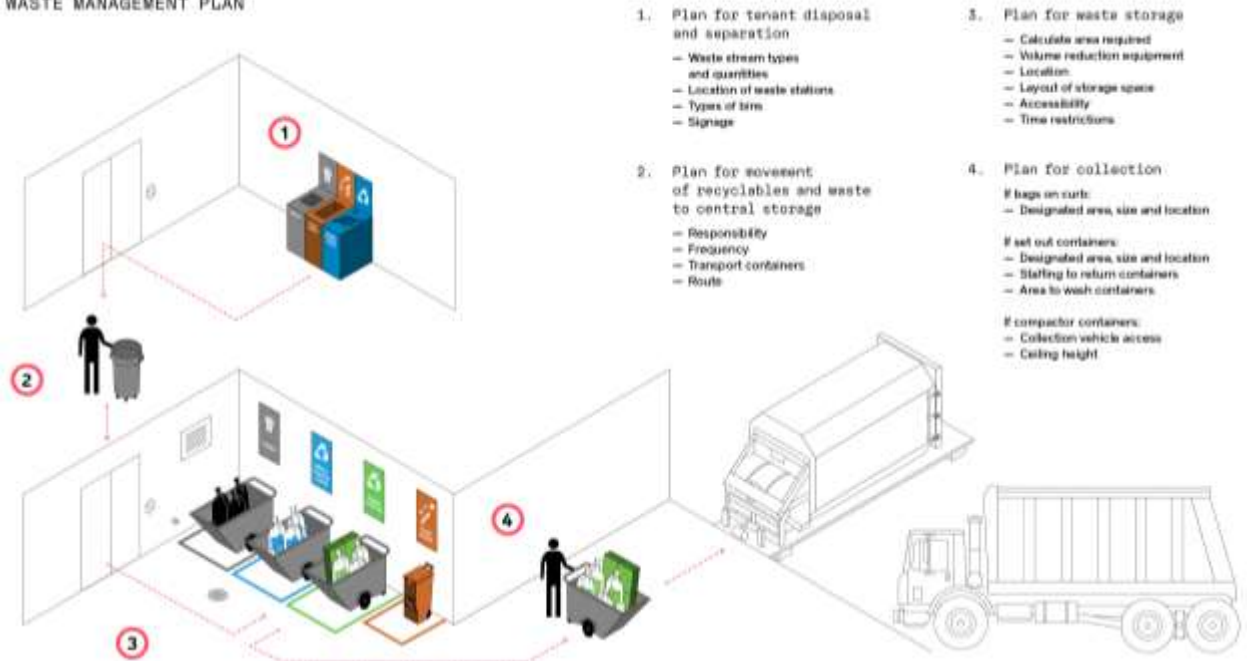


Fig.2.3: Chute option and waste management system in multi stories buildings, (Source: Clare et al., 2017)

From zero waste design guidelines, Architect should consider how to reduce waste during building design. There provide different chute option as the above figures. Source-separated organics recycling requires them to not only keep their waste in a separate container within their apartment but also to physically transport it down through the

building to the area (generally the trash chute room) where the organics containers are located (O'Brien, 2018).

In Addis Ababa, Yohanes Kidane was done solid waste collector and removing from a building by using metal plates attached to the condominium. This vertical trash chute was applied to one of the condominiums in Addis Ababa “Basha Wolde-Chilot” site with two partition one for decomposable waste and the second one is for plastic solid waste. If once collected the solid waste it's easy to use as a potential.



Fig.2.4: Solid waste management in one of condominium building (Source: Author, 2018)

2.3. MUNICIPAL SOLID WASTE COMPOSITION

The types of Municipal Solid Waste (MSW) Produced change according to the standard of living in the city. Wastes generated in low- and middle- income cities have a large proportion of organic waste, whereas the wastes in high-income cities are more diversified with relatively larger shares of plastics and paper (UN, 2011). The changing composition of waste, in turn, influences the choice of technology and waste management infrastructure and underscores the importance of waste separation (Course Hero, 2018).

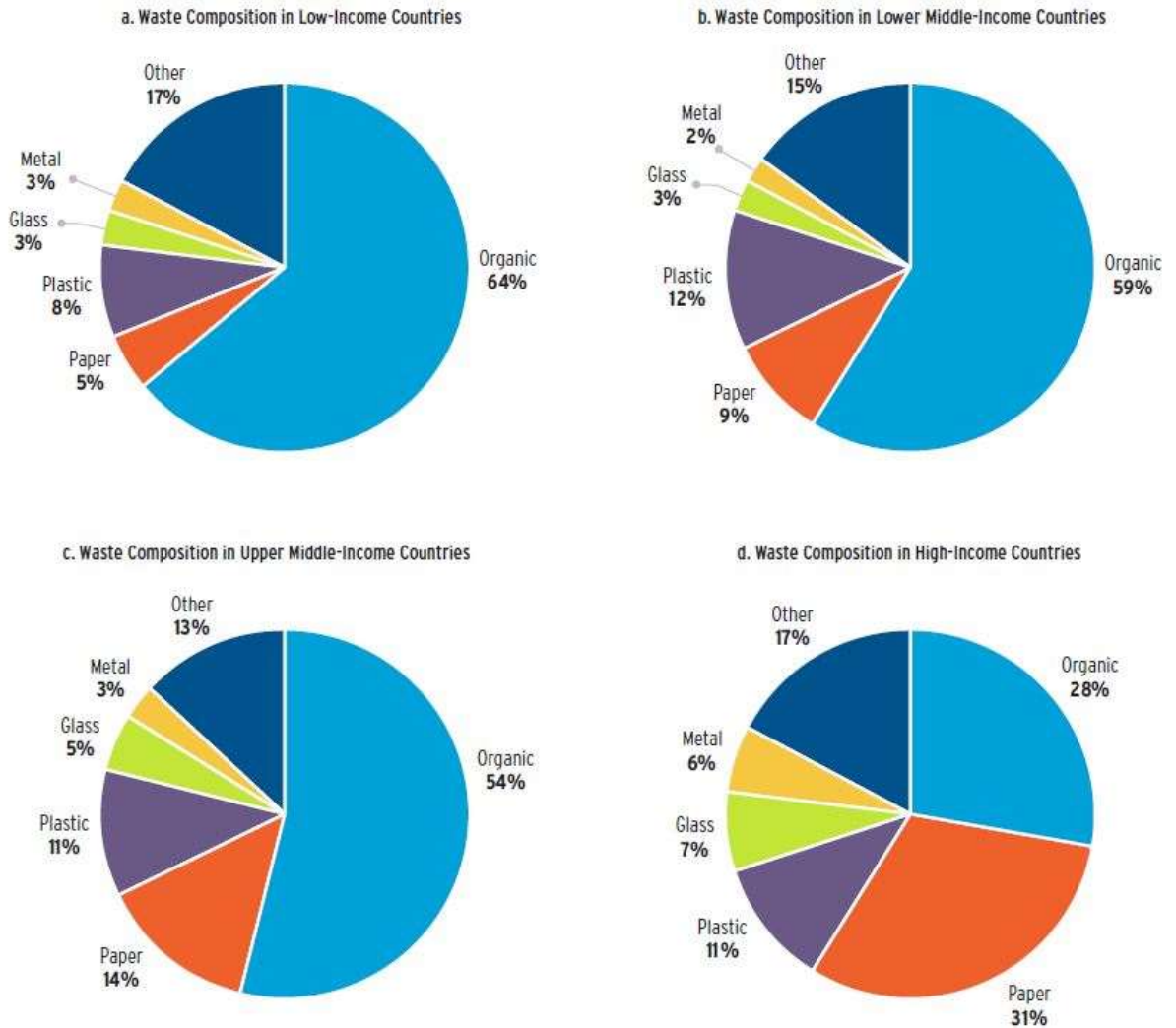


Fig.2.5: Waste compositions by income level (Source: World Bank)

More than 200,000 t are collected each year and from this the larger portion 76% waste generated from the residential house (Derege, 2012). (Conference and Arnold, 1995) was analyzed in Addis Ababa the physical composition of household waste is presented and from total household waste, 62.6% of the waste is the organic waste, being the largest fraction. It is followed by fines (7.5%), paper and cardboard (5.7%), plastic (5.4%), textiles (4.0%), sanitary products (3.4%), glass (2.4%), charcoal (1.9%), inert material (1.7%), and metals (2.7%). All other fractions make up less than 1% of the composition each. When compare IGNIS report with the World Bank, almost lay in the figure of organic waste 63% and 64% respectively (Steinbach and Dieter, 2014).

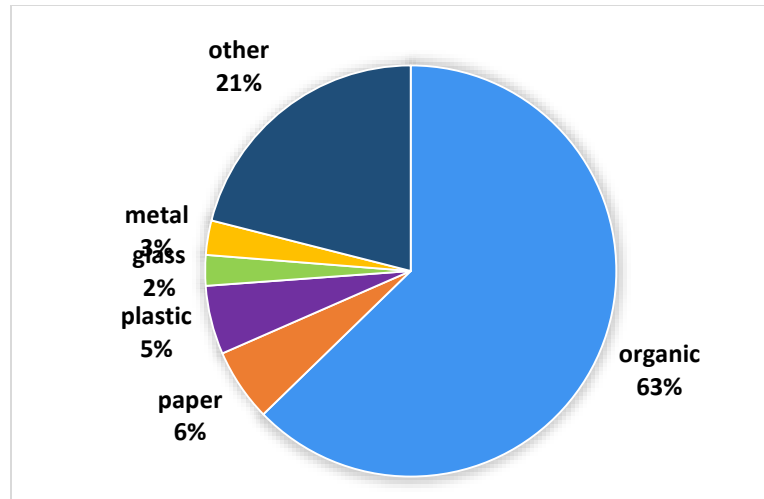


Fig.2.6: Physical composition of household solid waste in Addis Ababa, (Source: Steinbach and Dieter, 2014)

According to the (World Bank ,2016) report in low-income country, the waste characterization of the organic solid waste 64% in 2012 and in 2015 decreases 2% and score 62% of the total.



Fig.2.7: Solid Waste compositions by income level in 2012 and in 2025, (Source: World Bank, 2016)

When change the World Bank to this thesis classification,

- Organic 64% - 62% , 2% decrease
- Plastic 8% - 9% , 1% increase
- Other 28% - 29%, 1% increase

This implies 64% organic solid waste dump in landfill site every year and this figure decrease 2% in 13 years interval, almost the same.

2.4. ORGANIC SOLID WASTE AND ENVIRONMENT

2.4.1. Organic Solid Waste Impacts on Environments

Solid waste has impacts on the ecosystem by buried the ground, unpleasant odors, environmental pollution, groundwater pollution, vegetation damage, affect biodiversity (Justyna & Pitchayan , 2016) and especially the organic solid in landfill site decompose without oxygen and generate methane (C40 Cities Climate Leadership Group, 2016) and this methane produces greenhouse gas (GHG) emissions. One of the primary reasons given for diverting organics from landfills is to reduce fugitive landfill GHG emissions (Stephen, 2010) and Composting keeps the organic wastes out of landfills (Weitz et al., 2002).

Landscape architects can work with solid waste through transformation and re-designing of waste sites into landscapes with new function and appearance, as well as implementing prior waste products into design projects and raise awareness of the garbage-related issues among the public (Justyna & Pitchayan , 2016).

2.4.2. Organic Solid Waste Benefit for Environments

Composting reduces the impact on the environment and benefits to people by giving fertilizer (C40 Cities Climate Leadership Group, 2016). Natural Compost is one of best and environmentally friend method. According to biodegradable products institute, Composting is a natural process that turns organic materials into a dark, rich substance which is called compost or humus, is an excellent conditioner for the soil (Biodegradable Products Institute, 2018). Most of the waste in the residential unit was biodegradable organic waste that includes food waste, manure, leaves, grass trimmings, paper, wood, feathers, crop residue, etc.

Good quality compost can be made from organic household wastes in urban areas and be used to grow healthy vegetables in gardens at home environment (Sue and Hailu, 2011).

Compost properties

- Improve the soil structure by providing humus
- Improve the resistance of the soil against the erosion action of rain and wind
- Retain water and release it slowly the plants live long period without water

- Retain nutrients and releases them to the plants slowly over a long period
- It helps to control weeds, pests and diseases.
- It contains the main nutrients nitrogen (N), Phosphorus (P), and Potassium (K), which become available to the plant after decomposition.

Compost method and processes

Composting can provide a viable alternative method for managing organic waste (Karnchanawong and Suriyanon, 2011) and different methods of making compost (Madeleine I. *et al.*, 2005). Aerated or turned windrow composting is one of the techniques suited for large volumes such as that generated by entire communities and collected by local governments, and high volume food-processing with low or no cost (EPA, 2017).

Aerated or turned windrow composting making the organic matter into rows and give air (oxygen) by turning periodically by using machines and manually (EPA, 2016) and the pile becomes dome-shaped (Sue and Hailu, 2011). To transform the organic solid waste into compost, there are processes that pass through 3 stages, heating, cooling down and maturation stages (Madeleine *et al.*, 2005) which consist of four main components: the **organic matter itself, moisture, oxygen, and bacteria (heat)** (Jouhara *et al.* 2017).



Fig.2.8: Windrow composting process, (Source: Sustainable Agriculture Research & Education, 2012)

Organic waste: Organic solid matter from household includes mainly kitchen waste including the waste product of vegetable, fruit rinds, grass. Organic materials used for compost should include a mixture of brown organic material (dead leaves, twigs, manure)

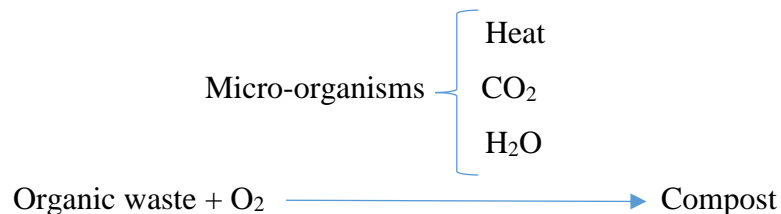
and green organic material (lawn clippings, fruit rinds). Brown materials supply carbon, while green materials supply nitrogen (The US Composting council, 2001).

Water: Moisture in compost process is essential. The organic matter decomposes with the help of micro-organisms (Williams, 2018) and to active and works this microorganism's moisture is essential. Composting materials should maintain a moisture content of 40–65 percent. Where the pile is too dry, composting occurs more slowly (FAO, 2003), or do not decompose (Sue and Hailu, 2011). While a moisture content more than of 65 percent develops anaerobic conditions (FAO, 2003).

Air: the solid organic matter decomposes with the help of bacteria, and these bacteria need oxygen to live. When there is enough oxygen, special bacteria can convert nitrogen into nitrate, the materials are decomposed properly, and there is a good smell. However, if there is not enough air, the nitrogen is converted into ammonia. The ammonia escapes into the air removing nitrogen from the compost and making it smell bad (Sue and Hailu, 2011). To get air (oxygen), the organic material need to turn (the inner material turn to outer and the outer material turn in to inner part). This rotating of material is good to fastest the compost process as well as to control the odor (Daniel et al., 1999).

Heat (Bacteria): Bacteria and other microorganisms are the real workers in the compost process. By supplying organic materials, water, and oxygen, the already present bacteria will break down the organic material into useful compost for the garden (Daniel et al., 1999). As the bacteria break down the organic material (decompose), they generate heat and this heat concentrate in the middle of the pile. Moreover, while compost or humus contains plant nutrients, it is typically not characterized as a fertilizer (StudyLib, 2018).

Therefore the compost process,



Simple equation of compost process, Jouhara *et al.*, 2017

The pile size dimension different with book from book. According to Anurage, Good pile size is height is between 121.92cm-243.84cm with a width of 426.72cm -487.68cm. This size pile is large enough to generate enough heat and maintain temperatures. It is small

enough to allow oxygen flow to the windrow's core (US EPA, 2016). The Food and Agriculture Organization of the United Nations compost pile dimension height is between 150cm-200cm with a width of 150cm - 300cm and the length depending on the amount. In the estimation of the compost pile dimensions it is essential to consider that during composting, the pile decreases in size (up to 50%) due to compaction and loss of carbon as CO₂(FAO,2015).

