



# **Evaluation of Selected Addis Ababa Buildings with respect to the Green Building Features**

M.Sc. Thesis in Environmental Planning and Landscape Design

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**DECLARATION**

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

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## **LISTS OF ACRONYMS**

<b>A.A</b>	Addis Ababa
<b>AAU</b>	Addis Ababa University
<b>AAWSA</b>	Addis Ababa Water and Sewerage Authority
<b>BREEAM</b>	Building Research Establishment for Environment Assessment Method
<b>CAD</b>	Computer Aided Design
<b>CASBEE</b>	Compressive Assessment System for Built Environment Efficiency
<b>CBD</b>	Central Business District
<b>DGNB</b>	German Sustainable Building Council
<b>DNA</b>	Deoxynicoaucie acid
<b>DPC</b>	Damp Proof Course
<b>EcoSan</b>	Ecological Sanitation
<b>EiABC</b>	Ethiopian institute of Architecture, Building Construction and City Development
<b>EPA</b>	Environmental Protection Authority
<b>FGD</b>	Focus Group Discussion
<b>GHG</b>	Green House Gases
<b>IBCC</b>	Inter Board Committee of Chairmen
<b>KII</b>	Key Informants Interview
<b>LEED</b>	Leadership in Energy and Environmental Design
<b>MoH</b>	Ministry of Health
<b>NGOs</b>	Non-Governmental Organizations
<b>QPCR</b>	Quantitative Polymerize Chain Reaction
<b>SBS</b>	Sick Building Syndrome
<b>UNICEF</b>	the United Nations Children's Fund
<b>VOC</b>	volatile organic compounds
<b>WHO</b>	World Health Organization

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## **ABSTRACT**

The green building movement originated from the need and desire for more energy efficient and environmentally friendly construction practices. Green building also brings together a vast array of practices, techniques, and skills to reduce and ultimately eliminate the impacts of buildings on the environment and human health. Green building often emphasizes taking advantage of renewable resources.

Nowadays it is hard to argue that existing buildings of Addis Ababa show such considerations to the environment or natural resources. Due to architectural experiments made to resemble the buildings in western world, our buildings have lost their identity and integrity. We witness buildings built from western building materials that are not suitable for our country. These materials cause glare and unwanted heat. Because they lack the integration between greeneries and infrastructures, the Addis Ababa buildings are faced with penetration of dust and smoke in the indoor spaces. These, as a result, have led most of the buildings to be considered unsustainable and uncomfortable.

This research paper mainly assesses the nature of the selected buildings in terms of building orientation and location, functional layouts, indoor environment quality, energy consumption, water consumption, waste management and building material and finds out how to adopt the green building theories and concepts to the sampled buildings.

The paper is pioneer research clearly showing the issues related to the nature of existing selected buildings found in *Bole, Arada, Kirkos and Lafto* Sub-city. Both descriptive and explanatory research method were used and also mixed type of quantitative and qualitative data were collected from primary data source and from secondary data source through reading and note-taking, scanning and photocopying, browsing and extracting trusted web sites. Software like Ms Word, Ms Excel has helped into interpreting the raw data into useful information and also Auto Cad 2007 and Archi Cad 15 have helped in making illustration. Additionally, Photoshop CS5 and Adobe illustrator 5 were used to enhance the qualities of the illustrations.

By using the methodology described above it was found that most of the sampled buildings had problems in their indoor environment quality, over consume energy, are indifferently laid out functionally and have disorganized waste management system compared to green buildings. Finally possible remedial solutions were given based on Environmental planning and Landscape design.

**Key words: Green Building, Sustainable building,**

## CHAPTER I: INTRODUCTION

Green building refers to a structure that uses the process that is environmentally responsible and resource-efficient throughout a building's life-cycle: from siting to design, construction, operation, maintenance, renovation, and demolition. It often emphasizes taking advantage of renewable resources (Plainiotis, 2006). Using sunlight through passive solar, active solar and photovoltaic equipment, and using plants and trees through green roofs, rain gardens, and reduction of rainwater run-off could be considered as examples of the taking advantage of renewable resources (Hopkins, 2002). Many other techniques are used, such as using low-impact building materials or using packed gravel or permeable concrete instead of conventional concrete or asphalt to enhance replenishment of ground water.

Although new technologies are constantly being developed to complement current practices and may differ from region to region, green building are constantly persist of fundamental principles: Siting and Structure Design Efficiency, Energy Efficiency, Water Efficiency, Materials Efficiency, Indoor Environmental Quality Enhancement, Operations and Maintenance Optimization, and Waste and Toxics Reduction. The essence of green building is an optimization of one or more of these principles. Also, with the proper synergistic design, individual green building technologies may work together to produce a greater cumulative effect.

Coming to our country, Ethiopia, construction is rapidly taking place in many aspect of development. Buildings as part of this development movement play a crucial role in maintaining sustainability in which our buildings are lacking these concepts, especially in Addis Ababa. In order to avoid serious environmental hazards these buildings (both the futuristic and existing) should consider the use of renewable energy, recycling of water, managing the produced waste and considering building materials suitable to the conditions of our country. In order to accomplish such standards of green buildings, each buildings of Addis Ababa must be contextualized to their respective site and can be exemplary as most of the constructions are taking place in the city. But, unfortunately, globalization has influenced the characters of Addis Ababa's buildings. Most of the buildings characterize the designers view rather than what the site demands and what the society needs. This injustice abuses the environment by not responding to areas that need conservation (special features on given sites like endemic plants or special resource underground that should not be contaminated by built up mass) and protection. Now, Addis Ababa has more than thousands of buildings that are mostly built in this manner. This concrete jungle has replaced and compromised most of our open/green areas because of the growing demand of infrastructures (mostly shelter) as a result of the increase in population.

Generally, this document contains of six chapters. The **Chapter I** will try to clarify the subject matter. It will also contain the background, the problem statement, the objective, the research question and the scope and limitation.

**Chapter II** will discuss clearly the methodology of how the research is conducted. **Chapter III** is where the existing situations of the buildings are discussed. This chapter will explain the existing situation of the selected buildings. **Chapter IV** in detail discusses the comparisons

between the assessed buildings and green buildings and among themselves and also the finding in chapter III will be analyzed in this chapter.. **Chapter V** is the section where possible remedial solutions are given. On the last chapter, **Chapter VI**, conclusion and recommendations will be provided.

## **1.1 BACKGROUND OF THE STUDY**

The building shelter consumes one sixth of world's fresh supply of water, one quarter of its wood harvest and two fifth of its fossil fuel and manufactured materials (Wines, 2010).

What we do to our environment, ultimately we do to ourselves. Our buildings damage nature. Each house produces, on average, 1 ton of climate- changing CO<sub>2</sub> each year. Building materials comprise some 70000 chemical products, everyone with a pollution history: the more synthetic, the longer the history (Christopher, 2002). With these critical points clearly stated, we should note that starting to heal environment starts not only by planning to improve the buildings built in the future but also by improving the already built buildings and turning them from ' Grey field sites' into 'Green field sites'. In order to bring forth change, throughout the era of civilization, there were many proposals on sustainability assessment. LEED (United States and Canada), Agenda 21, IPCC Fourth Assessment Report, UNEP and Climate change, FIDIC's PSM, GHG Indicator, BREEAM (United Kingdom), DGNB (Germany) and CASBEE (Japan) are some of the examples of the systems used to rate a sustainable building. And the most recent developments have given rise to Principles of Green Building.

Green building features include the use of renewable energy and recycling of water. Also it gives priority to inhabitant by providing a comfortable indoor environment that increases productivity. The building materials of green building are those considerate of the environment

A green building indicates society's level of development towards attaining sustainable environment. A step in the direction of sustainability could only be attained if people are aware of the damages careless trend of construction is causing.

Green building connects many professionals. But majorly, Architects and planners play an important role in Green building principles. Good designers and planners consider the environment and know how to protect it and also use it wisely. As Bacow(1995) clearly stated in his book, good designer (that designs for sustainable environment) considers promoting public, health, safety and welfare; making a city work better, not just look better , reducing the long term life cycle of operating and maintaining buildings infrastructure and site within the building environment. In addition, a good design promotes economic growth and good community interaction. This in turn encourages sustainability to be attained within the city.

In our country, academicians have played an important role in universities by giving lectures on sustainability for young designers that will build the future Ethiopia. These lectures and researches are mostly about those buildings that are yet to be built in future. But no proposals or schemes have been boldly suggested to heal the existing buildings that are mainly responsible for the present environmental condition of our country. Even though the proposals to improve the existing buildings of the capital are crucial in the country's struggle to achieve

sustainability, there are no implications that prove there are applications of remedial green building features onto the buildings of Addis Ababa.

Buildings are being built rapidly in our country. In Addis Ababa, buildings are being constructed in noticeable and swift speed. Taking *Laphto* Sub-city as an example, most of the buildings that have been built in the Sub-city were G1 and G+2 which served mostly for residential purpose. After the construction of Ring Road that stretched from *Ayer Tena* to *Maseltegna* (around Akaki) was finished in 2003 the characters of the buildings that were proposed were changed too.