How long does it take to get compost?

Organic matter includes plant materials and some animal manures. Organic materials used for compost should include a mixture of brown organic material (dead leaves, twigs, manure) and green organic material (lawn clippings, fruit rinds, etc.). Brown materials supply carbon, while green materials supply nitrogen. The best ratio is 1 part green to 1 part brown material (Weitz *et al*, 2002). Materials with good nitrogen content help in making good compost, but they should be less than the carbon-containing materials. Carbon-containing materials should always be more than those containing high nitrogen. A good balance of carbon and nitrogen is needed to make good compost. Table 1 gives the carbon-to-nitrogen balance for some types of composting materials (Sue and Hailu, 2011).

For producing compost, there is no fixed amount of time. This variation in a time dependent on compost pile size, types of organic material, time to turn the pile the type of composting technology used, climatic conditions, and the level of operator control and management. The number of times the pile is turned influences composting speed and also Shredding, chopping or mowing these materials into smaller pieces will help speed the composting process by increasing the surface area (Sue and Hailu, 2011).

Active composting can last from 3 to 4 weeks, or it can take 8 to 12 months (Environment Canada, 2013). In general summertime, warm temperatures encourage bacterial activity and the composting process is quicker and in another side in winter time, the movement of the bacteria slows, and the composting process is slow, and it is recommended that stop turning the pile to keep heat from escaping the pile's center (University of Illinois, 2018). In Addis Ababa, the average time to get full compost product from organic household waste three month – four month as Waltenege W.(practicing windrow compost in EiABC).

Household organic waste vs Compost ratio

Household organic waste varies in composition depending on the community and its consumers' incomes and lifestyles and so on (Jouhara *et al.* 2017). The organic waste material will have been reduced in volume by 20 to 60%, the moisture content by 40% and the weight by up to 50% (Alberta Agriculture, Food and Rural Development, 2005). In Addis Ababa, according to Waltenegus W., works compost production specific on household solid organic waste, from his experiment 6kg organic solid waste produce 1 kg organic fertilizer (compost).

6kg organic waste = 1kg compost

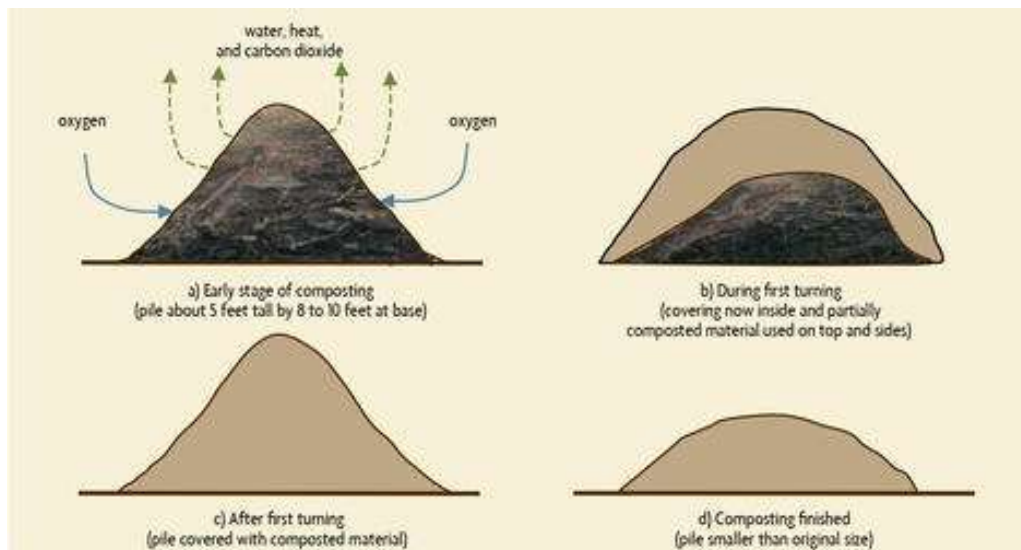


Fig.2.9: Original organic matter Vs Compost size, (Source: Sustainable Agriculture Research & Education, 2012)

Application of compost

To grow plant the soil type and condition is essential element to consider. Soil in urban area are disturbed and contaminated in many factors and this factors reduce the soil fertility and difficult for the plant to grow and live. Therefore the soil need amendment and restoration to become fertile, Compost provide significant benefits in the restoration of disturbed soils in urban (Bilal *et al.*, 2016).

Moreover, the compost has a high content of organic matter with the advantages that entails (FAO, 2015). It contains available nutrients of slow release, beneficial for plant nutrition (Sue and Hailu, 2011).

The amount of organic matter (Compost) to be applied to the soil depends on the type of soil, vegetation, environmental conditions such as moisture also temperature (FAO, 2015). Using compost in the vegetable garden, or on small plots of land are very suitable (Madeleine *et al.*, 2005) especially for row planted crops, for example, maize, sorghum and vegetables, the compost can be put along the row with the seeds or seedlings are good.

The mature compost is used largely for seedlings, planters, and pots. Usually mixed (20% -50%) with soil and other materials such as peat and rice husk as substrate preparation (FAO, 2015). Artificial (chemical) fertilizer last for only one growing season and must add every growing season but Soil gave good compost effects last for more than one growing season. According to Ethiopian farmers' report, mature compost to give a rate of 8–10 tons per hectare can be achieved in areas where there are plenty of composting materials, a good water supply and labor (Sue and Hailu, 2011).

1hectar= 10,000m²

1 tone = 1000 kg

1hectar need 8,000kg – 10,000kg

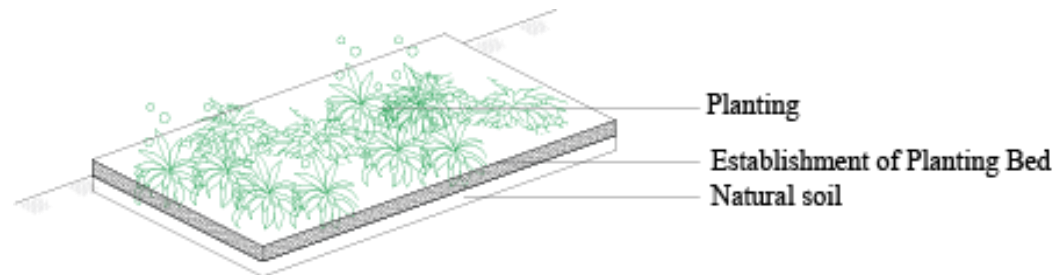
In Europe, where the soils are cold, and there is much rain, the general guideline is that 20–25 tons of compost are needed to replace 100–150 kg of chemical fertilizer. The range is because the nutrient content of compost depends on the materials used to make the compost (Sue and Hailu, 2011).

The (US compost council, 2001) describe the compost application for different uses:

- **For the Establishment of Planting Bed**

If the soil are poor quality compost amend the soil in different ways. The application rate of compost is low in soil which have good organic matter and high in poor soil quality. Sandy soil or clay soil require high compost rate. Sandy soil does not hold much water and in Clay soil water cannot pass through easily (Sue and Hailu, 2011). One of compost properties was Retain water and release it slowly the plants live long period without water.

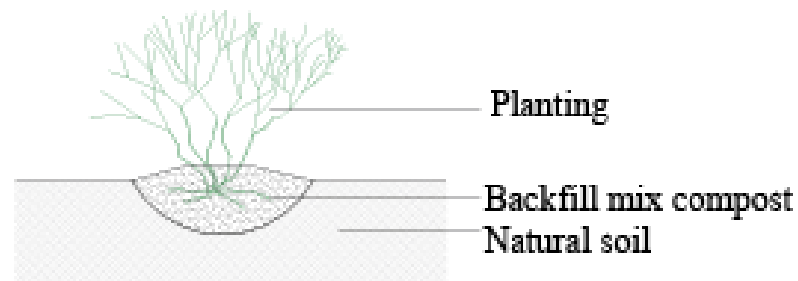
Compost rate: The compost rate of 135-270 cubic yards per acre (1-2 inch layer) or 3-6 cubic yards per 1000 square feet. Rates range from 90-400 cubic yard (2/3 - 3 inch layer) or 2-9cubic yards per 1000 square feet.



- **For Component as a Backfill Mix**

Component to backfill mix for the establishment of planting of various tree and shrubs and this improve the root growth of the plants.

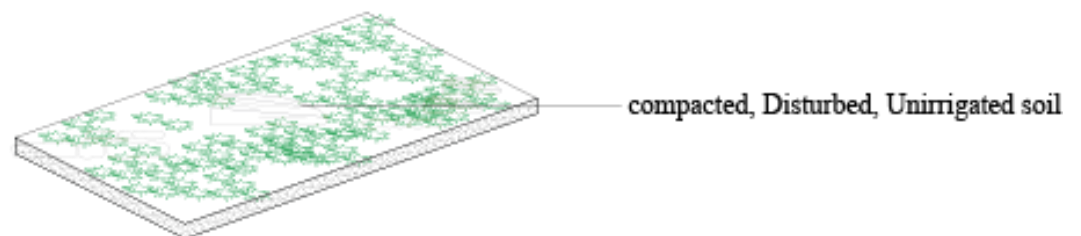
Compost rate: 25%-50% compost mix with soil, the most common rate is 33%.



- **For upgrading marginal soils**

Soil with upgrading compacted, Disturbed, Unirrigated, Low-maintenance sites area poor quality soil difficult.

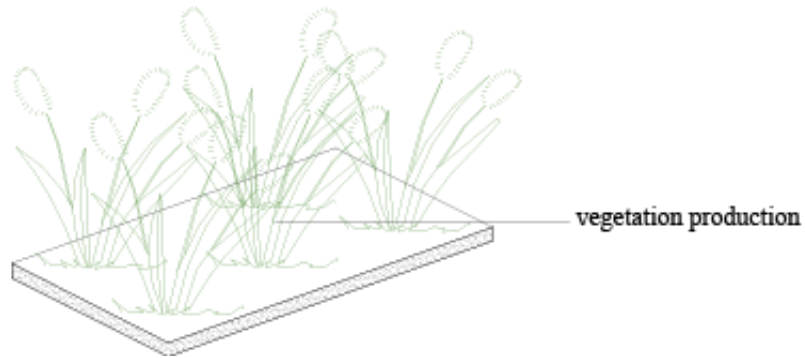
Compost rate: 135-400 cubic yards per acre (1-3 inch layer)



- **For vegetation production**

Compost gives for the vegetation production by giving fertility, holding water for long time and it helps to control weeds, pests and diseases.

Compost rate: 10-60 dry tons per acre.



Compost use estimator

To know how much cubic yards of compost is needed to the specific given area the US Composting Council derive formula:

Cubic yards of compost	=	Specific area to cover	*	Amount of compost to apply
* 0.0031				
(Cover a specific given area)		(Express as square feet)		(Expressed as depth in inches)
=.....ft² *inches of compost * 0.0031				

2.5 .URBAN AGRICULTURE

Urban agriculture (UA) is defined as the production of crop and livestock goods within cities and towns, which may provide products to the local population include the cultivation of vegetables, medicinal plants, spices, mushrooms, fruit trees, ornamental plants, and other productive plants, as well as the keeping of livestock for eggs, milk, meat, wool, and other products (Brenda et al., 2015).

Different types of UA can be found in *Community or allotment gardens* (Brenda et al., 2015). In Addis Ababa also the open /green space in condominium area planed for UA purpose. According to (Ministry of Urban Development and Housing, 2016) Open spaces in communal green areas can serve several functions. The most obvious functions include:

a) **Corner planting** – this area can be used to plant plants of different nature and should serve in enhancing aesthetics, provide for improving food security for example small vegetable plants, and medicinal purpose.

b) **Shrub planting** – shrubs that provide for shade, aesthetics and or food security can be planted around the corner or in front of the building.

c) **Tree planting** – trees can be planted in the open space between the buildings provided that there is enough space to accommodate the root system and canopy growth. Knowing about the size of a tree at maturity is an important consideration to be made at the beginning. The trees to be planted should serve, as far as possible multiple purposes of shading, aesthetics, and food production (fruits, or has medicinal value).

UA provide Ecosystem Services are:

Habitat services - Habitat for biodiversity

Provisioning services - Medicinal resources and aromatic plants; Food supply (quantity and quality)



Regulating services - Air purification; Local climate regulation; Global climate regulation; Maintenance of soil fertility; Pollination

Cultural services - Social cohesion & Integration; Place-making; Political fulfillment; Biophilia (connection with nature); Aesthetic information; Nature & Spiritual experiences; Relaxation & Stress reduction; Entertainment & Leisure; Exercise & Physical recreation; Learning & Education; Maintenance of cultural heritage (Thomas,2014)



There are plants indigenous to the country as well as plants adapted to the environment and used by the community. Most common vegetable consumed by the households are Kale, Swiss chard, carrots, cauliflower, leek, cabbage, lettuce, beetroot, and shallot (Girma et al.,2010). The growing season of the plants differ plant to plant (See table 2.1).

Urban soils are usually compacted, have low levels of organic matter, altered soil moisture characteristics, and sometimes have lead or other heavy metal contamination due to urban environmental processes thus uses alternative methods, organic compost is used as a growing medium instead of existing soils (Brenda et al., 2015).

Table 2.1: Common plants used by the households for different purpose

Plant picture	English name	Amharic name	Scientific name	Family	Use	Growing season	Spacing	Time needed	source
	Kale	Gomen	Brassica oleracea var. sabellica	Brassicaceae	food, anti-inflammatory, and treatment for glaucoma and pneumonia	It grows best in the spring and fall and can tolerate fall frosts	8 to 12 inches apart	max 3month	gentleworld.org
	Swiss chard	Kosta	Beta vulgaris subsp. vulgaris	Amaranthaceae	food	Grown year round and is sometimes thought of as a winter vegetable, its peak season is in the summer.	Thin successful seedlings from 8 to 12 inches apart. Space rows 18 to 24 inches apart.	1-11/2 month	gardeningchannel.com
	carrots	carrot	Daucus carota subsp. sativus	Apiaceae	food,	3monthy-4month	Spacing between rows requirements are 16-24 inches	2-21/2 month	gardeningknowhow.com
	cauliflower	Ycabeba gomen	Brassica oleracea	Brassicaceae	food,		In rows 18inc, and space between rows 24inc-46inc	2-4month	google.com
	leek	Yeshorba ketel	Allium ampeloprasum	Amaryllidaceae	food	spring in the north and latesummer or fall in the south	2-6 inches apart with 12-36 inches between rows	2-3 month	gardeningknowhow.com

...continuation of table 2.1

	beetroot	Keyeser	Beta vulgaris	Chenopodioidae	food,		Seeds 2cm (3/4"-1") deep. Keep seeds or seedlings apart at a distance of at least 5 to 10cm (2-4").	2-3month	almanac.com
	lettuce	selata	Lactuca sativa	<u>Asteraceae</u>	food	season crop that grows well in the spring and fall in most regions	plant in rows 12" (30 cm) apart, and set plants out (or thin seedlings) to 6-8" (15-20 cm) apart	1 1/2 - 2month	burpee.com
	shallot	Shenkurte	Allium cepa var. aggregatum	Amaryllidaceae	food	planted in the late fall for an early summer harvest or in the early spring for a late summer crop	Space cloves 6 to 8 inches apart in rows 12 inches apart.	3month	gardeningknowhow.com
	rosemary	Yega metebsha	Rosmarinus officinalis	Lamiaceae	food, medicinal	evergreen	Paced between 18 and 24 inches (45 - 60 cm) apart.		gardeningknowhow.com
	Artemisia	Ariti or Chikugn	Artemisia abyssinica	Asteraceae	cultural, Medicinal	annual evergreen	plant spacing in the row should be 30 cm with a 60 cm row width		gardeningknowhow.com

...continuation of table 2.1

	fringed rue	Tenadame	Ruta chalepensis	Rutaceae	food, medicinal, ornamental	evergreen	spread of 20 to 30cm (8 to 12in)		gardeningknohow.com
	myrtle	Ades	Myrtle bush	Myrtaceae	Cultural, medicinal, ornamental	evergreen	spacing of at least 15 to 20 feet between trees		gardeningknohow.com
	eucalyptus	Bahirzaf	Eucalyptus globulus	myrtaceae	medicinal, ornamentals and shade, firewood	evergreen	2-3 meter		gardeningknohow.com
	olea	weyra	olea hochstteri	oleaceae	medicinal, ornamental, cultural	evergreen	1.5 spacing along and 4meter apart		gardeningknohow.com
	Avocado	Avocado	<i>Persea americana</i>	Lauraceae	Food, ornamentals and shade	evergreen	8m rows of tree spaced and 2m apart in rows		gardeningknohow.com

...continuation of table 2.1




	<i>Podocarpus</i>	Zegba	<i>Podocarpus falcatus</i>	Podocarpaceae	medicinal, ornamental, shade, firewood	evergreen	1 meter apart and 1.5 meter along		gardeningk nowhow.com
	redwood	Koso	<i>Hagenia abyssinica</i>	Rosaceae	medicinal, ornamental, shade, firewood	evergreen	4.5m apart		gardeningk nowhow.com
		zenbaba	<i>Phoenix dactylifera</i>	Areaceae	Food, ornamentals Cultural and shade		2m apart		ardeningk nowhow.com

Table 2.2: Summary of vegetables with compost application per year:

No	Plant type	Growing season	production /year	Amount of compost /year	Remark
1	Kale	3month	4 times	2 times	
2	Swiss chard	1-11/2 month	8 times	4 times	
3	carrots	2-21/2 month	5 times	2.5 times	
4	cauliflower	2-4 month	3-6 times	2-3 times	
5	Leek	2-3 month	4-6 times	2-3 times	
6	beetroot	2-3 month	4-6 times	2-3 times	
7	lettuce	11/2 – 2 month	6-8 times	3-4 times	
8	shallot	3month	4 times	2 times	

CHAPTER 3 – METHODOLOGY

3.1. DESCRIPTION OF THE STUDY AREA

“Basha Wolde-Chilot” condominium is located at $9^{\circ} 1'59.51''\text{N}$, $38^{\circ}45'32.54''\text{E}$ and spread on $62,985.67 \text{ m}^2$ of land. This condominium site is found in Arada Sub City at Woreda 09

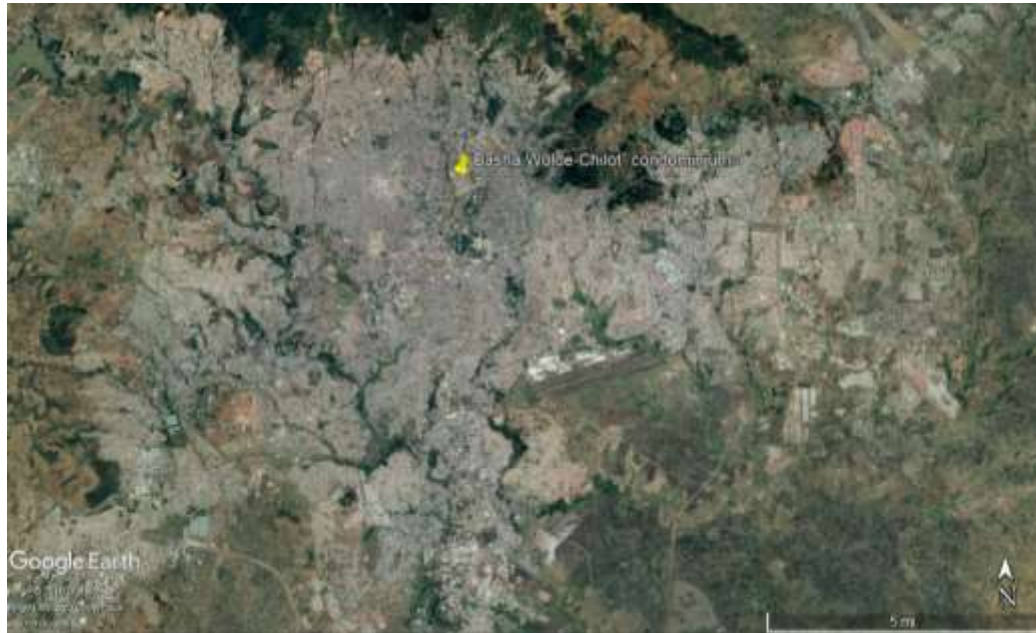


Fig.3.1: location map, (Source: Google map, 2018)



Fig.3.2: Site map, (Source: Google map, 2018)

The solid waste management is managed by Arada sub-city, woreda 9 with the collaboration of small-scale corporation. The research conducted in this condominium site because of:

Good solid waste management system: compare to other condominium site this site have:

In “Basha Wolde-Chilot” condominium site, there are three ways of waste collection and disposal mechanism. the first one was vertical trash Shute attached to one of the building, free stand metal garbage was the second, and the last one the resident collect their waste by Trash bag(madabria) at their home and put their waste in front of their building after the microphone alarm.

1. Vertical trash Shute attached to one of the building

In this waste collection & disposal mechanism the household collect their waste at their house and at any time dump their waste easily with their floor. The vertical trash have two partition one for decomposable waste and the second one is for plastic.



Fig.3.3: Vertical trash Shute at “Basha Wolde-Chilot” (Source: Author, 2018)

In decomposable waste include waste other than plastic waste e.g. organic waste, sanitary material, paper waste.

2. One free stand metal garbage

This waste collection & disposal is located around the condominium entrance and used by condominium near to the metal garbage. The household collect their waste at their house and dump their waste if they collect much. In this case the households forced to move long distance from their block. The free stand metal garbage have three partition one for plastic waste ,second for decomposable waste and the third one is for bottle which will be broken.



Fig.3.4: Free stand metal garbage at “Basha Wolde-Chilot” (Source: Author, 2018)

3. Trash bag(madaberia)

The resident collect their waste at their home and put their waste in front of their building after the microphone alarm. In this case there is no separating waste the household collect their waste in trash bag”madaberia” and give to the waste collectors in three days interval.

The small-scale corporation comes with two days gap, which means if the collectors come on Tuesday early morning, the next day was Friday early morning come to collect the waste. Early in the morning one of the people from collectors voiced to the household by the microphone to out their waste, and the resident put their waste in front of their building except building with vertical trash and building near to free stand garbage.

Most of the resident put their waste in front of their building after the microphone alarm. If the resident separated their waste its good for the collector otherwise force to separate the waste degradable waste, plastic waste and other waste at the site and tied up by trash bag “madabria”. All the waste collected from the site disposed at Genfle temporary dump station (a buffer area used as a transfer station), when the temporary site collects much amount of waste, the compressor truck come and take the waste and dump to last landfill site Repi.





Fig.3.5: Waste collectors while on collecting, transporting and dumping (Source: Author, 2018)

Near to Riverside: have space for the application, input for the buffer zone

Manageable block number: because of shortage of time limit the site have manageable block number.

The Same typology: all the 22 blocks have the same typology, and it's good for sampling and tangible data.

Once collected the solid waste it's easy to use as a potential. The site has 22 blocks of the G+4 building. It contains a different family type studio, one-bedroom, two-bedroom, and three-bedroom. The place surrounded by building with three sides and on the one hand, there is a river that was not given function.

3.2. DATA COLLECTION

In this thesis quantitative data methods were employed in the primary data source. The primary data was collected from the sampled households in “Basha Wolde-Chilot” condominium site by measuring the generating solid waste (*see annex 1*). Besides, to the measured data from the sampled resident, the resident and waste collectors fill questionnaires (*see annex*) to knowing their knowledge about waste was input for this paper. All available published and unpublished documents of relevant organizations was conducted as secondary sources.

3.3. DETERMINE THE NUMBER OF SAMPLING

The site has 22 blocks of the G+4 building. For a single block, the floor is typical and have different bedroom type. It contains studio, one-bedroom, two-bedrooms and three bedrooms and a total of 25 family per block. Therefore for the 22 neighborhoods 550 families with the different social mix. Use the representative bedroom types is mandatory.

For this research, the sampling technique was to determine the sample size by Taro Yamane's formula. After specifying the number of blocks use Systematic sampling.

In one building:

- 5 studio
- 5 one bedroom
- 10 two bedrooms
- 5 three bedrooms, in total 25 household.

Systematic Sampling: the site has the same type of building, but in some of the buildings the ground floor is commercial. Therefore it is necessary to sort out systematically the full residential building from the 22 buildings.

The compositions measured at block level.

To determine the sample sizeTaro Yamane's formula (Taro Yamane, 1967)

$n = \frac{N}{1 + Ne^2}$	n- Sample size number N- Number of population e- Merjion of error
$= \frac{550}{1 + 550(0.05)^2}$	if confidence level 95% error 5% = 0.05
$= \frac{550}{2.375}$	
$= \underline{\underline{231.57}}$	

One block have 25 household

$$= \frac{231.57}{25}$$

$$= 9.26 \text{ blocks}$$

$$\approx \underline{\underline{10 \text{ blocks}}}$$

For the questionnaires (*see annex*) 35 household selected random sampling method to know their knowledge and attitude toward waste.

3.4. CHARACTERIZATION OF HOUSEHOLD IN THE SELECTED COMMUNITIES

According to Addis Ababa city solid waste management system, Physical composition categories in three Organic 60%, Recyclables 15%, others 25% (AACSWMS, 2010). And

also the committee in this condominium provides one free stand collection site with three categories blue for organic matter, red for plastic, and yellow for others like metal, glass waste. To be simple for the households, adapted the existing color code.



*Fig.3.6: Physical composition of household waste done by condominium committee
(Source: Author, 2018)*

3.4.1` .Source Separation System of Household Solid Waste

The resident’s requested to sort their waste as organic, recyclable and other with different colored bags. For the selected household give the colored trash bag “madaberia” with door to door with a clear explanation which color for what kinds of waste.

Organic Waste	Plastic	Other
Kitchen waste (food waste)	rigid plastics/bottles	textiles
Paper waste	Loosen plastic bags	woods
Yard waste		batteries
		Metals
		Glass containers/gar
		Other from organic & recycles

3.4.2. Measuring the sampled household waste

The research needs to explore the amount of household waste generation and characterization of waste from the specific site. The Characterization of household solid waste categorized into three (fig 3.3). The Characterization carried on sampled buildings. Each building contain a different social mix from studio up to a three-bedroom. Before the survey, gave colored trash bag (“madaberia”) for the resident door to door with clear waste separation awareness and collected the solid waste according to the color code in each representative blocks.

Quantitative measurement of household solid waste generation & characterization in kg at block level within 3days. To be more tangible the measurement done in two different collected days. Both data will be calculated and take the average, mean.

$$\text{Average} = \text{Mean} = \frac{B1 + B2 + \dots + B9 + B10}{10}$$

After the mean calculate the standard deviation how much the value deviate. Standard deviation is a measure of the dispersion of a set of data from its mean. It is calculated as the square root of variance by determining the variation between each data point relative to the mean. If the data points are further from the mean, there is a higher deviation within the data set (Investopedia, 2018).

$$\text{Standard Deviation} = \sqrt{\Sigma (B - \dot{B})/10} \quad \text{Where } \dot{B} \text{ is mean}$$

Quantitative measurement of household solid waste generation & characterization in kg at site level within 3days (*see annex*).

3.4.3. Questionnaires

The research questionnaires (*see annex*) prepared for the resident in condominium and waste collector for the condominium site in order capture their knowledge about waste as potential especially about landscape value and in their common green space, what kinds of urban agriculture to be needed. And also to ask if they are willing to participate. For the waste collectors to know what type of waste is necessary by them, in which month the household waste score maximum and minimum and if they know the reason is the main one.

3.5. DATA ANALYSIS AND PRESENTATION METHODS

In this study, quantitative data analysis methods employed. The sampled measured data analyzed and present in excel through a table, percentage, graphical maps. The data obtained through questionnaires explained in the quantitative data analysis method, and the data was analyzed and interpreted the number in percentage, graphical and merge with maps.

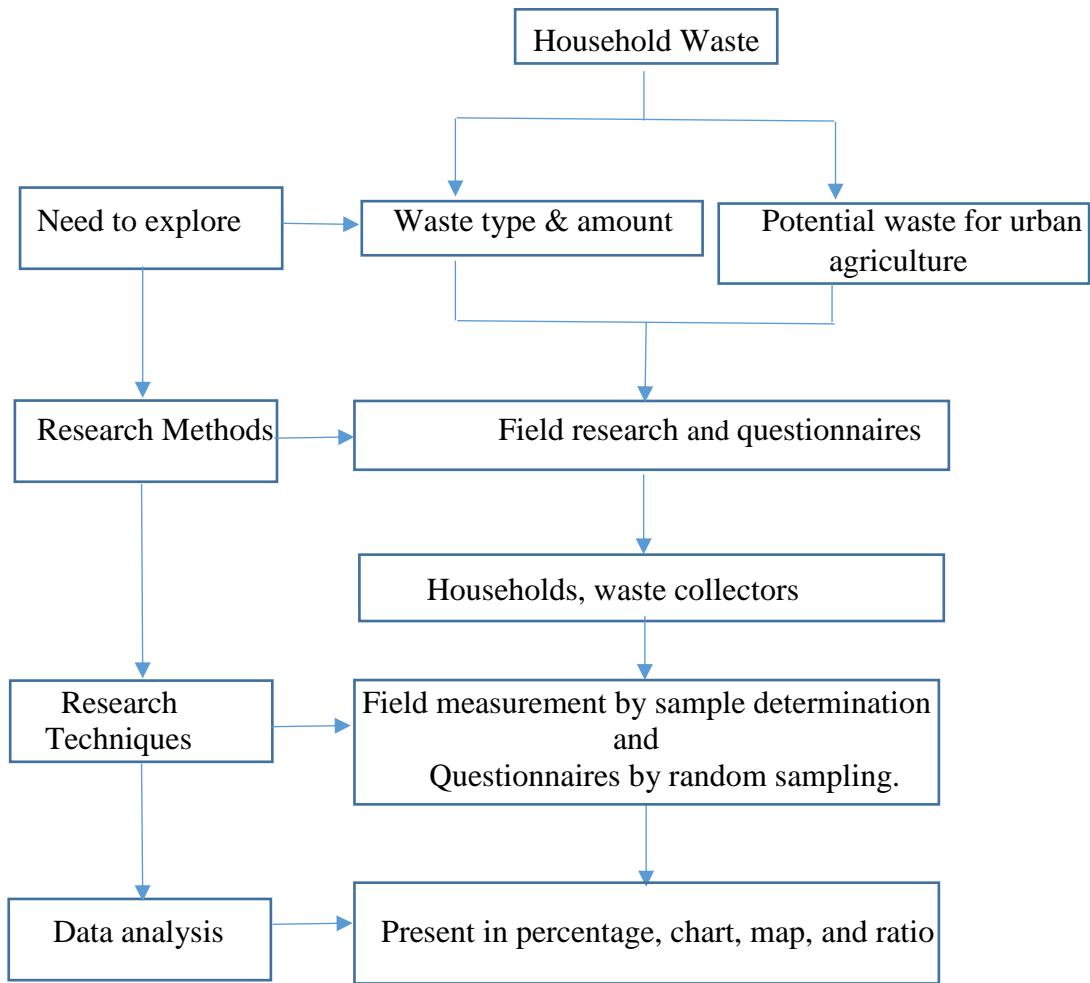


Fig.3.7: Methodological organization of the research

CHAPTER 4- RESULTS AND DISCUSSION

4.1. RESULTS

4.1.1. Existing solid waste management system, Household Solid Waste generation, Household Solid waste Characterization

Existing solid waste management system



Fig 4.1 Waste management from “Basha Wolde-Chilot” condominium to final disposal site (Source: Author, 2018)

Household Solid Waste generation

To determination of the household waste generation rate, sample building was collected on May 3, 2018, and May 6, 2018 (*Table 4.1*). The first sample indicates (*Table 4.1*) that the average waste generation was 36.7 kg/3days with ranges of minimum 28kg/3days and maximum 49kg/3days, with a standard deviation value of 6.68. On the second day, (*Table 4.1*) the average waste generation 41.65kg/3days with minimum 27kg/3days and maximum 49.5kg/3days, with a standard deviation value of 5.87. Both results indicate that even within the same blocks every day the waste generation rate was different. On average household in “Basha Wolde-Chilot” condominium site generate 13.05kg/ days. The waste generation rate found 9kg /day (minimum) and 16.5kg/day (maximum) at a block level.