Buildings that followed the main road were strictly to have four and greater floors with mixed functions. In an informal interview held with one of the officials of *Laphto* Sub-city, Ato Getachew Hailu, it was clear that until 2003 the buildings that were given permission to be built were residential buildings. After 2003 condominiums and multistoried apartments started to develop in major areas throughout the Sub-city. Now, it is estimated about 40 building permits are given per month in *Laphto* Sub-city on average. And from those 40 permits almost 30% are above G+4 buildings. This gives us an overall idea of how many buildings are being built within a year within a Sub-city.

The other Sub-cities are also faced with such numbers on monthly basis. And the more buildings with global context are being built, the more the environment is exploited due to lack of consideration to the city's site context. The long historical nature of our country's buildings following that of the western culture is a sure way of reaching the same dead end circumstances of unsustainable and unbalanced hazardous stage of degradation that the western world has already reached. Thus, to avoid such unfortunate fate, the existing buildings of our capital must be renovated according to the green building principles that are remedial solutions guaranteeing sustainability.

## **1.2 STATEMENT OF THE PROBLEM**

The Constitution of the Federal Democratic Republic of Ethiopia sets the overall environmental values to be preserved and protected under the Environmental Objective of 92(sub-articles 2&4). But, the uncontrollable rate of urban population growth in the country has damaged the environment by degrading the resources found on it. Additionally, the misuse of resources in rural and urban areas leads to different environmental degradation. Buildings, both in urban and rural, misuse the quality and quantity of sensitive resources. With the ongoing rapid construction dynamics, our city is prone to such degradation.

Nowadays, there are many improvements in constructing sustainable buildings. Many initiatives and experiments have been taken in order to make buildings to be built in the future sustainable and durable. This concept is poorly applied on the currently being built buildings in Ethiopia particularly in Addis Ababa.

Currently rapid road constructions are being carried out in urban centers of Ethiopia mostly in Addis Ababa. Following this road construction multistory and multi functioning glazed buildings are being built along the roads. These collections of buildings alongside of the road have

caused for the formation of urban heat island. The temperature is higher around those buildings as areas are dominated with impervious parking lots and paved walkways. Multi storied buildings which are situated next to wide vehicular roads are suffering from noise pollution, vehicular smoke pollution and dust particles, lack of privacy and discomfort due to increase in CO<sub>2</sub> from smoke. Greeneries that can sequesterate CO<sub>2</sub> produced due to urbanization are being degraded and altered to more build up masses because of population pressure.

Curtain walls which had been used in western world to let in sufficient light to their buildings are invading our high-rise buildings as fashionable construction material. Although Addis Ababa does not have problem of receiving sufficient natural light all year round, curtain walls are being used as finishing material redundantly. This unnecessary usage of glass has caused glare and entrapment of unneeded heat. Green house effect is the gradual result of the un-proportional application of Curtain walls in our country. And the extra energy used to cool such interior spaces has increased the overall energy consumption of the buildings’.

The other problem one comes across while overseeing the characters of buildings in Addis Ababa is that they are simply abandoned units that are functional only in the inside. But externally they do not compliment the environment or their aesthetics is somewhat alien when we look at them from nature’s point of view. They do not merge into the environment or emerge from the environment. There is no anchoring natural element that connects the buildings to the ground they are built on.

Therefore, researching the contextual aspect of buildings in Addis Ababa towards the natural environment and proposing green building concepts, which this research paper is aimed to address, is very important.

### **1.3. OBJECTIVE**

#### **1.3.1 GENERAL OBJECTIVE**

The main objective of this research is to find out the nature of the selected buildings based on the Green Building framework and also to recommend possible remedial solutions to the selected buildings based on Environmental planning and Landscape design.

#### **1.3.2 SPECIFIC OBJECTIVES**

1. To assess the current nature of buildings that are selected as case studies in terms of building layout, indoor environment quality, waste, energy and water management and building material.
2. To compare the assessed buildings’ nature among themselves and generally with Green buildings.
3. To examine and adopt the key issues involved in providing Green Building theories to the sampled buildings
4. To recommend possible remedial solutions based on environmental planning and landscape design.

## **1.4. RESEARCH QUESTION**

What is the nature of the selected buildings with reference to the Green Building frame work and how to provide remedial solution based on Environmental planning and Landscape design? Is the principal research question which was addressed in this research.

The specific research questions that were addressed:

1. What are the current situation of buildings to be selected as case studies in terms of their layouts, indoor environment quality, waste management, water consumption, energy consumption and building material?
2. What are the natures of the assessed buildings when compared among themselves and also with Green Buildings?
3. What are the key issues and theories of Green Buildings to be adapted to the sampled Buildings?
4. What are the possible remedial solutions that can be applied based on environmental planning and landscape design?

## **1.5. SCOPE AND LIMIATION OF RESEARCH**

### **1.5.1. SCOPE OF THE RESEARCH**

The spatial scope of the research paper is confided within the Addis Ababa city only focusing in *Bole, Kirkos, Lafto and Arada Sub-cities*.

Though Green Buildings Theory states many issues , this paper's thematic scope is limited to : Buildings' situation and orientation; Building function and description; Testing for indoor air quality (Temperature, Windows and light, Orientation of buildings, Efficiency of employees and residents); Energy Consumption; (Renewable energy; Energy efficient items; Energy consumption of items) Waste management, Water consumption; Building material and its durability.

### **1.5.2. LIMITATION OF THE RESEARCH**

Basically, the limitations while doing this research includes, absence of previously done research on Green Buildings adapted to buildings in Addis Ababa; lack of timely updated data that are relevant to the research; since the idea of Green Building is new relatively, while conducting such research it needed the collaboration of organization that may longer collected data formally and on time.

## **1.6. SIGINIFICANCE OF RESEARCH**

The ultimate aim of a research is to contribute in some way to the existing knowledge we have in the field of Architecture and Environmental sustainability.

This research is important because this is a relatively a new idea that could potentially fill the gap between sustainable environment and energy consumption. And more importantly it tries

to answer what the difference between the trend of building and designing in Addis Ababa and the Green Building theory of building.

This research paper will have its own significance as an academic input, social transformation, economical development and technological improvement. The outcome of the research depends on the facts collected from up dated resources and current situations. This in turn will add to reliability of the information gathered.

Academically this paper can be used as pioneering ground to professionals and other individuals whom in the future may establish too deeply conduct further researches related to the topic.

## CHAPTER II: METHODOLOGY

Research Methodology is the path to find answers to a research questions. It is a practical step through which a researcher must pass in his/her research journey in order to find answers to his/her research questions (Kumar, 2005).

### 2.1 TYPES OF RESEARCH

This research consists of both descriptive and explanatory research types. Descriptive research type tries to describe a certain problem, phenomenon, or a situation systematically to simply to provide information about the living condition. Whereas explanatory type of research is used to explain the how and why there is an existence relationship / interdependence between two or more aspects of a situation.

The Mixed types of quantitative and qualitative approaches were used under the two structures of inquiry modes:

**Structured approach:** The first inquiry mode used was the structured approach in which everything that forms the research process, objectives, design, sample, and the questions planned to ask the respondents was predetermined. This approach was applied to determine the extent of a problem, issue or phenomenon by quantifying the variation.

**Unstructured approach:** This approach allows flexibility in all aspects of the research process. It was selected to more appropriately explore the nature of a problem, issue or phenomenon without quantifying it. The main objective was to describe the variation in a phenomenon, situation or attitude which included the description of an observed situation, an account of different opinions of different people towards an issue.

### 2.2 TYPES OF DATA & MATERIALS

The types of data and materials used in this research helped in figuring out what the major problems of the study area are and also in filtering the causes in hierarchical value.

#### 2.2.1 PRIMARY DATA

These include the Problem, Interest and the Attitude of the residents toward their living and working conditions which includes waste management (sanitation), water resource, energy consumption, and living comfort.

#### 2.2.2 SECONDARY DATA

These include written literature in the fields of sustainable environment, green building and other collateral data that were of great help to the research. Also utilities and infrastructure facilities: maps showing infrastructure distribution; drainage maps and toilet facilities; and other illustrations were used to better understand the research at hand.

## **2.3 DATA SOURCES AND COLLECTION TECHNIQUES**

The research relied on the data collected from Related Literature Reviews, site visits and observations, sample survey. Since the concept of Green Building is relatively new to our country, it was necessary to rely upon internet search on legitimate web sites.

Focus groups discussion consisting of fellow colleagues that had worked on the title of sustainable environment or green infrastructures was of great help to understanding the issue at hand.