Table 4.1: Waste generation in “Basha Wolde-Chilot” Condominium

Block number	Total waste Kg/3days
Block 1	28
Block 2	39
Block 3	49
Block 4	34
Block 5	31.5
Block 6	36
Block 7	43.5
Block 8	42.5
Block 9	30
Block 10	33.5
Sum	367
Count (n)	10
Average(mean)	36.7
Standard deviation	6.68

Waste generation in May 3, 2018

Block number	Total waste Kg/3days
Block 1	40.5
Block 2	45
Block 3	44
Block 4	40.5
Block 5	43.5
Block 6	44.5
Block 7	27
Block 8	40
Block 9	42
Block 10	49.5
Sum	416.5
Count (n)	10
Average(mean)	41.65
Standard deviation	5.87

Waste generation in May 6, 2018

$$\begin{aligned} \text{The average of the two days} &= \frac{36.7\text{kg} + 41.65\text{kg}}{2} \\ &= \underline{\underline{39.2 \text{ kg / 3days}}} \end{aligned}$$

To know the maximum waste generation time questioner was conducted within the Households. According to the Households, the maximum waste generated was during holidays, weekends, a ceremony like a wedding, birthday, and funeral. The dominant holydays are: Ethiopian New Year, finding cross, - September

- Birthday of prophet Mohamed – November
- Ethiopian Christmas, Ethiopian epiphany – January
- Ethiopian good Friday ,Ethiopian Easter – April
- Eid Al Fitr – June
- Eid Al Adha – Aug, in this month some waste is added to the normal one.

Table 4.2: Household waste generation variation within a month at “Basha Wolde-Chilot” Condominium

Waste type	Jan.	Feb	Mar	April	may	June	July	Aug	Sept.	Oct.	Nov.	Dec.
Total waste in Kg(one block)	13.05+	13.05	13.05	13.05+	13.05	13.05+	13.05	13.05+	13.05+	13.05	13.05+	13.05

Household Solid waste Characterization

The first survey data collected on May 3, 2018 day.



Fig.4.2: Shows taking measurement of the waste at site (Source: Author, 2018)

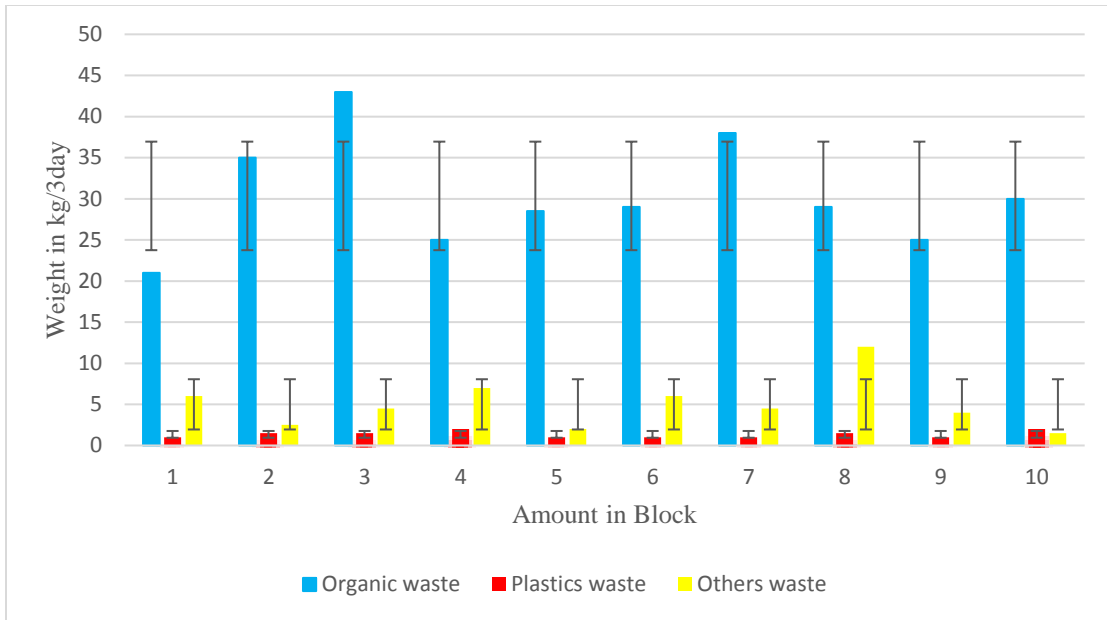


Fig.4.3: Waste Characterization of “Basha Wolde-Chilot” condominium in kg/3days, May 3, 2018

Therefore the site generate in a day:

$$\text{Organic waste} = \frac{30.35 \text{ kg in 3day}}{3 \text{ day}} * 22 \text{ blocks} = \underline{\underline{222.57 \text{ kg}}}$$

$$\text{Plastic waste} = \frac{1.35\text{kg in 3day}}{3 \text{ day}} * 22 \text{ blocks} = \underline{\underline{9.9 \text{ kg}}}$$

$$\text{Other waste} = \frac{5\text{kg in 3day}}{3 \text{ day}} * 22 \text{ blocks} = \underline{\underline{36.7 \text{ kg}}}$$

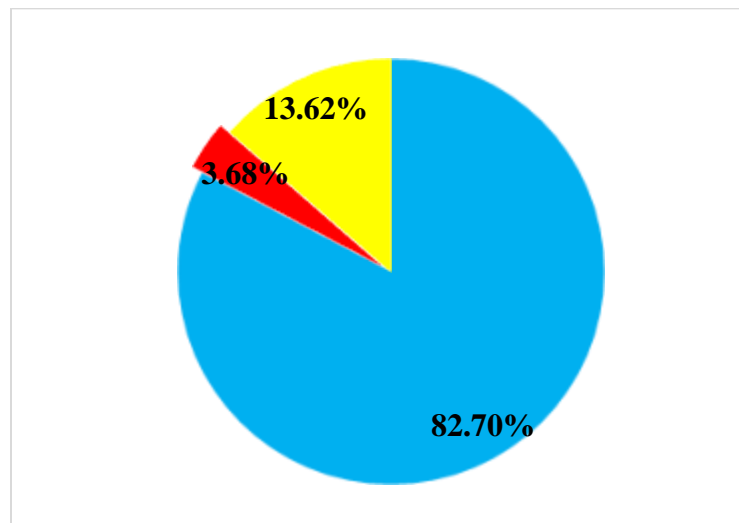


Fig.4.4: Waste Characterization in “Basha Wolde-Chilot” condominium, May 3, 2018

To be more concrete data, done the same procedure for second times on May 6, 2018.

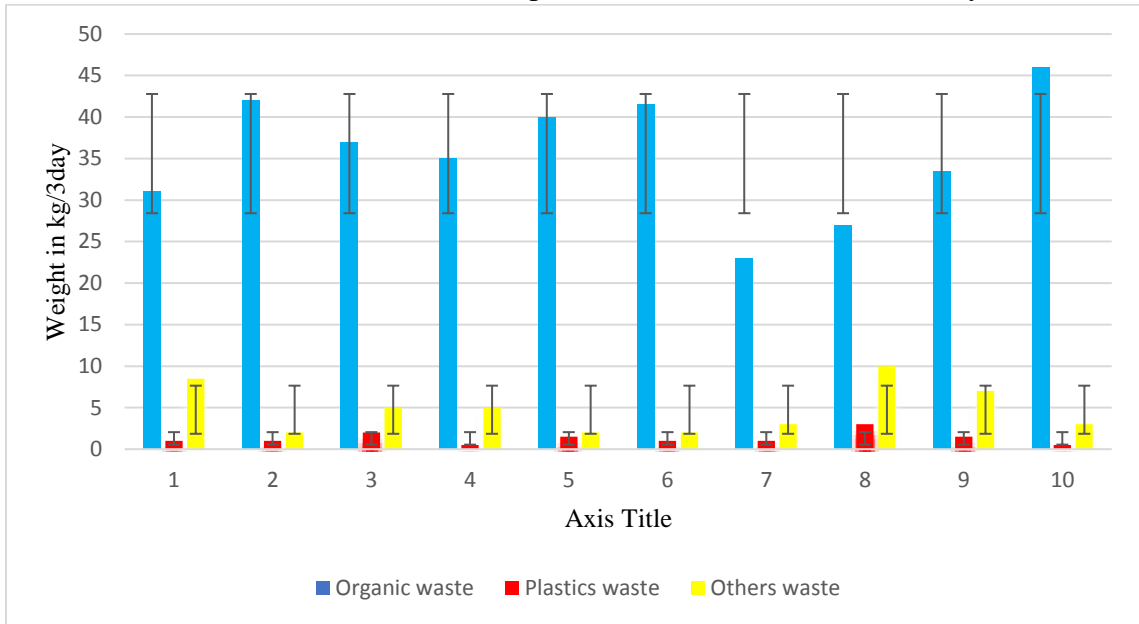


Fig.4.5: Waste Characterization of “Basha Wolde-Chilot” condominium in kg/3days, May 6, 2018

Therefore the site generate in a day:

$$\text{Organic waste} = \frac{35.6 \text{ kg in 3day}}{3 \text{ day}} * 22 \text{ blocks} = \mathbf{261.06 \text{ kg}}$$

$$\text{Plastic waste} = \frac{1.3 \text{ kg in 3day}}{3 \text{ day}} * 22 \text{ blocks} = \mathbf{9.53 \text{ kg}}$$

$$\text{Other waste} = \frac{4.75 \text{ kg in 3day}}{3 \text{ day}} * 22 \text{ blocks} = \mathbf{34.83 \text{ kg}}$$

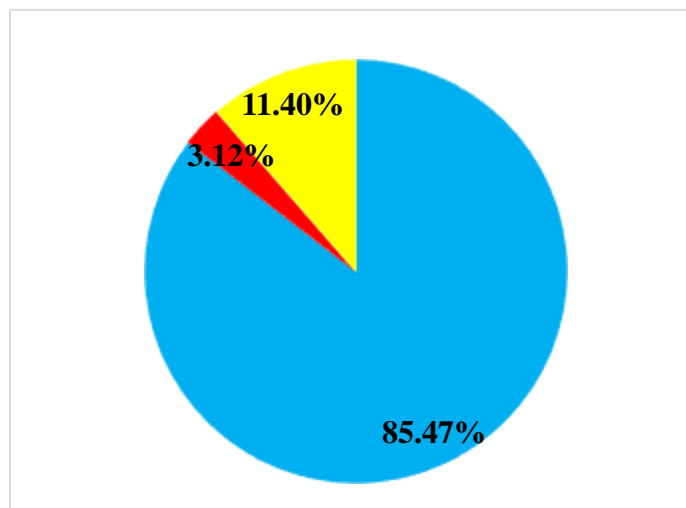


Fig.4.6: Waste Characterization in “Basha Wolde-Chilot” condominium, May 6, 2018

The waste Characterization in first collection day score 82.7% organic waste, 3.68% plastic and 13.62% other types of waste. The higher score was organic waste. On the second waste characterization day, score 85.47% organic waste, 3.12% plastic and 11.40% other types of waste. On this day also, the higher score was the organic waste. The average household Characterization in one block is 10.99kg/day of organic waste, 0.441kg/day of plastic waste and 1.625kg/day of other types of solid. This average household waste characterization into a percentage of 84% of organic waste, 3% of plastic and 13% of other types of waste.

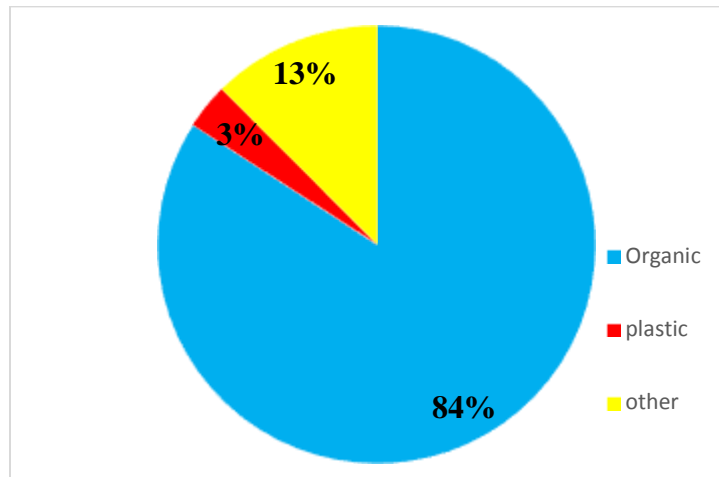


Fig.4.7: Average Waste Characterization in “Basha Wolde-Chilot” condominium

The waste collectors collect some of the waste type to recycle and reuse .To know which waste was needed by them questioner was conducted for waste collectors. According to them plastics, metal, electronics, shoes and clothe are the main waste to recycle and reuse.



Fig.4.8: Percentage of waste composition in different station (Source: Author, 2018)

4.1.2. Potential of household organic waste for landscape value

Table 4.3: Organic waste in weight (Kg)/3days at May 3 and, May 6, 2018

Block number	organic waste Kg/3days(X) in May 3, 2018	organic waste Kg/3days in May 6, 2018
Block 1	21	31
Block 2	35	42
Block 3	43	37
Block 4	25	35
Block 5	28.5	40
Block 6	29	41.5
Block 7	38	23
Block 8	29	27
Block 9	25	33.5
Block 10	30	46
Sum	303.5	356
Count (n)	10	10
Average(mean)	30.35	35.6
Standard deviation	6.60	7.18

The waste measurement was done in block level. To know the dominate waste at household level questionnaires (*see annex*) was conduct to 35 households. According to the questioner 94% of the household generate large organic waste compare to other plastic, paper, or other types of waste.

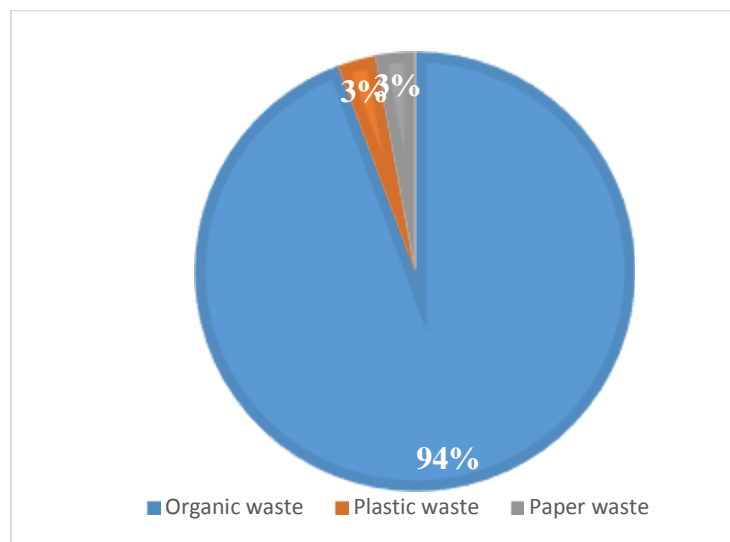


Fig.4.9: Dominant Waste at Household Level (Source: Author, 2018)

The most dominant waste at household level was the organic waste. To know the households have the awareness of the potential of organic waste for soil amendment conduct questionnaires (*see annex*) Only 23% of the respondent knowing organic waste have a potential the other 77% not have awareness.