### **2.3.1 PRIMERY DATA SOURCE AND COLLECTION TECHNIQUES**

Personal observation and experiences; *building occupiers, owners* and managers, the residents in the study area, concerned government officials and professionals were the main sources of the primary data. The following data collection methods were used to collect these primary data:

#### **2.3.1.1 PHYSICAL OBSERVATION METHOD**

Own direct observation is used through taking photographs of the study site aided with field notes.

#### **2.3.1.2 CONTACT METHOD**

Key Informants Interview (KII) was used for gathering descriptive information from *building occupiers, owners* and managers.

#### **2.3.1.3 SURVEY METHOD**

Both direct and indirect approach questions were used with the aid of Structured Surveys (using predefined lists of questions in which all respondents were asked in the same way) and Unstructured Surveys (by probing the respondents and guide the interview according to their answers).

##### **2.3.1.3.1 SAMPLING FRAME AND UNITS**

The frames that were used to limit the number of samples that are taken under consideration were as follows.

1. The buildings to be assessed are to be within the sub city of *Arada, KirKos, Bole* and *Laphto* Sub Cities
2. Buildings with high land value following main road
3. Buildings having flat roof, the roof ranging from 0 - 2% slope
4. If the buildings assessed are purely apartments, at least one side of the building must consist of balconies and the apartment roof should be  $\leq 10\%$
5. Mixed use buildings, institutional buildings, apartment buildings, shops and governmental buildings (service giving or rentals) must be included in sample survey to

analyze the different level of consumption and production of buildings of different type of function.

This framing technique helps to limit not only the number of buildings that are within the Sub Cities sub city but also facilitates us to focus and centralize our attention on the objective the paper plans to accomplish.

#### **2.3.1.3.2 SAMPLE SIZE AND SAMPLING TECHNIQUES**

Purposive random sampling was used to select different buildings with different functions. These sampling techniques were selected based on: (i) the experience gained during the selection of the study area (ii) the purpose of the study and also (iii) for the need to reach the targeted issues and I have chosen 21 buildings which qualify the criteria and can represent the other building typologies.

#### **2.3.2 SECONDARY DATA SOURCE AND COLLECTION TECHNIQUES**

The main sources used to collect the secondary data were both hard and Softcopies which include: Published books and journals; unpublished norms and standards, reports, brochures from internet, libraries and office stacks;

The secondary data were collected through reading and note taking; scanning and photocopying books, journals, reports and maps; browsing and extracting through trusted websites.

#### **2.4 DATA ANALYSIS AND INTERPRETATION TECHNIQUES**

Software such as Microsoft office Word, Microsoft office Excel was used to write texts, create tables and graphs. These software are also used to analyze and present the surveyed data from questionnaires and interviews.

The collected primary and secondary data were analyzed through the comparison among the selected buildings and selected building with Green Buildings. Different software such as AutoCAD which was used for working on the general functional layout of buildings and ArchiCad was used for working on the development of the functional layout of the selected buildings and on the 3D proposals.

#### **2.5 PRESENTATION TECHNIQUES**

Illustrations that were easily understood and could be translated were used to present the analyzed data, results and proposals. Charts, tables, maps, contextual drawings are self explanatory and used in such a way that they could explain a certain relationship among issues.

## **2.6 OUTPUTS AND REPORTS**

This research paper contains remedial solutions for possible problems that revealed through the research process. The solutions are design modifications which are shown by illustrating the existing buildings supporting with graphs and charts.

This paper will be reported in both hardcopy and Soft copy for Addis Ababa University , Ethiopian institute of Architecture, Building Construction and City Development (EiABC) and EiABC Post Graduate Program Office.

## CHAPTER III: THE EXISTING SITUATIONS OF THE SELECTED BUILDINGS

This chapter discusses about the results gained through the methods predefined under the methodology of the study to answer the objectives stated to be attained in this thesis paper. The result includes: the general information of the respondents, the building location and orientation, indoor environment quality, energy consumption, water consumption, waste management and building material's durability of all 21 buildings.

### 3.1 “RAS LEYU KETFO” HOUSE (RAS SHELL)

“ራስ ልዩ ከትፎ” ፎቅ

Area - 29 m<sup>2</sup>

Function – Gas Station, and Restaurant

Ownership – Governmental Building

Location – Around Legehar Station (Kir Kos Sub City)

Woreda - 07

#### 3.1.1 BUILDING SITING AND ORIENTATION

One main road that goes from *Leghar* to Churchill and the other arterial road that connects *Beherawi* to *Mexico* define this building's location. It is a Modern Building built before the *Modern Addis Ababa* was starting to take shape. The building gives its frontal façade to the North East direction. Though this orientation is said to have the optimum sun rays comfortable for residential buildings (especially bed rooms), same facts cannot be stated for commercial buildings such as this one. There is no tree in the surrounding area that could account as part of green infrastructure of the building's radius. The concrete pavement and asphalt, as most part of the city's character, forms a singular impervious space.

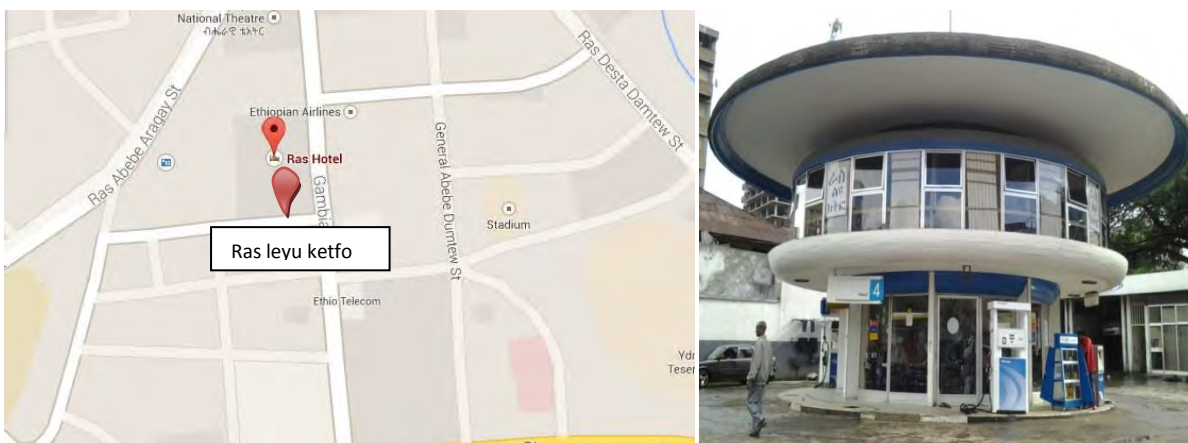


Figure 3- 1 Location of Ras Shell

Source: Google Map

#### 3.1.2 BUILDING FUNCTION & DESCRIPTION

Designed by the Italian Architect Arturo Mezzedimi in the 1960s, the unique round form and impeccable suspended round roof makes the building stand unique and elegant from those tall

buildings surrounding it. The building's functional plan is a very simple one and also guided equally by its form. The wise placement of stairs according to sun's orientation and the wide and generous windows are character of good architecture.

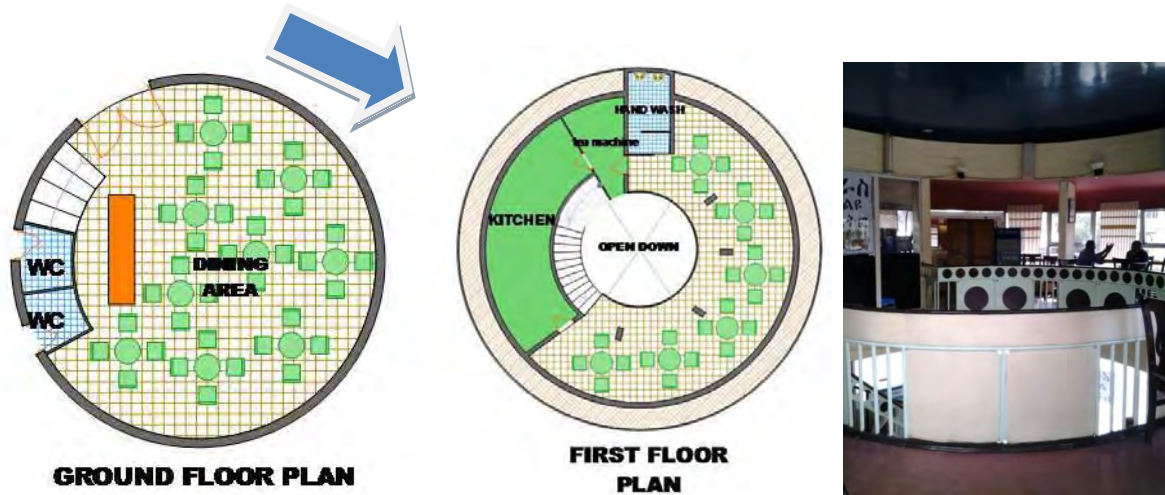


Figure 3- 2 Illustration of floor plans of Ras Shell

Source: illustration by Taeka Haileleul

Since a building's functional lay out is one of the necessary points in Green Building, it is not out of place if we take a closer look at the functional lay out of this building. As we enter the building we are faced with the stair seen in fig 3.2. The Ground plus one building has windows around all direction except the one in the rear in which the stair is placed.

### 3.1.3 THE INDOOR ENVIRONMENT QUALITY FINDINGS

It was observed that the afternoon sun (harsh sun) enters the building through the rear side making that area a bit hot. Due to its huge round concrete roof the building is under its own shadow for the most part of the day except on late afternoons as stated repeatedly in the above paragraphs. The shadows of the building and harsh sun that mostly gets the rear of the building have their own impacts on the indoor environment. The quality of indoor environment is one of the main concerns of Green Buildings and here are the following facts that were gathered during assessment of this particular building.



Figure 3- 3 Photograph showing the afternoon sun entering through the entrance and shining on the stair and the toilet underneath.

Photograph taken around 11:30 AM local time.

### 3.1.3.1 TEMPREATURE OF THE BUILDING

Due to the North East facing building orientation, the indoor air tends to have a chiller quality to it. Since the North orientation is accompanied by prevailing wind, most of the building part does not get to experience much warmth except the rear side which is occupied by stair and toilet. But as stated in section 3.2 because of its relatively large round roof, the building stays under its own shadow from, approximately, 12:30 am to 10: 30 pm local time.

Though this building may seem to cope with fluctuating weather of Addis Ababa, many respondents claim that it is too cool in the mornings and a bit too warm in the late afternoons (for small period of time).

### 3.1.3.2 WINDOWS & LIGHT

As seen in fig 3.2, the building has windows all around its façade except on its rear side. The respondents explained, they do not actually turn on the light during the day time. The toilet of “Ras Leyu Ketfo” does not share the same curtsy as that of the main building. The light should be turned on as one enters.

When we come to our building, some customers claimed the light was *just too much and made the dining experience uncomfortable*. Some claimed it was alright. Others suggested if only the windows were not so revealing, i.e. lack of privacy.

### 3.1.3.3 MICROBIA GROWTH, VENTILATION AND DAMPNES

Since the room is not ventilated well enough the smell of dampness and urine is kept contained.

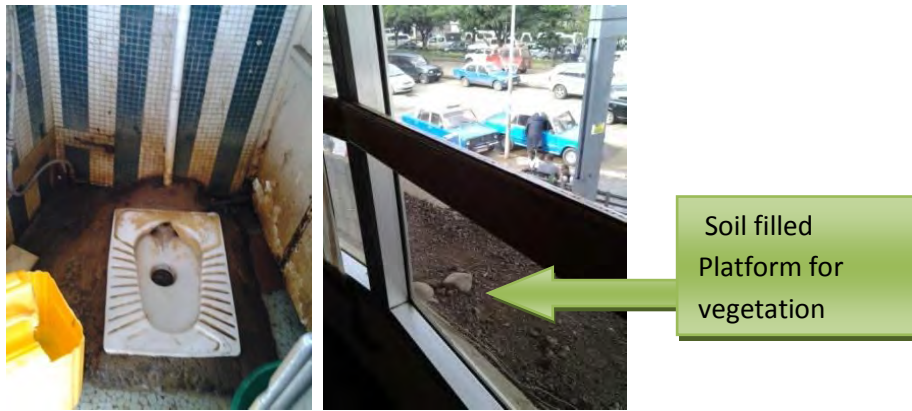


Figure 3- 4 Dampness and microbial growth in the toilet of Ras Shell and plat form for greenery (from left to right)

When we go up the first floor, since the kitchen and the dining area are placed in near proximity the wave of smell as food is being cooked diffuses through the walls easily. Though the smell of meat being roasted or other food being cooked is mouth watering, the chopping of onions and chilly is somewhat uncomfortable.

### 3.1.3.4 GREEN INFRASTRUCTURE

#### 3.1.3.4.1 GREEN ROOFS

“Ras Leyu Ketfo” house, though provided with a flat roof with full potential to support vegetation and green infrastructure, none is seen (fig 3.4).

#### 3.1.3.4.2 GREEN WALLS

The building’s walls do not support Greenery.

### 3.1.4 ENERGY CONSUMPTION FINDINGS

Barista (Coffee and tea machine), cashing machine, lamps, refrigerator and stove are the equipments that use energy that could be found in the building. The lamps this building use are energy efficient. And respondents say that it has a significant reduction in electric bills.

### 3.1.5 WATER RESOURCE MANAGEMENT

Recycling and usage of rain water is a distant resolution that the respondents could not come to use. “In a week, water may be gone for three or two days.” said the waiter in “Ras Leyu Ketfo”. For a building that does not have a container for reserving water, this is a problematic fact.

### 3.1.6 WASTE RESOURCE MANAGEMENT

The waste of this building is mostly organic and food material that decomposes easily. The system of sorting garbage is somehow applied here in this building. The plastic bottled water and the food material garbage is sorted and put in different sacks and placed in front of the building at the end of the day. And door to door collects of garbage take it in an ordered manner. Since the building has no back door the garbage is taken through the front, through the mass of sitting customers. The system the building uses for disposing solid/liquid waste material is garbage Can bin for the solid waste material and pipes for liquid waste material and septic tank for toilet waste.

### 3.1.7 BUILDING MATERIAL

#### 3.1.7.1 DURABILITY

The building is by far one of the most historical *modern* buildings in Addis Ababa. It was built in the 1960s when hints of Modernism were starting to be seen in the capital. Many years have passed. And this building has witnessed many Generations. The building material concrete is said to have 50-85 years of life span. If managed well, this number could even get higher. Respondents have said the building has been maintained very few times and still happens to function very well. The floor tiles of the upper floor appear to be repaired; they seem to have cracks here and there.

### 3.2 “RED TERROR” MARTYRS MEMORIAL MUSEUM

፳ቀይ ሽብር ሰማዕታት መታሰቢያ መዝናኛ

Area - about 2000 m<sup>2</sup>

Function – Museum + Shops + Cinema

Ownership – Governmental

Location – Bole road (Meskel Adebabay) (Kir Kos Sub City)

Woreda-09

House Number – new

#### 3.2.1 BUILDING SITING AND ORIENTATION

Located in *KirKos* Sub-city, the “Red Terror” Martyrs Memorial Museum is one of the most recently erected buildings in the capital. The building frontal façade faces the new Egyptian hotel under construction. If we stand in the middle of *Meskel* square and consider the under construction Egyptian hotel as an axis line, the Architect’s building will appear to mirror the St Stephan’s Church huge stone masonry walls. This system of considering the environment and site in Architecture is called Response. With its longest side oriented South East to North West, the building mostly exposed to North direction on the front and Southern direction at the rear.

The Green infrastructure of the compound where the building is sited is one of the characters that accentuate the building’s aesthetics. The ground in front of the building is covered with greenery.

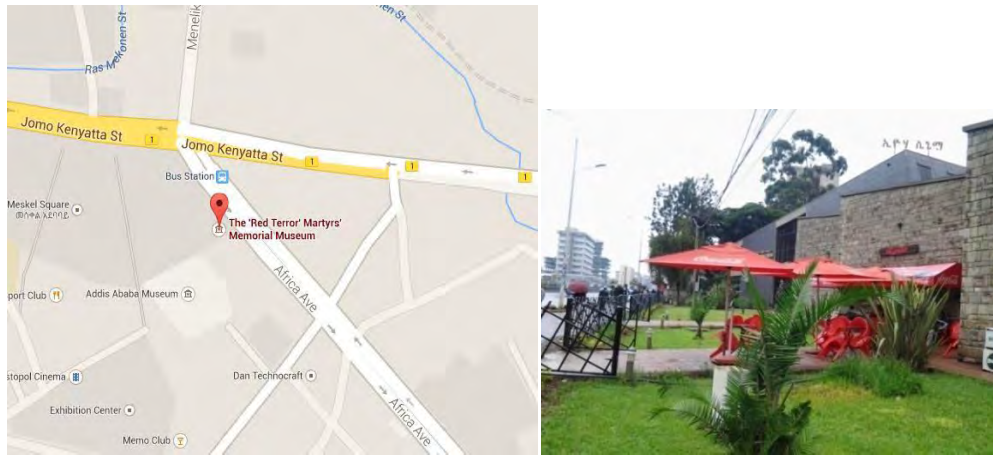


Figure 3- 5 Location of “red terror” martyrs memorial museum  
Source: Google map

### 3.2.2 BUILDING FUNCTION & DESCRIPTION

Designed by Architect *Fasil Goirgis*, the Memorial Museum of “Red Terror” Martyrs stands as an iconic structure that can be spotted as one passes from Bole to *Meskel* Square. The building is built following the post modernism theory (Personal observation). The slanted roof of the building is accessible from behind making it possible for functions to sustain on it.