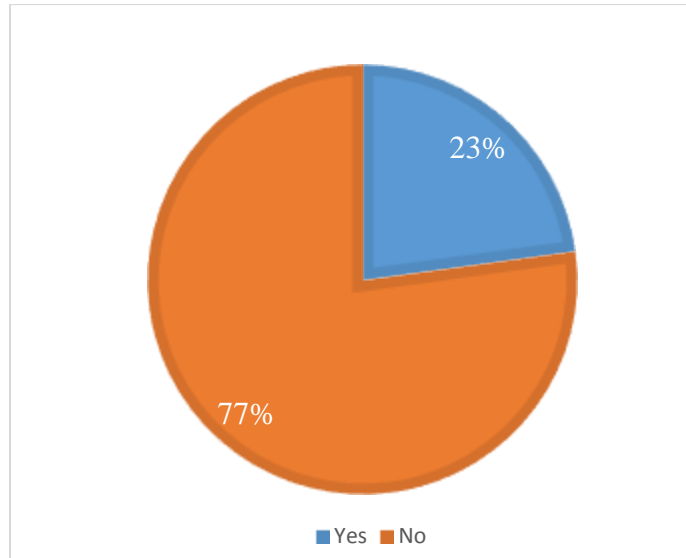


Fig.4. 10: Awareness towards organic waste have a potential for soil amendment (Source: Author, 2018)

Plants types needed by the household

To know the specific type of plant, conducted Questionnaires. The household needs

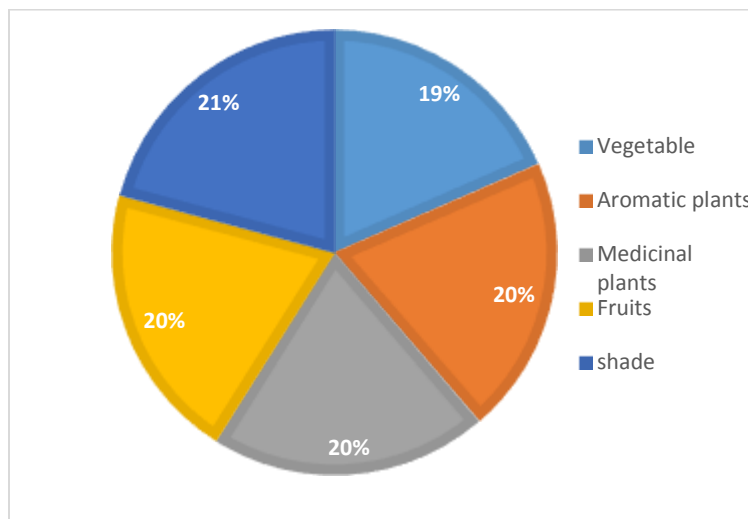


Fig.4. 11: Plants types needed by “Basha Wolde Chilot” condominium households (Source: Author, 2018)

Questionnaires (*see annex*) was conducted to know the attitude in waste separation with in the households at “Basha Wolde Chilot” condominium. Among the 35 respondents, 13 respondents separate their waste according to the site rule but the other 22 respondents not separate their waste correctly because of no awareness, Ignorance and need for more space.

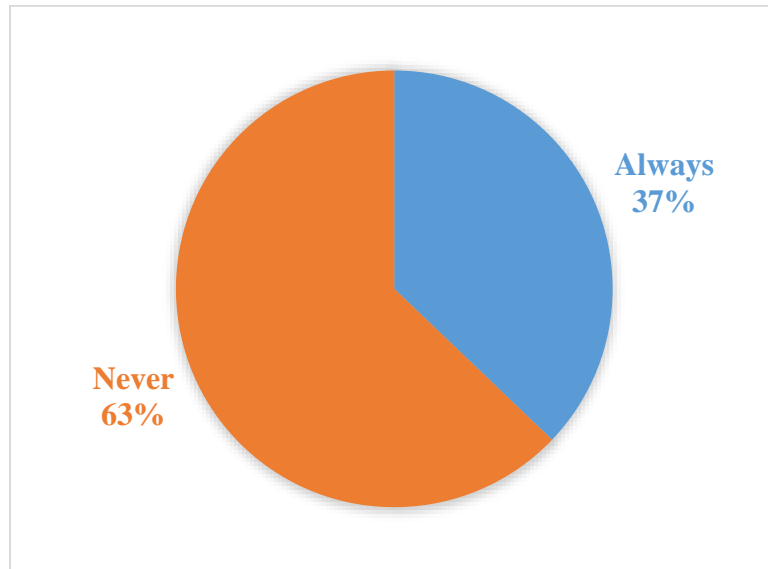


Fig.4.12: Attitude towards waste separation at “Basha Wolde-Chilot” (Source: Author, 2018)

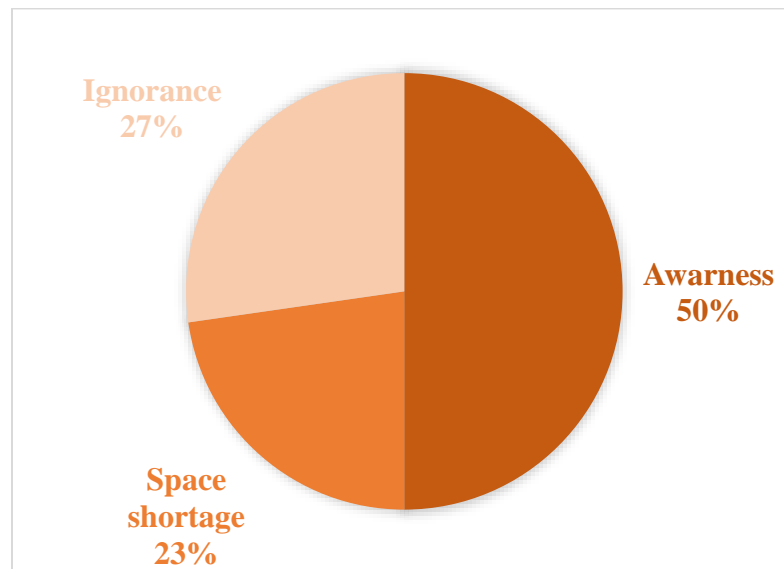


Fig.4.13: Reason for not separate their waste at “Basha Wolde-Chilot” (Source: Author, 2018)

4.2. DISCUSSIONS

4.2.1. Solid Waste management system, Household solid Waste generation, Household Solid waste Characterization

Solid Waste management system

“Basha Wolde-Chilot” condominium site follows an outdated waste management system which is simply dumping the collected waste to a landfill area. The condominium design was not considered sustainable solid waste management system. Waste management system are all the activities and actions required to manage waste from its inception to its final disposal (Irum *et al*, 2017). Lately, for one of the condominium building (*See fig. 4.1*) one volunteer was added vertical chute by metal structure. From zero waste design, the Architect should be consider the waste management at design level. Especially in large number of floor buildings provide vertical trash chute with different waste categories is the best solution. Vertical trash chute reduce waste separation and collection time, labor and pollution.

Meanwhile, the waste issues being hot, the condominium committee provide free stand waste collection (*see fig.4.2*) in one of the place in the compound. This indicates that the communities itself take measurement for create comfortable space. Sustainable communities are places that people like living in, and want to stay in, neighborhoods with real character and sense of place. These successful places should have well-designed green spaces that people will want to use and respect (Commission for Architecture & the Built Environment, 2015).

Even if the waste collected from the household separately (from Vertical trash chute & free stand waste collection) but dump together expect plastic waste. The main reason was most of the households and the waste collectors has not have detailed awareness about recycling specially the organic solid waste. If once collected the waste separately at source, it will be easier to use the waste as a resource.

Household solid Waste generation

On an average, the household waste generation in “Basha Wolde-Chilot” condominium site is 13.05kg/ days. The waste generation rate found 9kg /day (minimum) and 16.5kg/day

(maximum) at a block level this implies the amount of waste varies on many factors (World Bank, 2016). The analysis was done in block level and within a block 25 households with different family size, different religion, different culture, mixed-income, and different age. Due to all these factors, the amount of waste will be diverse.

Household Solid waste Characterization

The average household Characterization in one block is 10.99kg/day of organic waste, 0.441kg/day of plastic waste and 1.625kg/day of other types of solid waste. This average household waste characterization into a percentage of 84% of organic waste, 3% of plastic and 13% of other types of waste. The average standard deviations of the organic solid waste were highest (6.89) compare to plastic solid waste (0.58) and other types of solid waste (2.98). Standard deviation told us by how much the quantity differs from the mean value for the group and if the standard deviation is near to zero the sample does not vary from the mean value. Therefore the organic solid waste highly varies in different condition. Even if the sample takes with the same block, the waste characterization is different within a blocks as well as blocks to blocks. The waste Composition depends upon many factors such as food habits, cultural traditions, socioeconomic status and climatic condition (Enayetullah *et al.*, 2005).

Low-income countries have the highest proportion of organic waste (UN, Government of Shanghai and Bureau international des exhibition, 2010) and landfilling is a popular waste treatment method in developing countries (Pharino 2017). Therefore this high amount of organic solid waste (84%) sent to landfill site and pollute the environment in different ways.

Calculate the amount of waste generated by the whole site, 22blocks 87,048 kg/ year Organic waste, 3,492 kg/year Plastic waste and 12,852 kg/ year other waste. In each year 87,048 kg Organic solid waste sent to the landfill site. This consecutive each year. According to the World Bank (2016) report in the low-income country, the waste characterization is reduced only 2% within 13 years interval. This means the waste proportion score almost the same for the next years.

Table 4.4: Projected waste composition according to World Bank (2016) report

Waste type	2018	2019	2020	2021	2022	2023	2024	2025
organic in Kg	7254.0	7230.0	7206.0	7182.0	7158.0	7134.0	7110.0	7108.0
plastic in Kg	291.0	291.5	292.0	292.5	293.0	293.5	293.7	293.9
other in Kg	1071.0	1072.5	1074.0	1075.6	1077.0	1078.6	1080.2	1081.7
Total in Kg	8616.0	8594.0	8572.0	8550.1	8528.0	8506.1	8483.9	8483.6

4.2.2. Potential of household organic waste for landscape value

Organic solid matter from household includes mainly kitchen waste including the waste product of vegetable, fruit rinds, grass, etc. (University of Illinois, 2017). Average household organic waste in one block is 10.99kg/day; form 22blocks 87,048 kg/ year Organic waste generate which means 84% of organic waste from the total amount of waste. The site collected the organic solid waste separately but because of lack of awareness this organic solid waste dump to landfill. Composting can provide a viable alternative method for managing organic waste (S. Karnchanawong, N. Suriyanon, 2011), reduce the impact on the environment and benefit to people by giving fertilizer. (C40 Cities Climate Leadership Group, 2016).

Summary for 22 block generate

- **241.8 kg** organic solid waste in a **day**,
- **7,254 kg** organic solid waste in a **month** and
- **87,048 kg** organic solid waste in a **year**.

Household organic waste vs Compost ratio

From the literature review, to change organic waste to compost need 3month – 4month with a ratio of six kg organic waste produce one kg compost (Waltenegus W. (practicing windrow compost in EiABC)).

In every month the site generates 7,254kg organic waste and 87,048 kg within a year. According to Walteneus W. (practicing windrow compost in EiABC):

6 kg organic solid waste = 1 kg compost
--

Change the organic waste to compost in a year

$$= \frac{87,120 \text{ kg}}{6\text{kg}} = \underline{\underline{14,520 \text{ kg}}}$$

But the compost need maximum 4 month, for one year produce 10,881kg compost to the site. According to Sue E. and Hailu A.in Ethiopia context, for one hectare give a rate of 8–10 tons mature compost if they have sufficient compost material.

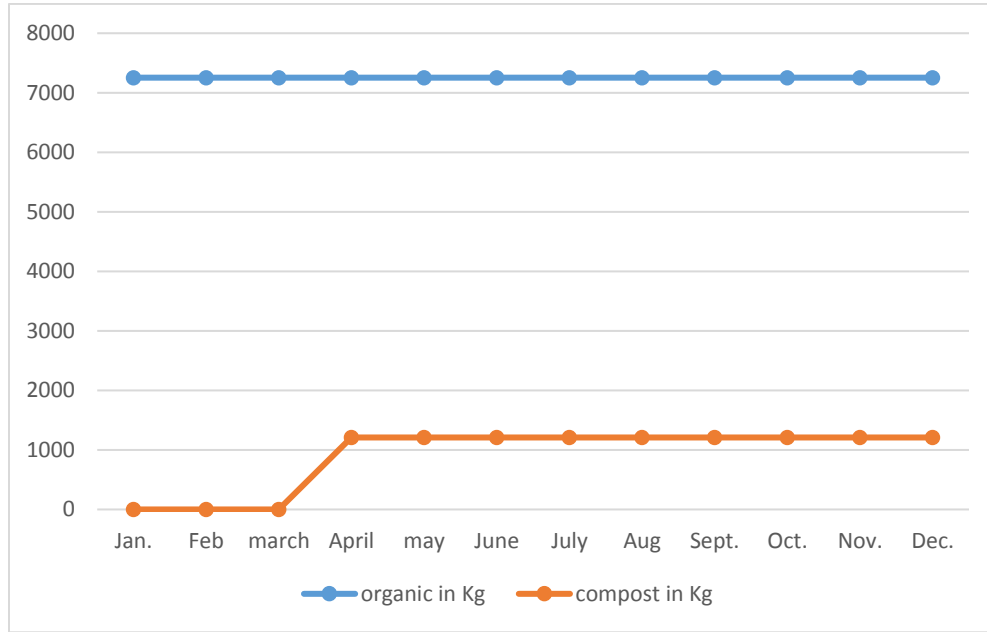


Fig.4.14: Organic Waste vs compost with in a months projected according to World Bank (2016)

1 hectare = 8 – 10 tons

1hectar= 10,000m²

1 tone = 1000 kg

10,000m² = 8,000kg – 10,000kg

1m² = 0.8 kg – 1 kg compost material

Table 4.5: Shows amount of Organic waste generation vs compost product in a years, projected according to World Bank (2016)

Waste type	2018	2019	2020	2021	2022	2023	2024	2025
organic in Kg	87,048	87,048	87,048	87,048	87,048	87,048	87,048	87,048
compost	10,881	14,508	14,508	14,508	14,508	14,508	14,508	14,508

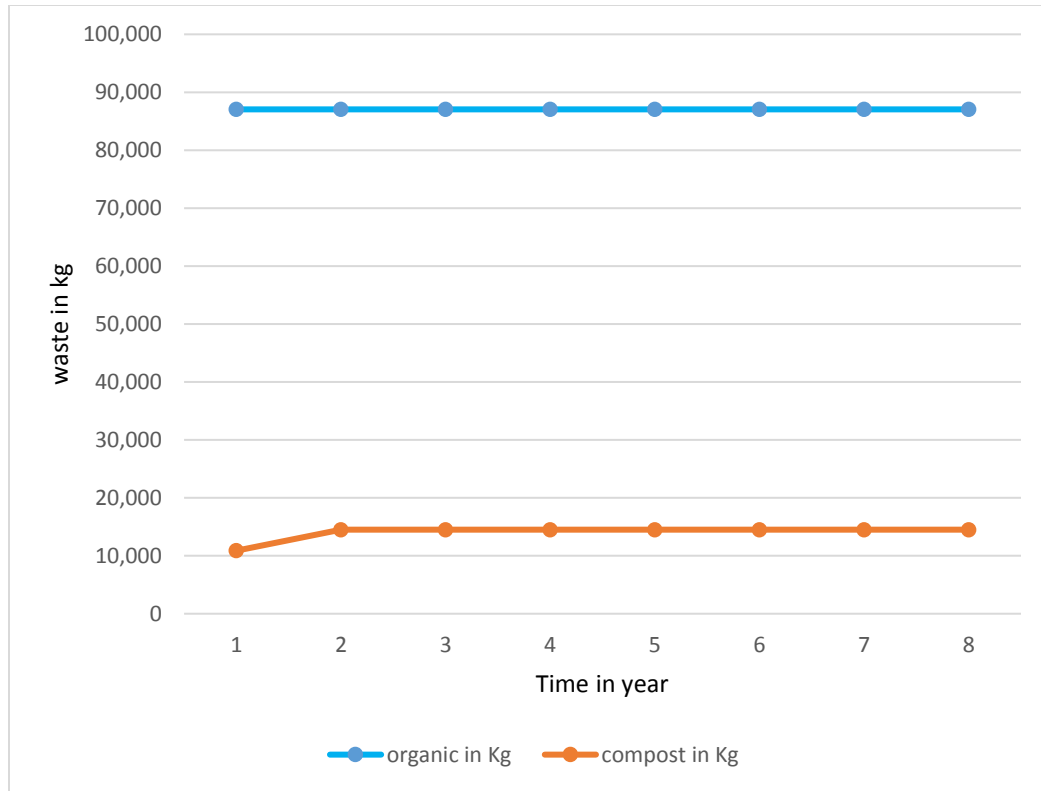


Fig.4.15: Organic Waste vs compost with in a years projected according to World Bank, 2016

In the first year, the site generates 87,048kg organic waste and this organic waste convert to compost with considering the composting time (maximum 4month) 10,881 kg produce. The next years 14,508 kg compost generate annually.