The museum was erected about five years ago in the summer of 2008. It then started to function in the same summer. The first thing a passerby notices when passing through is the green area that lay in front of the dark gray tiled building. Though it may seem the building possess more than one story due to its huge slanting roof the actual floor above ground does not exceed one. Connected to the main building that serve as a Museum, there are four other cubes that interlock to form one continues form that make sense when being observed in accordance to the surrounding. These four cubes function as book store, computer store, Café and office for *Eyoha* cinema. The space in front of the Museum is completely used up as an outdoor eating and green area. Parking space is a bit further to the right in front of National Museum.

On the ground the functions that are laid out with sufficient areas are, museum display area in the first cube as we move from left to right, then cinema’s office in the next cube built from stone masonry, then cafeteria in the third, computer sales store on the fourth and in the last cube, book store. Library and Cinema are confided in the first floor. And on the roof it is where the people that are going in to the cinema wait having tea or coffee or snacks.

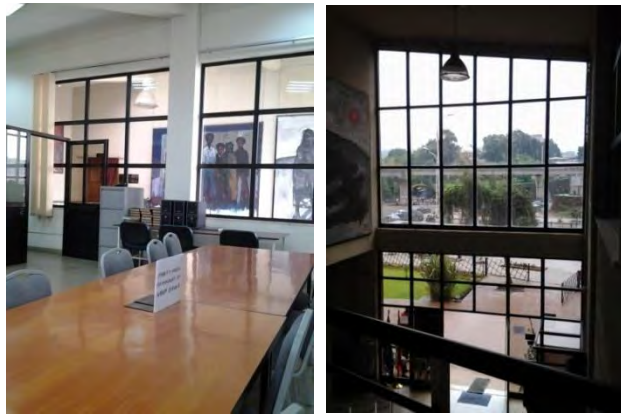


Figure 3- 6 “Red terror” martyrs memorial museum first floor, library and window location

The orientation of the building is South East to North West resulting in its own impacts on indoor air quality.

### **3.2.3 THE INDOOR ENVIRONMENT FINDINGS**

As one enters the building he/she cannot help noticing the large window on the hall way. This window makes it possible for light to enter without any interruption. This light is mostly Northern light that is accompanied by prevailing wind. This prevailing wind carries moisture and also can create a cooler air that tends to have a slight chilling feeling to it.

The interior does little to compact the very small amount of heat that enters due to its very high ceiling (About 6.20 m high). The building material used as a finishing material is a lighter tiles that are slippery and add to the somewhat chiller indoor environment.

#### **3.2.3.1 TEMPREATURE OF THE BUILDING**

When asked, the workers at the Museum and shops claim that due to the North facing windows and openings they experience a chiller and cooler environment indoors. As stated above, the North orientation is accompanied by winds and moisture carrying air movements that with other factors like ceiling height and window to room ration had added to a number of mild discomforts in occupants.

#### **3.2.3.2 WINDOWS & LIGHT**

All of the rooms have windows that let in light but the book shop and cafeteria still artificial lighting system during day time.

#### **3.2.3.3 MICROBIA GROWTH AND DAMPNESS**

Though they were self conscious to show their toilet, they claimed to have relatively healthy and neat toilets, one for male and another for female. But one thing they wanted to reveal eagerly was fact that the accessible roof leaked causing dampness and microbial growth those occupants underneath it. They mostly occur during construction and when proper precaution is not taken to prevent leakage, the first victims are the structure itself and the occupants that may experience mild to series range of sickness.

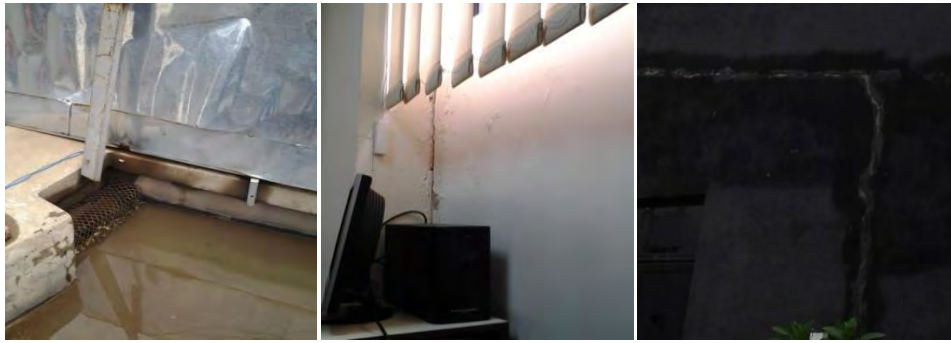


Figure 3- 7 Leakage that has occurred on the roof and walls affect the interior equipments of the building

### 3.2.3.4 GREEN INFRASTRUCTURE

The building has a vast green area in front of it. This green area not only adds to its sustainability but also increases the building’s aesthetic value.



Figure 3- 8 Green infrastructure around the Museum

### 3.2.4 ENERGY CONSUMPTION FINDINGS

The building experiences the regular shortage in Energy and water that the country seems to undergo these days in general. The generator works in irregular sequence making daily work tad bit hard. The respondents’ knowledge about renewable energy is limited and quiet low. And the use of renewable energy is still unapplied.

### 3.2.5 WATER RESOURCE MANAGEMENT

No tank reservoir witnessed on or around the building area. They claim to use clean water for toilets, for watering the vegetation and also for other functions. No recycling water or double plumbing for toilets. And the concept of using rain water was a completely new notion that was strange to the respondents.

### 3.2.6 WASTE RESOURCE MANAGEMENT

Though some people think the idea of burning trash is confided in rural areas, the respondents of the building burn trash every day on the side of the building site. This, they admit, is not healthy to the environment but since they have no other alternative to collect their garbage the only solution they could come up with was to burn it.

### 3.2.7 BUILDING MATERIAL

Built from concrete, stone masonry and tile the building seems to have many years before it. As floor finish they have used white marble tiles that add to cool indoor air.

#### 3.2.7.1 DURABILITY

Concrete as stated in the above sections lasts for above half a century and the buildings built with stone masonry in Emperor *Haile Selassie's* era in our city still stand tall and proud till this generation. So the combination seems perfect for strength. But that is possible if the construction and workmanship is carefully undertaken.

### 3.3 'SOFONIAS' APARTMENT BUILDING

Area - about 4000 m<sup>2</sup>

Function – shops + Apartments

Ownership - Government ( *kiray Betch*)

Location – piassa, habte Gorgis deldeye (Arada Sub City)

Woreda –

#### 3.3.1 BUILDING SITUATION & BUILDING ORIENTATION

The main road that takes us from Piassa (Ethiopia Cinema) to *Arat Kilo (Habte Giorgiss Deldey)* defines the building informally named “*Sofonias Pastry*”. This building is located between the Ethio Enterprise building and the Ethiopian Commercial bank building. One of the oldest apartments owned by the Government are located around this area.

Facing the slightly slanted northwest orientation the curved building is also prone to noise disturbance due to the nearness to the ever active road of Piassa. There seems to be no Green infrastructure located near the building that could account for any beneficial purpose in aesthetic or sustainability.

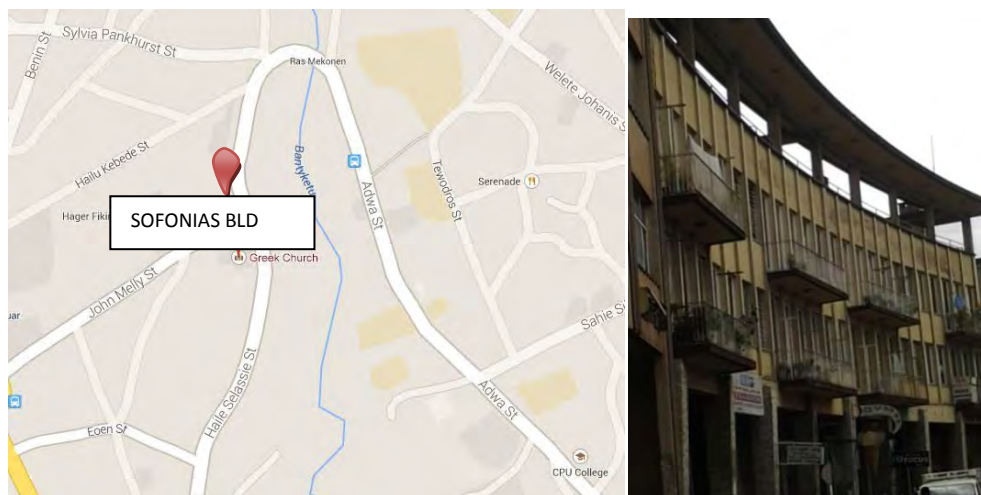


Figure 3- 9 Location map of the building

Source: Google map

### 3.3.2 BUILDING FUNCTION & DESCRIPTION

It looks like for the past five or six decades, this building stood at its current location giving function and defining Piassa along the way.

Though the naming of the building is not yet found out it is nonetheless a well known building. The famous ice cream cartoon sign hanging on the building makes it unique and recognizable. This multi functional building is used as a cafeteria on the ground, as an office on the first floor and on the second and third floor apartments.

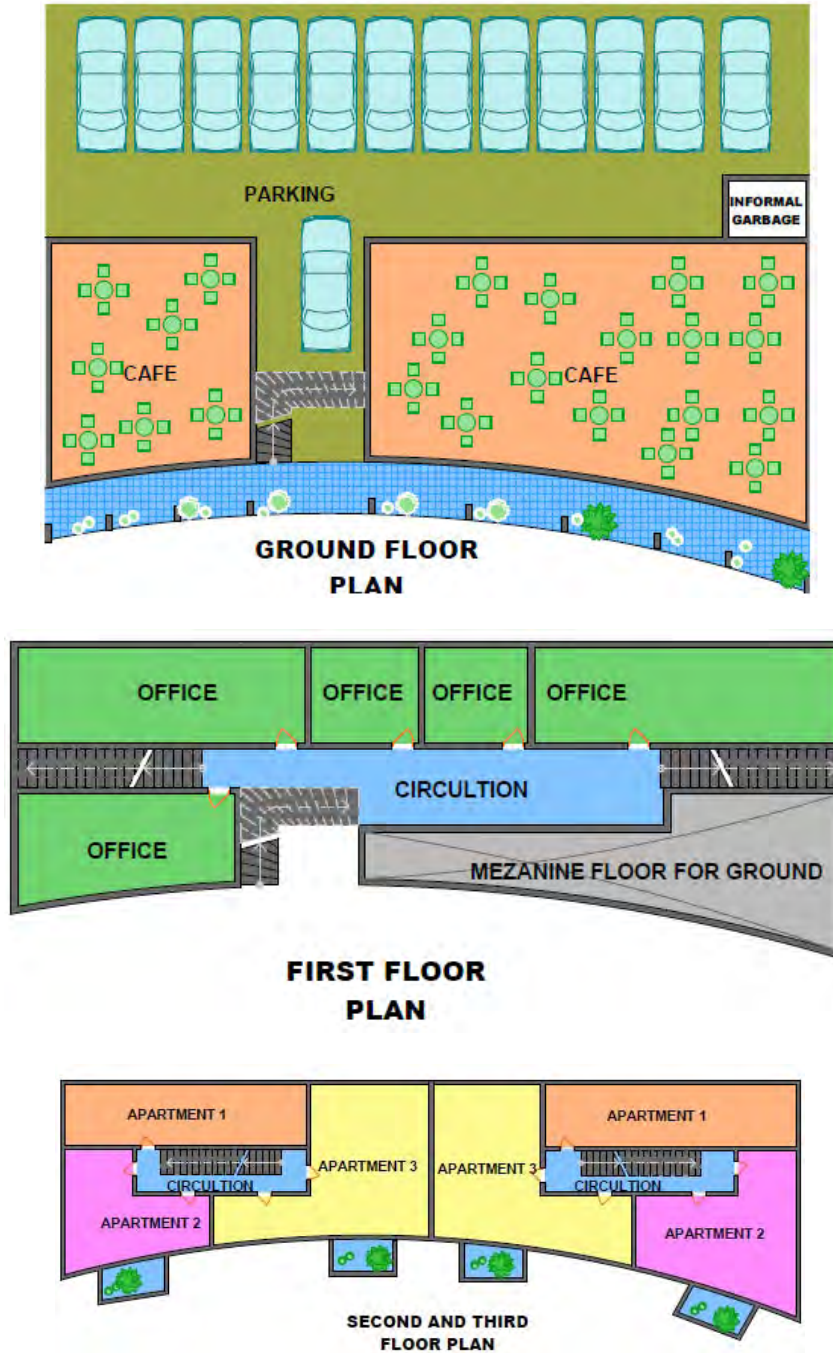


Figure 3- 10 Rough representation of buildings floor plan

There are two stair cases that lead to 3 apartments each.

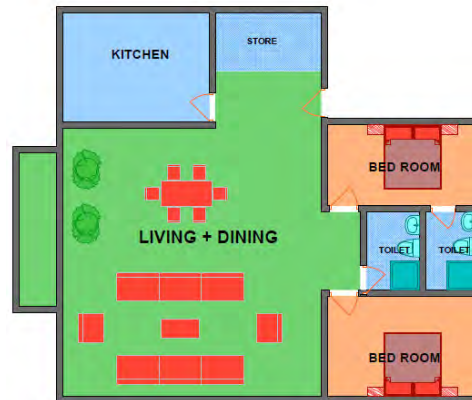


Figure 3- 11 Rough illustration of the apartment lay out

### 3.3.3 THE INDOOR ENVIRONMENT FINDINGS

The indoor environment findings of the building are the direct result of orientation, building's functional layouts and openings.

#### 3.3.3.1 TEMPREATURE OF THE BUILDING

There seems to be a divided condition when it comes to temperature. The respondents that occupy the frontal space of the building say that they experience mild and cool air temperature that is found to be very good for performance. Those that occupy the flats at the rear building face the harsh sun that is too warm for performing any type of activity.

#### 3.3 3.2 WINDOWS & LIGHT

As stated in the section 3.3.1 the stairs and corridors of this building are ventilated and lighted mechanically.



Figure 3- 12 Window and light in stairs and corridors

Though the public spaces like corridors and stairs may lack natural light the most of the interior rooms of the apartments are rich in it. If we take a look for example the typical apartment

arrangement in apartment 3, here is what we will find out. But still some rooms lack windows and sun light.



Figure 3- 13 Interior of apartments

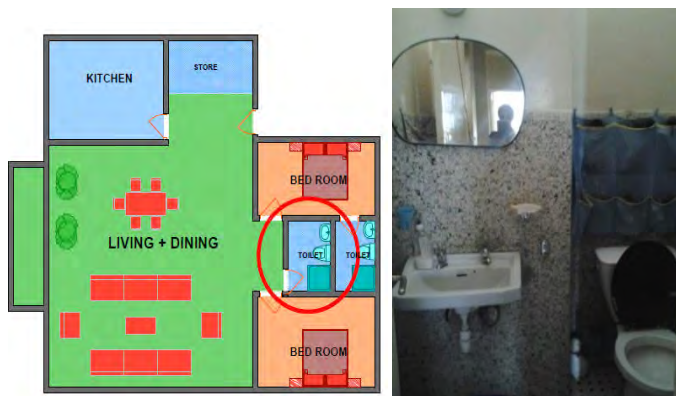


Figure 3- 14 Unlighted portion of apartment

### 3.3.3.3 MICROBIAL GROWTH, VENTILATION AND DAMPNES

Spaces that do not have windows are prone to have a damp smell and eventually will be a perfect site for microbial growth. Due to lack of ventilation and the respondents were able to identify the following problems:

- Smell of food from the cafeteria's kitchen
- Smell of unclogged toilet
- Air of dust hanging in the atmosphere not able to get out by the process of ventilation

Some problems they had due to microbial growth were:

- Unattractive façade that were degraded in strength



Figure 3- 15 Unpleasant looking façade because of leakage and dampness and effects of dampness due to open roof (from left to right)

- Mild to serious infection of flu
- Unpleasant smell from toilets

And also respondents were supportive enough to identify the causes of dampness in the building which are:

- Inter wall leakage ( water seepage through walls from kitchen to bath and vice versa)
- Due to the uncovered stair roof rain water would seep through the walls of the apartments
- Toilet malfunction

These and many more problems accompany the lives of the users of this building. The space is vast and relaxed enough to carry out any function. But some systems need adjustments so that dampness is not caused followed by microbial growth.

### **3.3.3.4 GREEN INFRASTRUCTURE**

#### **3.3.3.4.1 GREEN ROOF**

There is no green roof seen on the roof.

#### **3.3.3.4.2 GREEN WALL**

Though balconies and verandas have green plants on them, the actual wall does not have such character.

### **3.3.4 ENERGY CONSUMPTION FINDINGS**

It was somewhat surprising to know that this area is not that much affected by the fluctuation of light and energy that seems to be going on all around the city. Light is pretty regular. But as the rest of building system we have seen before this building does not have other means of energy utilizing system that can be of use for people that use it.

### **3.3.5 WATER RESOURCE MANAGEMENT**

Water usage management is a concept that eludes most of the building systems. They do not recycle or care how much water we spend on secondary activities that do not particularly need pure water to be completed.

### 3.3.6 WASTE MANAGEMENT

The system of garbage disposing they is quiet informal and unsanitary. It is unhealthy because the waste mater that is collected from every house hold and office is damped on a space that is near the parking area unclosed and unmaintained. This helps pathogens to pick any type of disease causing maters and transmit it to people that live nearby.

### 3.3.7 BUILDING MATERIALS

The building material, as most of the building material in the case of Addis Ababa's buildings is HCB and mortar.