Application of compost

Soli in “Basha Wolde-Chilot” condominium site disturbed by many factors and need to restore, Compost provides significant benefits in the remediation of disturbed soils in urban (Bilal *et al.*, 2016). Using compost in the vegetable garden, or on small plots of land is very suitable (Madeleine *et al.*, 2005) especially for row planted crops, e.g., maize, sorghum, and vegetables, the compost can be put along the row with the seeds or seedlings are good. Soil given compost good effects last for more than one growing season. According to Ethiopian farmers’ report, mature compost to provide a rate of 8–10 tons per hectare can be achieved in areas where there are plenty of composting materials, good water supply and labor (Sue and Hailu, 2011).

Table 4.6: Compost production in a year, Projected according to World Bank, 2016

Type	1 year	2 year	3rd year	4th year	5th year	6th year
organic in Kg	87,048.00	87,048.00	87,048.00	87,048.00	87,048.00	87,048.00
compost in Kg	10,881.00	14,508.00	14,508.00	14,508.00	14,508.00	14,508.00
Min. compost application in m2 (1m2- 0.8kg)	13,601.25	18,135.00	18,135.00	18,135.00	18,135.00	18,135.00
Max. compost application in m2 (1m2- 1kg)	10,881.00	14,508.00	14,508.00	14,508.00	14,508.00	14,508.00

Compost has a good effect at least two growing seasons (Sue Edwards and Hailu Araya, 2011). A growing season is a year when crops and other plants grow successfully. The length of a growing season varies from place to place. Most crops need a growing season of at least 90 days (Nation Geographic, 2018). Kale, Swiss chard, carrots, cauliflower, leek, cabbage, lettuce, beetroot, and shallot are popular vegetables consumed at home in Addis Ababa (Girma).

The most effectively protect people and the environment by involving and evaluating specific local needs and conditions, and then selecting and combining the most appropriate waste management activities for those specific conditions (Environmental Protection Agency, 2002).

Attitude of Waste collectors towards organic solid waste

The waste collector is the primary participant of the management, collect the waste, transport and dump to a landfill site. In the collection stage, most of the household did not separate their trash and forced to separate at the site. They divide the waste organic, plastic, metal, and other kinds of waste. Plastic waste, metal and other waste (like old shoes, electronics...) took by themselves, and the rest sent them to the landfill site. They already separate the organic waste but none of them does not have awareness about organic waste potential.

Plant type suitable for site

The plant type needed by households are Good-looking plants, Vegetables, Aromatic plants, Medical plants, Fruits and plant for Shade. By referring the growing season of this plants uses the compost material effectively. There are plants indigenous to the country as well as plants adapted to the environment and used by the community. Common vegetable consumed by the households are Kale, Swiss chard, carrots, cauliflower, leek, cabbage, lettuce, beetroot, and shallot (Girma K.).



*Fig.4.16: Potential green space at “Basha Wolde-Chilot” condominium site and nearby,
(Source: Google map, 2018)*

Total potential green space = Green / open space in condominium + River buffer

$$= 16,317.6 \text{ m}^2 + 17,079 \text{ m}^2$$

$$= \underline{\underline{33,396.6\text{m}^2}}$$

If $1\text{m}^2 = 0.8 \text{ kg} - 1 \text{ kg}$ compost material, $33,396.6\text{m}^2$ is

$$= 33,396.6\text{m}^2 (0.8\text{kg compost}) - 33,396.6(1\text{kg compost})$$

$$= \underline{\underline{26,716.8\text{kg compost} - 33,396.06\text{kg compost}}}$$

In one year time, the site will generate 10,881kg compost materials. If covering all the potential green space without any other program this compost material covers half of the site. To cover full site with compost material need two-year compost product around 26,716.8kg compost – 33,396.06kg compost. According to (Sue and Hailu, 2011) if apply compost in the Soil it serves for two years, not need it again in the next year. The new compost can then be used for the part of the field that had no fertilizer the previous year.

Table 4.7: Shows amount of Organic waste generation vs compost product in a years, projected according to World Bank (2016)

Type	1 year	2 year	3rd year	4th year	5th year	6th year
organic in Kg	87,048.00	174,096.00	261,144.00	348,192.00	435,240.00	522,288.00
compost in Kg	10,881.00	21,762.00	32,643.00	43,524.00	54,405.00	65,286.00
Min. compost application in m² (1m²- 0.8kg)	13,601.25	27,202.50	40,803.75	54,405.00	68,006.25	81,607.50
Max. compost application in m² (1m²- 1kg)	10,881.00	21,762.00	32,643.00	43,524.00	54,405.00	65,286.00

The green space area depend on the design and maybe less than 16,317.6 m². Even if the compost material more than the site, will be apply in the river buffer next to the condominium sites.

CHAPTER 5-CONCLUSIONS AND RECOMMENDATIONS

5.1. CONCLUSIONS

5.1.1. Solid Waste management system, Household Solid Waste generation & Household Solid waste characterization

“Basha Wolde-Chilot” condominium site follows an outdated waste management system which is simply dumping the collected waste at landfill. Especially the organic solid waste. But this site start good solid waste collection system. The first system attached the condominium with two categories, the second one is free to stand waste collection with three divisions and the last one is just drop with trash bag.

On average household in “Basha Wolde-Chilot” condominium site generate 13.1kg /day with minimum waste generation rate found 9kg /day and maximum 16.5kg/day at a block level. This average household waste characterization into a percentage of 84% of organic waste, 3% of plastic and 13% of other types of waste. From the three waste characterization, the highest score is the organic fraction.

5.1.2. Potential of household organic waste for landscape value

Every year the site generate 87,048kg organic waste and this organic waste convert to compost with considering the composting time (maximum 4month) 10,881 kg produce in the first year. The next year’s 14,508 kg compost generate. Condominium site has ample open space/green space provide the housing agency for a different purpose, and most of the open space have not fertile soil because of many factors. To amend this soil structure compost is the best solution. To apply compost in 1m² area need 0.8 kg to 1 kg compost material, and this variation depends on soil type. The plant type needed by households are Good-looking plants, Vegetables, Aromatic plants, Medical plants, Fruits and plant for Shade. By referring the growing season of this plants uses the compost material effectively.

The design starts at floor level by providing a collection point and all floor will connected (vertical trash collection) at the suitable arrangement. These vertical trash collection duplicate over the blocks. After the vertical trash, design efficient movement for labor to the composting site. The composting site is placed at river buffer space to minimize the

water consumption, and there are other design parameters like slope, wind direction, etc. after 3-4 month the compost processed and ready apply to the soil. This gives soil fertility and will be producing urban farming to the community. The ecosystems service get from urban agriculture are promotes community development and education, and increases self-reliance, community health, wildlife habitat, environmental awareness and social interaction among residents.

5.2. RECOMMENDATIONS

For government policy makers:

Most of Addis Ababa Municipal Solid Waste (MSW) was organic, and much of the contributors are households. Therefore it's good the government policy force to use this waste as a potential for fertilizing and amendment of the contaminated urban soil and create a livable city.

For housing agency:

The housing agency is the responsible body to design a condominium starting from urban design to architectural design. In addition to those design, the solid waste management system must plan from the single floor, individual block to NHD design.

- Provide vertical trash(to separate different solid waste categories) in each building in design stage
- Design effective movement to transport the wastes
- Provide space for compost
- Integrate the compost to the provide green space
- Provide green space for urban agriculture

For household/ resident in condominium:

The condominium resident must separate their waste according to the provided vertical trash. After the collected organic solid waste in the vertical trash, easy to change to compost material and use for their greenery space. The household/residence advantageous.

- Have proper solid waste management
- Have compost material

- By using compost make productive greenery
- Create job for jobless household/ residence
- Get fresh food, shade,
- Ecosystem service

For Solid waste collector agency

The average household waste characterization was 84% of organic waste, 3% of plastic and 13% of other types of waste. From this three waste characterization, the highest score is the organic fraction used as a potential for landscaping. Therefore the waste collectors collect 16% of solid waste. Previously the waste collectors come in every two-day interval and after recycling the organic waste the waste collectors will come in a week or above. This means will reduce labor cost, material cost, transport cost, time and landfill space and impact of landfilling's.

5.2.1. Design proposal

From zero waste design guidelines, Architect should consider how to reduce waste during building design by provide different chute option. Source-separated organics recycling requires them to not only keep their waste in a separate container within their apartment but also to physically transport it down through the building to the area (generally the trash chute room) where the organics containers are located (O'Brien, 2018). This design proposal is to show the potential of household organic solid waste for urban agriculture by restoring and giving fertility for urban soil in condominium open / green space. The proposal include solid waste management in condominium area, designing their open space and linking to organic solid waste product (compost) to the open/green space area.

Solid waste management in condominium building

The waste collection point (Vertical trash chute) with proper waste categorization must locate in each floor without disturbing the household. The separated household solid waste collect at bottom with collection garbage.

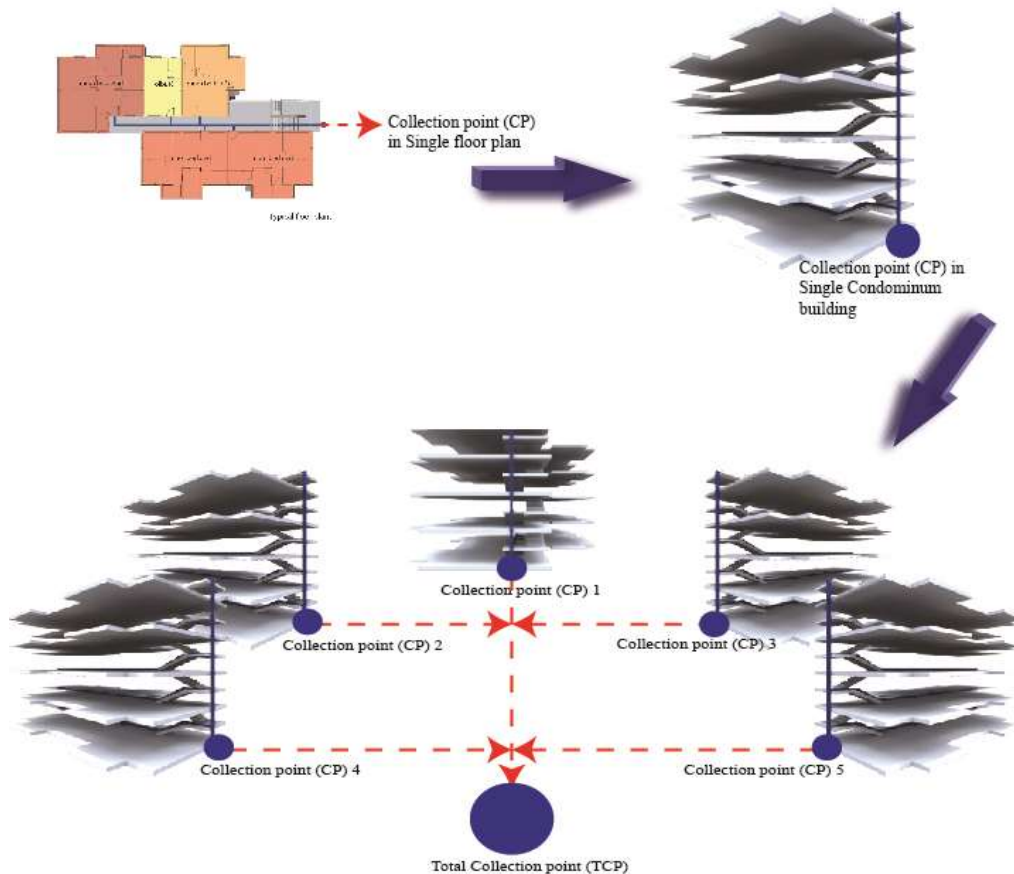


Fig 5.1: Proposed solid waste collection system for "Basha Wolde-Chilot" condominium

Collect the separating solid waste from each building with considering efficient movement and reduce labor.



Fig 5.2: Proposed movement for organic solid waste collection point for “Basha Wolde-Chilot” condominium

This thesis paper only focus on organic solid waste, the average organic solid waste in “Basha Wolde-Chilot” condominium 84% with 10.99kg/day in one block. The total collection point (compost site) located by considering wind direction, slope, and water source.

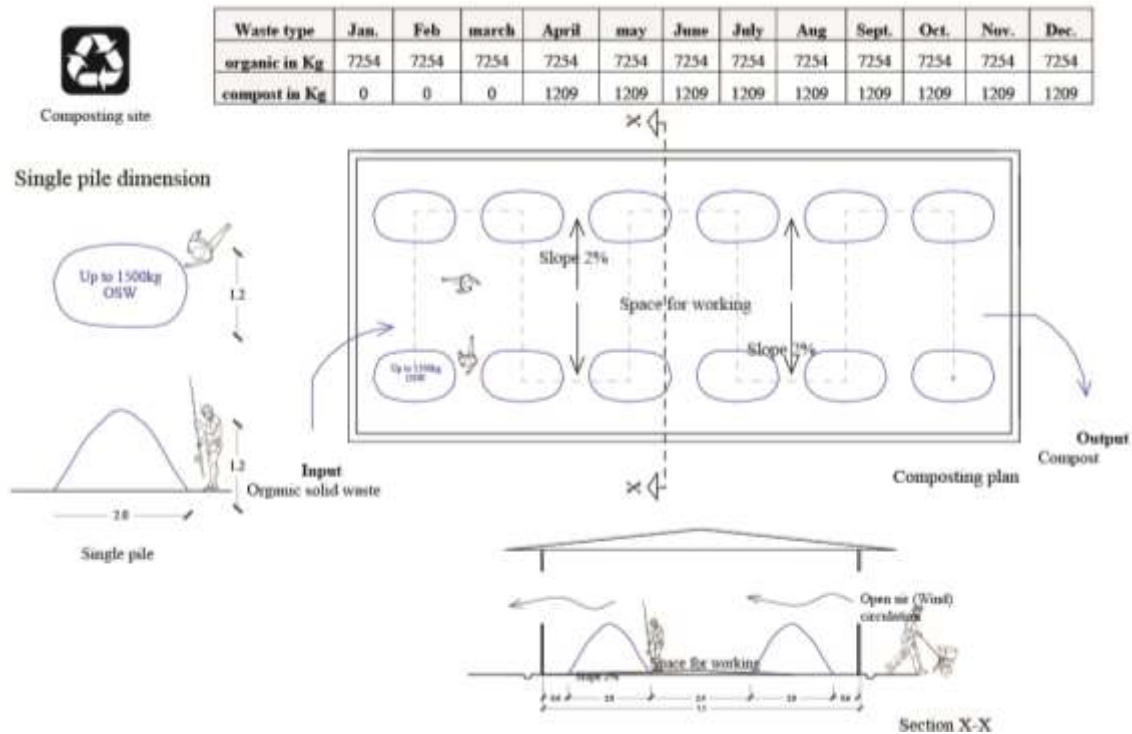


Fig 5.3: Proposed compost shade for “Basha Wolde-Chilot” condominium

Landscape design

Landscape architects can work with solid waste through transformation and re-designing of waste sites into landscapes with new function and appearance, as well as implementing prior waste products into design projects and raising awareness of the garbage-related issues among the public (Justyna & Pitchayan ,2016).



Fig 5.4: Existing Land use map of “Basha Wolde-Chilot” condominium



Fig 5.5: Existing Soil map of “Basha Wolde-Chilot” condominium

VEGETATION MAP



Fig 5.6: Existing Vegetation map of "Basha Wolde-Chilot" condominium

TOPOGRAPHY

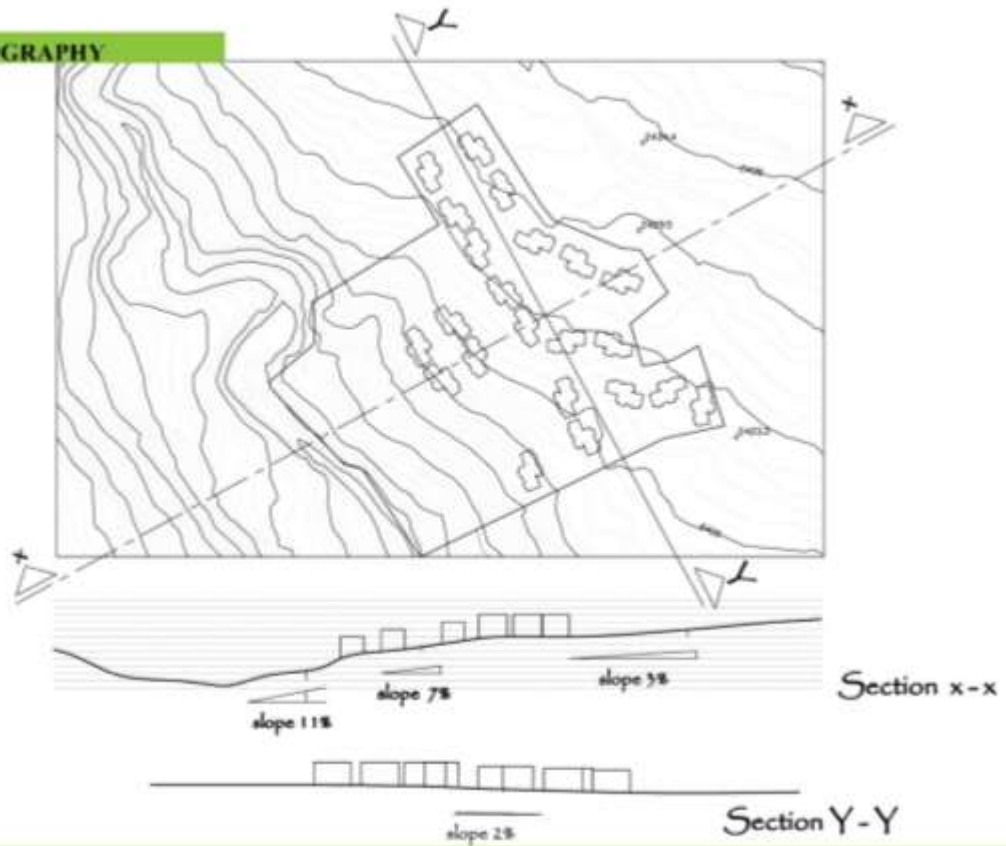


Fig 5.7: Existing Topography map of "Basha Wolde-Chilot" condominium

STORM WATER DIRECTION MAP

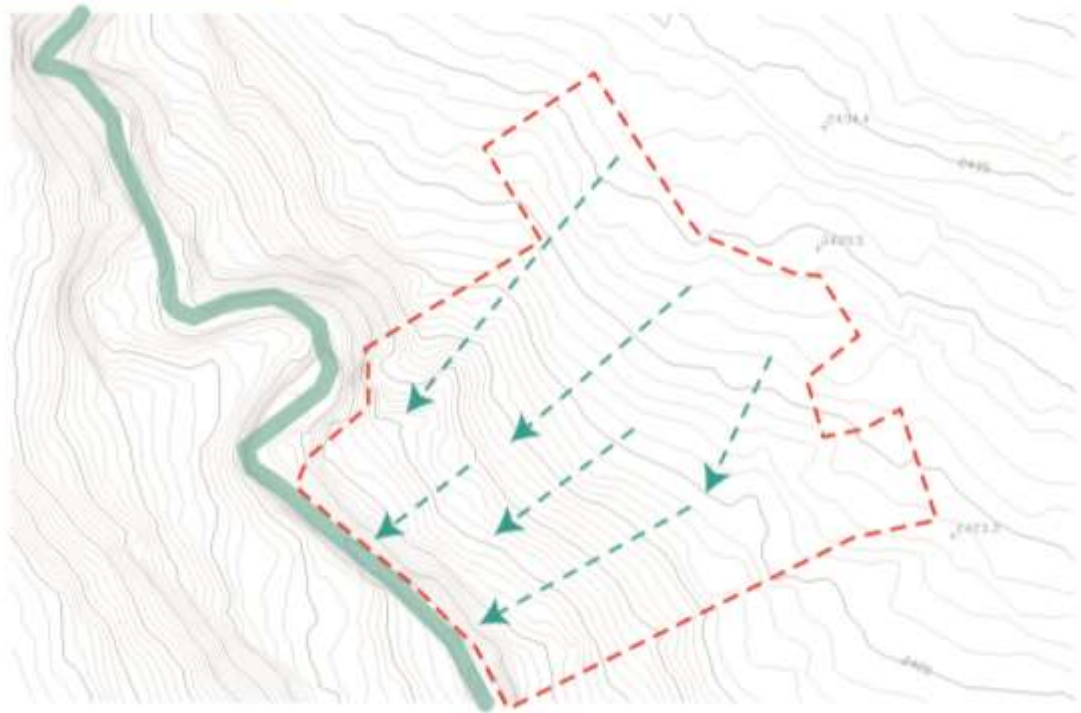


Fig 5.8: Existing Storm water direction map of “Basha Wolde-Chilot” condominium

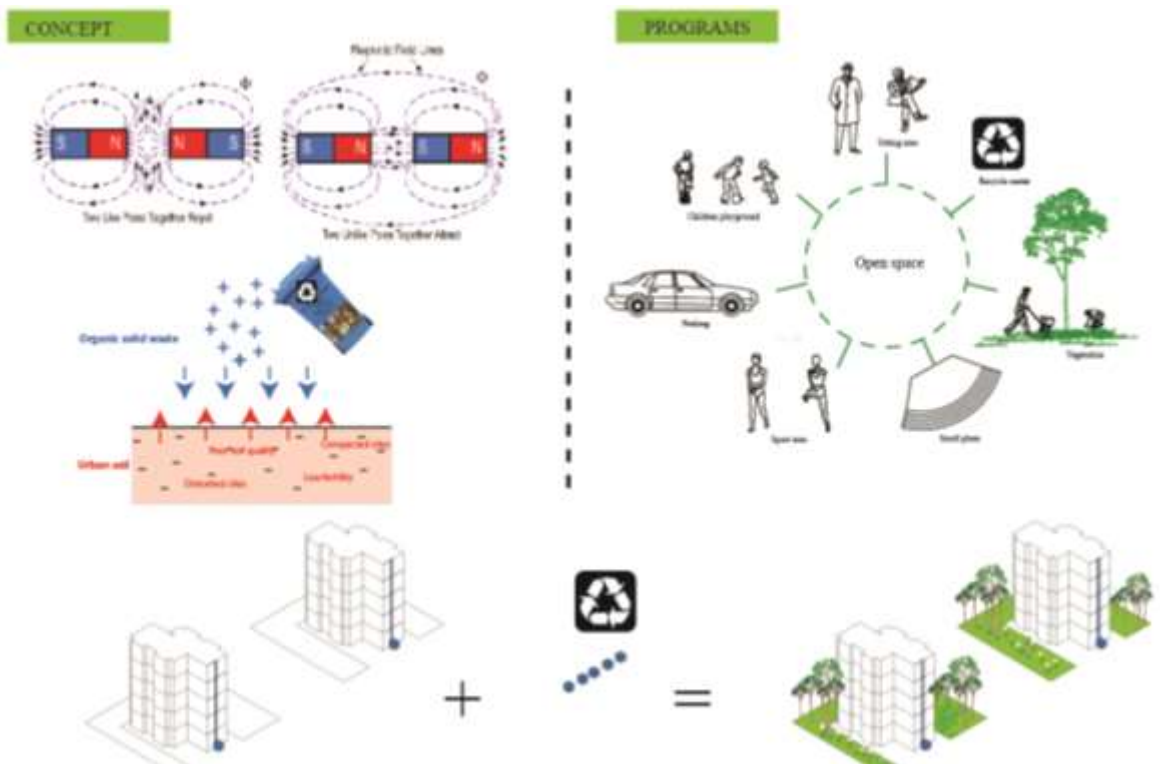


Fig 5.9: Concept diagram and program development



Fig 5.10: Zooning



Fig 5.11: Landscape design for “Basha Wolde-Chilot” condominium

Typical Functional Layout Plan

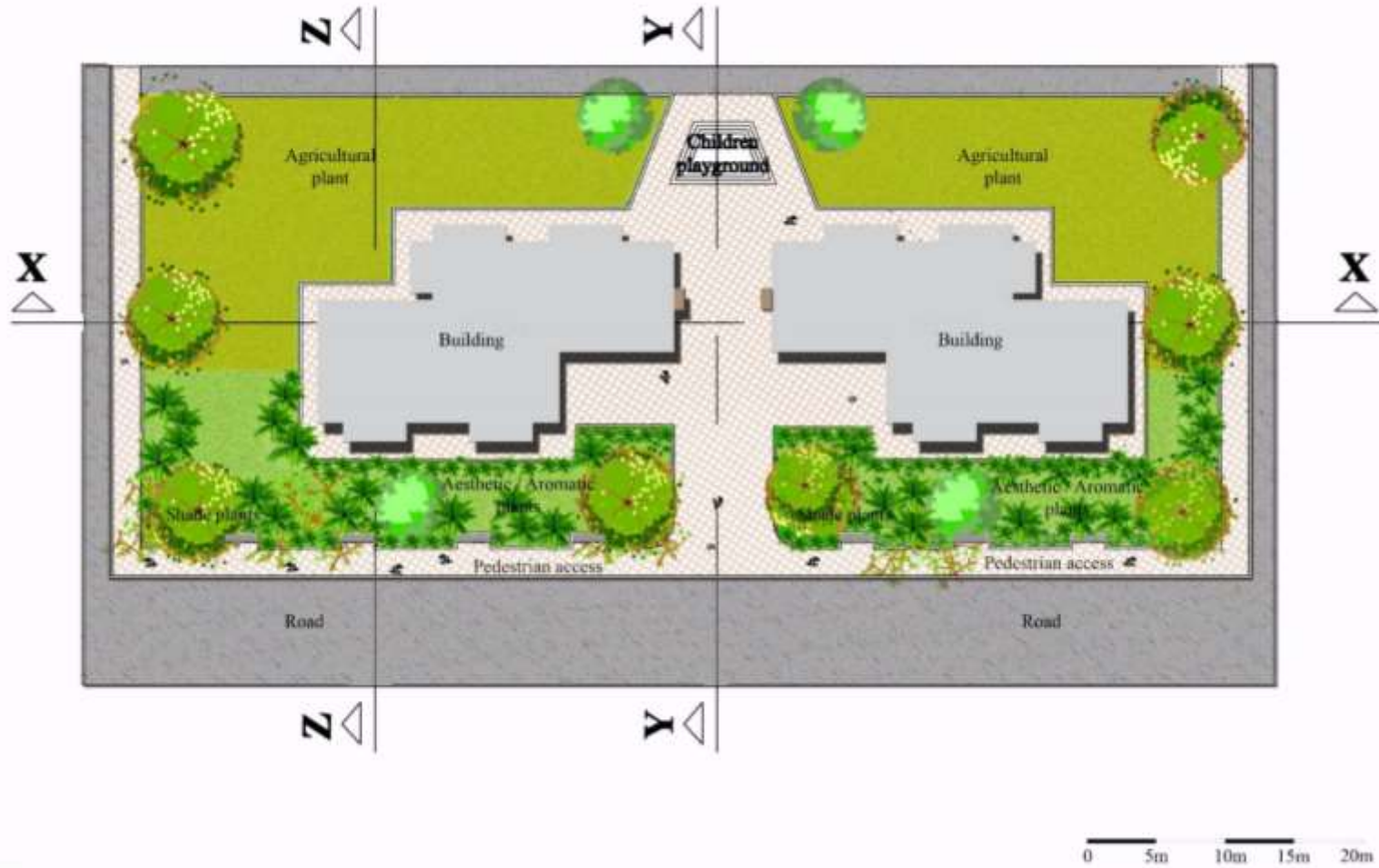


Fig 5.12: Typical functional layout plan

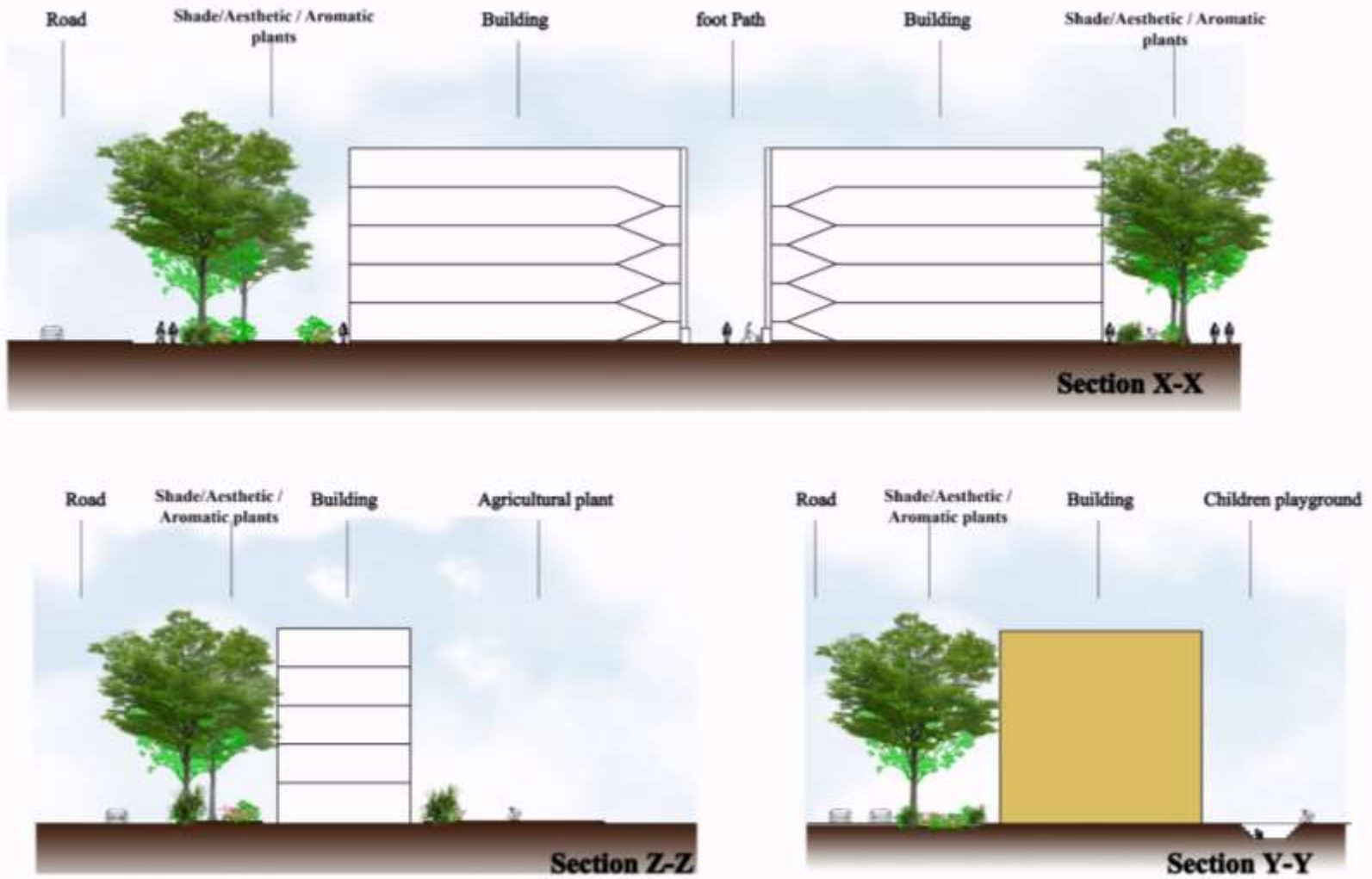


Fig 5.13: Typical functional layout sections

PLANTATION PLAN

Area for Agricultural plant

- From Condominium open space - 11,228m²
- From river buffer - 17,079 m²
- Total - 28,307 m²**

Area for Aesthetical and Aromatic plants

- From Condominium open space - 5,348m²

Area for trees and shrubs for 200 piece

- 1 piece - 0.25m²
- 200piece - 50m²

According to Sue E. and Hailu A. in Ethiopia context, for one hectare give a rate of 8–10 tons mature compost if they have sufficient compost material.