#### 3.3.7.1 DURABILITY

This building has offered everything that it could offer in its years. It's been a long journey, and it's obvious that during that journey damage has been done to it. Be it due to low maintenance or damages in utilities causing dampness, the buildings durability is compromised.

### 3.4 STAIRS

Area – 64 m<sup>2</sup>

Function – Stationary + Architectural Office (Architect Zeleke Belay)

Ownership – Private

Location – Sar Bet road to Kera (Kir Kos Sub City)

Woreda – 04

#### 3.4.1 BUILDING SITING AND ORIENTATION

On the road from Sar Bet to Kera one can't help seeing the simple yet elegant five story building. The building opens its frontal façade to the North Direction which is accompanied by prevailing wind.



Figure 3- 16 Location of STAIRS

Source: Google map

### 3.4.2 BUILDING FUNCTION & DESCRIPTION

Stairs is a four story building above the Ground level with Basement floor that could be accessed from the back. On the ground, there is a very generous space used for stationary and having its own toilets, making it very wise placements of spaces. The very fact that the stair structure of the building is outside makes the building stand out.

The east facing building is constructed with plain concrete and the stair is left untreated. The functional lay out is just as clear as the building form itself. That is, the ground is totally occupied by a stationary and appliance sales room with its own toilets.

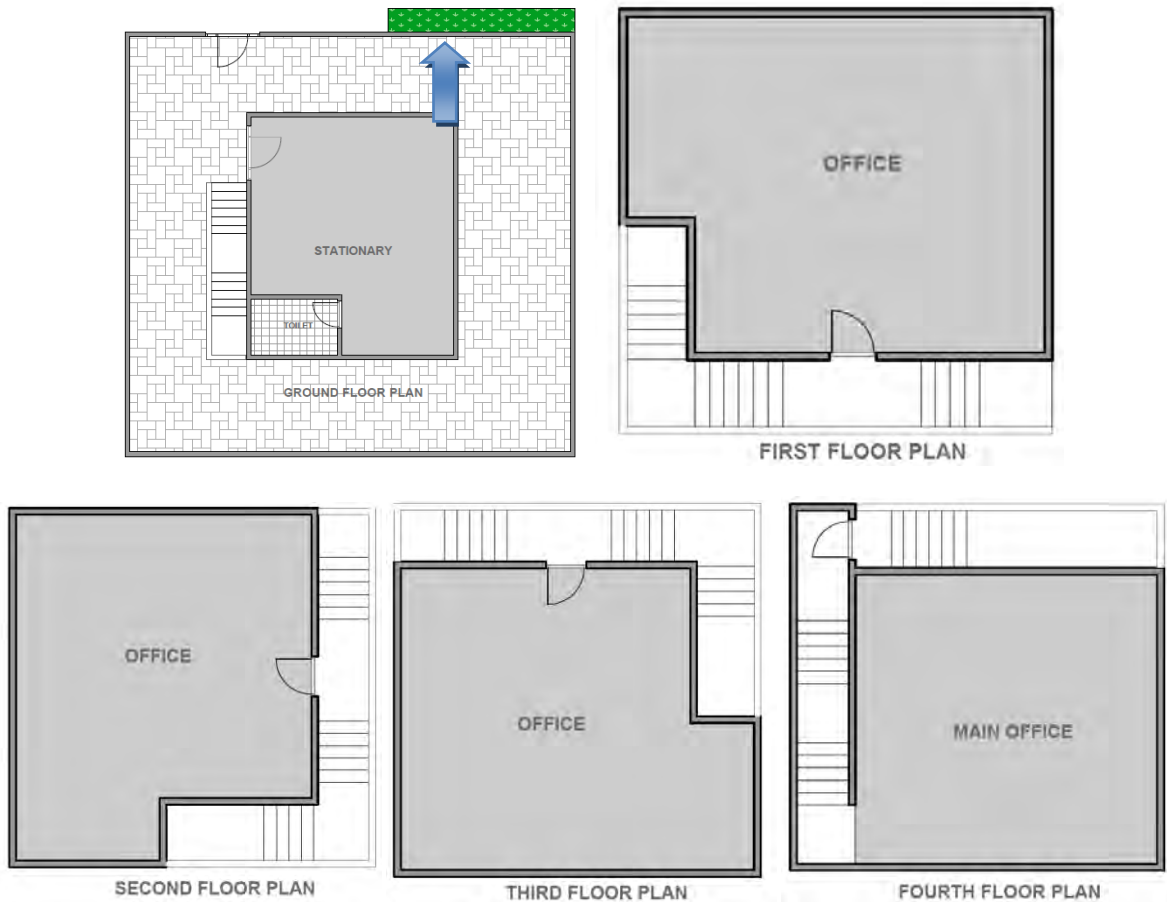


Figure 3- 17 Rough representation of the floor plans of STAIRS

### 3.4.3 THE INDOOR ENVIRONMENT QUALITY FINDINGS

The indoor environment quality of a building is a collective result of orientation, building lay out and building material.

#### 3.4.3.1 TEMPREATURE OF THE BUILDING

The building faces the chiller direction of north so as the conducted interviews show; this has resulted in a relatively cooler indoor air quality. The respondents claim that during the cold seasons of the winter the room is very cold and unbearably attacked by prevailing winds (which adds to the coldness of the indoor temperature.)

On the third floor, this temperature difference becomes visible. Due to the open up with in the third and fourth floor (done to increase interaction) has created a problem for the third floor space in trapping heat. One of the respondents Ato Kaleabe who works on the third floor has explained that during the winter times, the room gets unbearably cold.



Figure 3- 18 Interior space of the office

#### **3.4.3.2 WINDOWS & LIGHT**

From data collected during site and building analysis, it was observed that the interior spaces have sufficient windows and light (fig 3.19).

#### **3.4.3.3 MICROBIA GROWTH AND DAMPNESS**

Since the down pipe of the building is built within the walls of the structures when the pipe faced malfunctions (seepage) it has worn out the walls. The diffusion of moisture has weakened the existing wall structures (fig 3.19 dampness caused by down pipe).

#### **3.4.3.4 GREEN INFRASTRUCTURE**

The green infrastructure of the building shows tendency toward to be classified under green walls rather than green roofs. On the ground the front space the greenery is quiet well maintained (fig 3.18).

Also, within the office spaces it has been seen that there are some potted green infrastructures. This has created beauty and diversity.

#### **3.4.4 ENERGY CONSUMPTION FINDINGS**

There is no green energy used in the building and the knowledge about the renewable energy ranges from medium to high.

#### **3.4.5 WATER RESOURCE MANAGEMENT**

Clean water is applied when using the toilet, for green infrastructures and also for cleaning cars. This has created the unbalanced over usage of water is unsustainable and unhealthy. They do not recycle and reuse for some secondary activities like toilet.

#### **3.4.6 WASTE RESOURCE MANAGEMENT**

Since the upper four floors are office spaces most of the waste disposed is paper. Though the office users claim to use and reuse this paper still the office gets rid of large amount of paper. The stationary on the ground floor does dispose fair amount of plastic.

### 3.4.7 BUILDING MATERIAL

The design quality and the lay out in addition to the wise application of HCB have made the building stand strong throughout the years. Since HCB is a very thermal resistant material the character is defined.

#### 3.4.7.1 DURABILITY

If the maintenance of the leakage in the down pipe is conducted the durability of the building as a whole will not be compromised. The durability of HCB is known to be dependable.

### 3.5 BANK O' DE ROMA (DON DENTAL CLINIC)

Area - about 1000 m<sup>2</sup>

Function – Office + Apartment

Ownership – Governmental

Location – Arada Sub City

Woreda-

#### 3.5.1 BUILDING SITING AND ORIENTATION

Piassa Churchill area is well known because of this building. It is erected near the cross roads that is formed from the intersection of a main road and semi arterial road. This seven story building (ground plus six) is similar to the Bedelu Hentsa that is spotted at Beherawi Road.

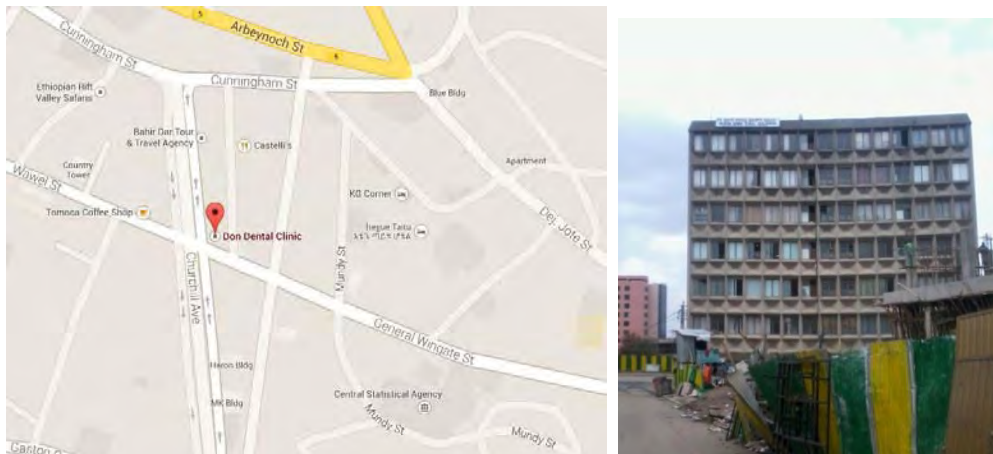


Figure 3- 19 Location of Don Dental Clinic

Source: Google Map

Situated on a slope site, bank o' de Roma is one of few buildings that withstood a lot of change in city. Giving its shortest side to a slightly slanted South West direction, this building was erected during the era of Emperor *Haile Selassie*.