1m² = 0.8 kg – 1 kg compost material

Type	1 year	2 year	3rd year	4th year	5th year	6th year
organic in Kg	87,048.00	87,048.00	87,048.00	87,048.00	87,048.00	87,048.00
compost in Kg	10,881.00	14,508.00	14,508.00	14,508.00	14,508.00	14,508.00
Min. compost application in m ² (1m ² : 8.8kg)	13,691.25	18,135.00	18,135.00	18,135.00	18,135.00	18,135.00
Max. compost application in m ² (1m ² : 3kg)	10,881.00	14,508.00	14,508.00	14,508.00	14,508.00	14,508.00

In the first year, the site generates 87,048kg organic waste and this organic waste convert to compost with considering the composting time (maximum 4month) 10,881 kg produce. The next years 14,508 kg compost generate annually.



Fig 5.14: Planting plan

PLANTATION TABLE

Plant picture	English name	Amharic name	Scientific name	Family
Urban Agricultural plants				
	Kale	Gomso	<i>Brassica oleracea</i> var. <i>sabellica</i>	Brassicaceae
	Swiss chard	Kosta	<i>Beta vulgaris</i> subsp. <i>vulgaris</i>	Amaranthaceae
	carrots	carrot	<i>Daucus carota</i> subsp. <i>Sativus</i>	Apiaceae
	cauliflower	Yenabha gomso	<i>Brassica oleracea</i>	Brassicaceae
	leek	Yashorba kutal	<i>Allium ampeloprasum</i>	Amaryllidaceae
	beetroot	Keywoer	<i>Beta vulgaris</i>	Chenopodioidae
	Lettuce	salata	<i>Lactuca sativa</i>	Asteraceae
	Shallot	Shankurta	<i>Allium cepa</i> var. <i>aggregatum</i>	Amaryllidaceae

• For vegetation production - 28,307m²

Compost gives for the vegetation production by giving fertility, holding water for long time and give pesticide for the plants.

Compost rate: 1m² = 0.8 kg – 1 kg compost material
28,307m² = 22,645.6 kg - 28,307 kg compost material

25,476.3kg Average compost material







Aesthetical and Aromatic plants				
	Rosemary	Yaga masobola	<i>Rosmarinus officinalis</i>	Lamiaceae
	Artemisia	Arin or Chikuga	<i>Artemisia abyssinica</i>	Asteraceae
	Fringed rue	Yandama	<i>Ruta chilopactis</i>	Rutaceae
	Myrtle	Ada	<i>Myrtle bush</i>	Myrtaceae
	Aran-ily	Yemudara abata	<i>Aran-ily</i>	Araceae
	Rose	Rose	<i>Rosa abyssinica</i>	Rosaceae
	Magic Herb		<i>Cassia Spinaria</i>	Apocynaceae

• For the Establishment of Planting Bed /Aesthetical and Aromatic plants - 5,348m²

If the soil are poor quality compost amend the soil in different ways. The application rate of compost is low in soil which have good organic matter and high in poor soil quality. Sandy soil or clay soil require high compost rate.

Compost rate: 1m² = 0.8 kg – 1 kg compost material
5,348m² = 4,278.4kg - 5,348kg compost material

4,813kg Average compost material

Shade Trees				
	Eucalyptus	Belerral	<i>Eucalyptus globulus</i>	Myrtaceae
	Olea	weya	<i>Olea bush/olive</i>	Oleaceae
	Acacia	Awadi	<i>Acacia</i>	Leguminosae
	Podocarpus	Zaha	<i>Podocarpus falcatus</i>	Podocarpaceae
	Euphorbia	Kese	<i>Euphorbia abyssinica</i>	Euphorbiaceae
		salaha	<i>Phoenix dactyloides</i>	Arecaceae

•For Component as a Backfill Mix / for tree and shrubs - for 200 tree/Shrubs

For trees, compost is put in the bottom of the planting hole and covered by some soil when the seedling is planted out. It can also be dug into the soil around the bottom of a tree seedling after it has been planted.

Compost rate: 25%-50% compost mix with soil, the most common rate is 33%.

WATER SCHEME

Water: Moisture in compost process is essential. The organic matter decomposes with the help of micro-organisms (Williams, 2018) and to active and works this microorganism's moisture is essential. Composting materials should maintain a moisture content of 40–65 percent. Where the pile is too dry, composting occurs more slowly (FAO, 2003), or do not decompose (Sue Edwards and Hailu Araya, 2011). While a moisture content more than of 65 percent develops anaerobic conditions (FAO, 2003).

To get sustainable waster system trap the river and design retention pond. The river waste is filtered through different plants as well as materials. After treated the water used for compost production and compost application too.



Site plan

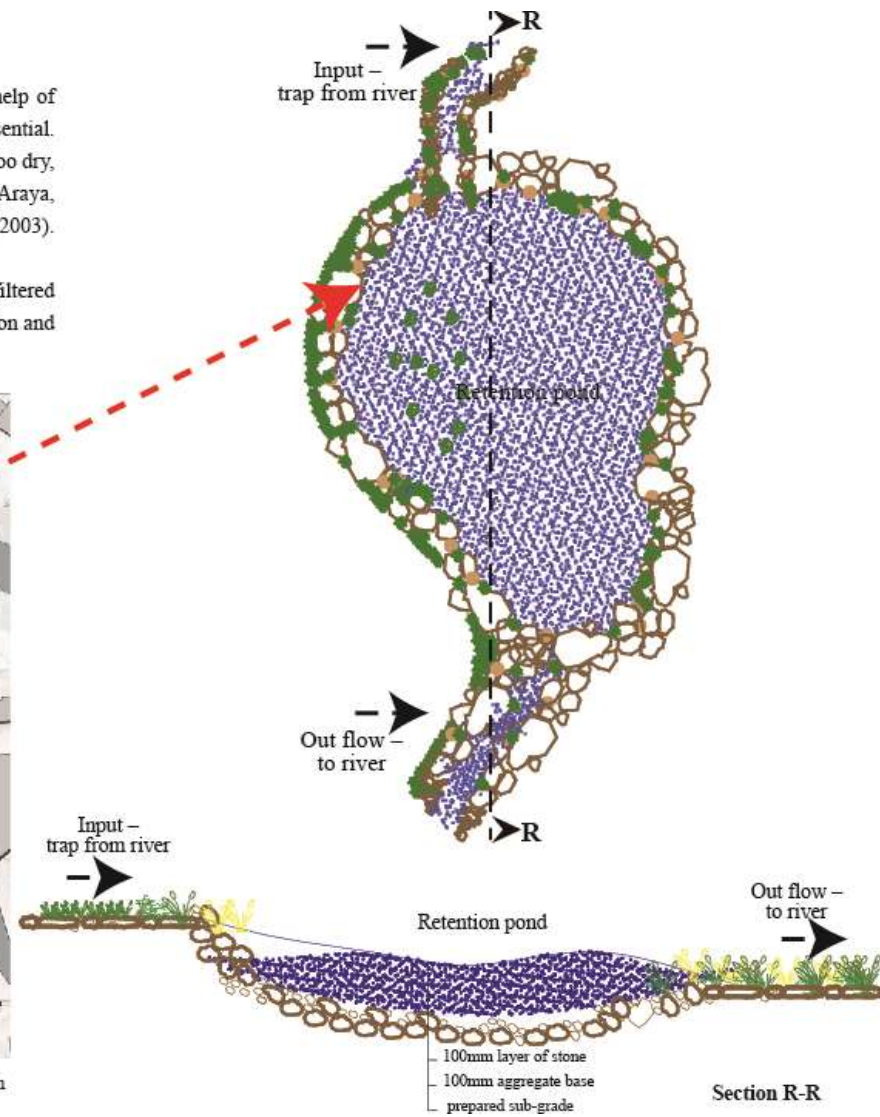


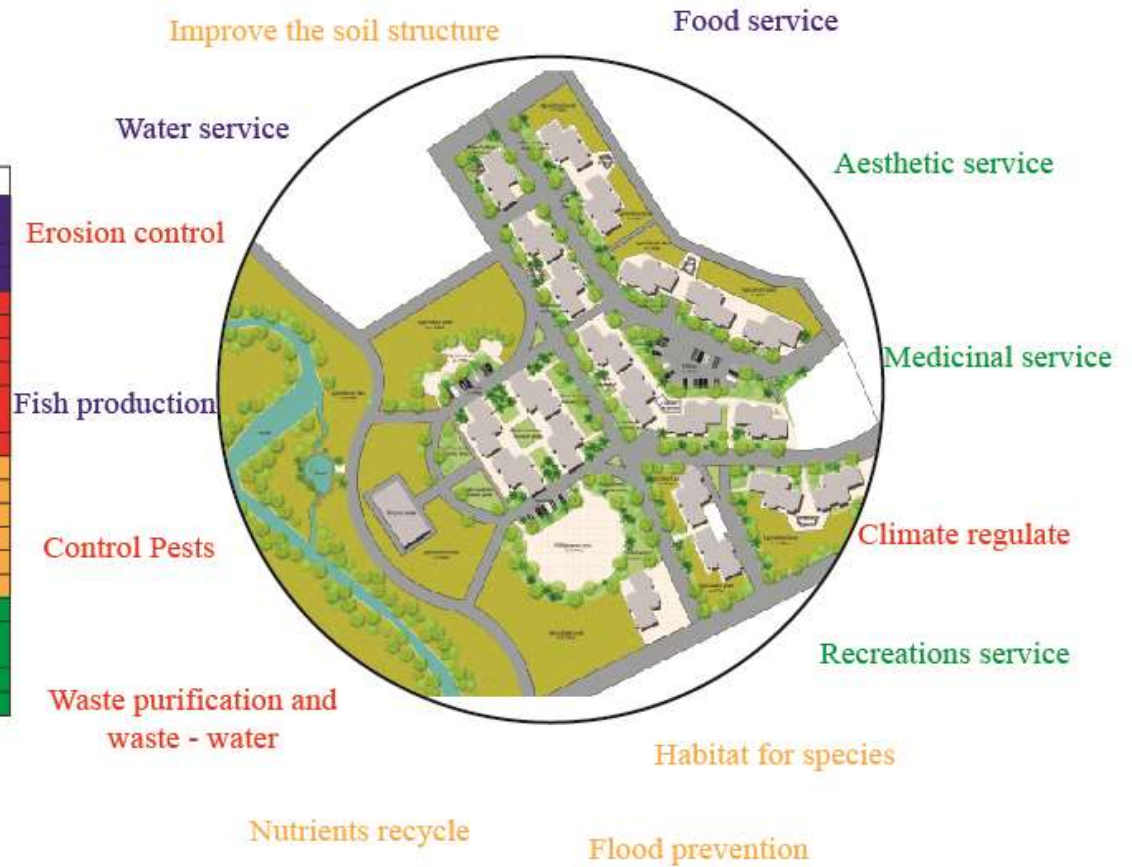
Fig 5.15: water scheme detail

ECOSYSTEM SERVICE

Ecosystem service, outputs, conditions, or processes of natural systems that directly or indirectly benefit humans or enhance social welfare (Britannica). Ecosystem service divided in to four

- Production/provision service
- Regulation service
- Supporting/Habitat service
- Cultural service

	ECOSYSTEM SERVICE	LOCATION
	Production/provision service	
1	Food service	In Urban agriculture, Retention pond
2	Water service	From river
3	Fish production	Retention pond
	Regulation service	
1	Climate regulate	From all plants, compost application
2	Flood prevention	Compost application
3	Control Pests	Compost application
4	Waste purification and waste - water treatment	In Retention pond
5	Erosion control	Compost application
	Supporting/Habitat service	
1	Flood prevention	Compost application
2	Habitat for species	In Retention pond, plants
3	Improve the soil structure	Compost application
4	Water purification	In Retention pond
5	Nutrients recycling	Compost application
	Cultural service	
1	Recreations service	Children playground, sitting space, multipurpose area, retention ponds
2	Aesthetic service	Aesthetic plants, Retention pond
3	Medicinal service	Medicinal plants



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ANNEX

This Research Question prepared for residence in condominium, to know how much knowledge about waste, waste separation and potential of waste for landscape value.

Block number.....

1. What Type of house do you have?
A. Studio B. one bed room C. two bed room D. three bed room
2. Do you have work?
A. yes B. No
3. Do you separate your house hold waste in Degradable and non-degradable your house?
A. Always B. never C. other
4. If sometimes or never, specify your reason?
.....
5. What types of waste generated?
B. Organic waste (kitchen waste) B. plastic bottle C. paper D. other E. all
6. Which one dominant waste?
A. Organic waste (kitchen waste) B. plastic bottle C. paper D. other E. all
7. Is there any practical usage of household waste in to income generating or reuse or ...?
A. Yes B. No
8. If yes what type?
.....
9. Do you know waste have potential for landscape value?
A. Yes B. No
10. If yes what kind of landscape value?
.....
11. Is there any plantation nearby?
A. Yes B. No
12. If yes, what kind of urban agriculture?
.....
13. What kind of urban agriculture need by the community do you need?
A. Vegetable B. Aromatic plants C. Medicinal plants D. Fruits E. All
14. Are you willing to participate to urban agriculture?
A. Yes B. No

Thank you

This Research Question prepared for waste collectors in condominium, to know waste type and amount, waste needed by them and to know where was gone.

1. How many years in this work?

.....

2. What types of waste generated by the community?

A. Organic waste (kitchen waste) B. plastic bottle C. paper D. other

3. Which one dominant waste?

A. Organic waste (kitchen waste) B. plastic bottle C. paper D. other

4. At what interval do you collect the waste from household?

A. 1-3days B. 4-7days C. 7-15days D. other

5. What amount of waste collect from this condominium site? In local measurement (“madaberia”)

.....

6. In which month the maximum and minimum waste generate?

.....

7. If you know the reason please specify?

.....

8. What are factors affects household waste? Please specify?

.....

9. Is there any deference(in waste type ,amount,...) in condomium area and other single stories buildings

.....

10. Which types of waste if needed by you?

A. Organic waste (kitchen waste) B. plastic bottle C. paper D. other

11. Where dump the collected waste?

.....

12. At what interval the Government trucks come and take the waste? And where is the final dump site?

.....

Thank you