Other buildings like *Haron Tower* and *MK Building* stand alongside this building following the famous Churchill road.

#### 3.5.2 BUILDING FUNCTION AND DESCRIPTION

The not so much emphasized entry to the building compound may confuse people experiencing it for the first time. If we are coming from the main road side (Churchill road) one

can spot a parking spot and an informal gate that leads to the building compound. And if one is coming from the semi arterial road, the small gate can't be viewed if not walked up to it.

The ground floor is totally occupied by the Ethiopian Commercial Bank and its small tea room. The dark stair case and the stuffed odor from the tea room welcome one as he/she enters through the door. Then the first floor is occupied by an Architectural firm and a somewhat larger dining and cooking area for workers of the bank.

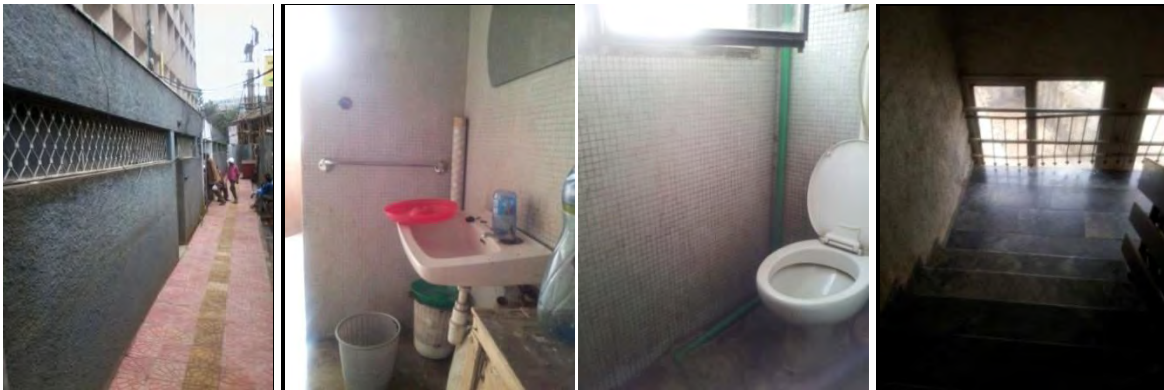


Figure 3- 20 Entrance and interior spaces of the building (sin, WC and stair case from left to right)

From the second to the fourth floor the famous dental clinic Don occupies different sizes of space. On the fifth there are some apartments, the administration office of the clinic and the office of the famous Architect *Mesfin Mulugeta*. On the six the laboratory of the clinic and two apartments occupy the floor.

With its two elevators not working, people go up and down the 12 flights of stairs all working hours. This is found to be very tiresome.

In order to maintain the façade balance even the windows in the toilet are the same sizes as those found in the offices and cafes. This poses a problem when it comes to privacy.

### **3.5.3 INDOOR ENVIRONMENT FINDINGS**

#### **3.5.3.1 TEMPERATURE OF THE BUILDING**

Since the longest side of the building faces the South West direction the whole building is classified into two thermal characters. Those spaces that face the two roads experience hotter indoor temperature. This separation of thermal characters is the result of indifference in design. A well designed building will have the same indoor environment temperature throughout its spaces.

#### **3.5.3.2 WINDOWS AND LIGHT**

There are sufficient windows in the buildings. These windows let in enough light for tasks to be accomplished. But the fact that it faces a glazed building across the street does not allow users of that building to open their windows as frequently as they want because of the glare caused by the reflection of Sun's ray from the glazed facade. So users choose to not open the windows and turn on artificial light during day time. But the colliders are darker relate to other spaces in the building (fig 3-21)

### **3.5.3.3 MICROBIAL GROWTH VENTILATION AND DAMPNES**

The toilet needs a serious consideration. A foul smell caused by microbes is the reason for a serious of illness the occupants complain about.

Leakage is an additional problem that needs to be considered for betterment of life in the building (fig 3-21).

### **3.5.3.4 GREEN INFRASTRUCTURE**

There are no green structures available near or on that area.

### **3.5.4 ENERGY CONSUMPTION FINDINGS**

Almost every office on the building has its own generator Machine when light goes off. But due to the new construction over taking the area, the front yard is becoming lesser and lesser decreasing the space to put those machines.

### **3.5.5 WATER CONSUMPTION FINDING**

Water pipes do not work easily as they supposed to. But still when water is available till sixth floor, the occupants tend to spend it carelessly because they do not have a general reservoir tank and also they do not recycle.

### **3.5.6 WASTE MANAGEMENT FINDINGS**

After collecting waste from each room in the building door to door collectors collect the collected garbage. But some dirt escapes due to proper management and join the street.

### **3.5.7 BUILDING MATERIAL**

As stated above the Concrete is a very strong material that has a long life span in the history of Ethiopian Architecture. It has good compression strength. And coupled with steel it will have the tensile and compression strength.

#### **3.5.7.1 DURABILITY**

Questions and statements we ask in the case of *Bedlu Hentsa* are still valid here. It is oblivious that the building material is of strength and durability. It has lasted the past forty years functioning and giving service. But the questions are

1. How long will it continue to function
2. What could be done to further its age of function

## **3.6 MAFI CITY MALL**

Area - 800m<sup>2</sup>

Function – Shopping mall and office building

Ownership - Private

Location – Bole Medhanialem (Bole Sub City)

Woreda – 03

### 3.6.1 BUILDING SITING AND ORIENTATION

Across the *Medhanialem* Church, Mafi City mall is located between *Bole Del dey* (bridge) and *Edna* Mall. The location is indicated on the map below. The building faces the east direction with full advantage of receiving morning sun. It stands on the same side with other buildings like *Edna* Mall, *Sheger* House, *Medhanialem* Mall and others.

The building site gives it advantage because the land itself has high land value because it is near to the main road.

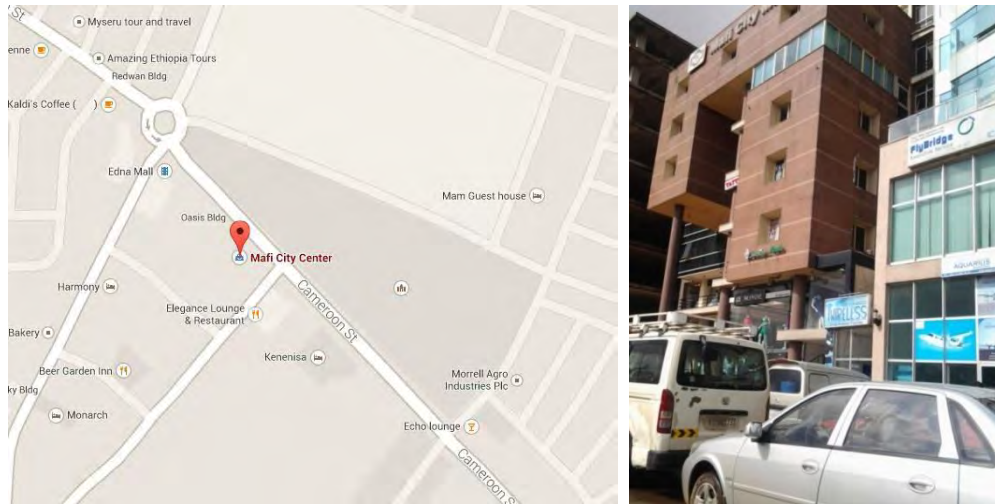


Figure 3- 21 Location of the MAFI CITY MALL

Source: Google Map

### 3.6.2 BUILDING FUNCTION AND DISCRPTION

Owned by the Architect himself, *Mafi* City Mall has the most lavish entrance that is rarely seen in other buildings. It signifies a grandness that only comes from a good internal functional lay out.



Figure 3- 22 Interior space of Mafi City Mall

With the middle part completely subtracted it is designed so that natural light diffuses all the way in. After walking in one is again mesmerized by the abundant light entering through the sky light that is all the way on the top floor showering in light to all of the lower floors.

Mafi City mall has two escalators that connect the ground floor to the first floor and a stair for regular circulation and a fire escape stair case in the case of emergency. Mafi has two elevators to aid in vertical circulation and also a very capable corridor for horizontal circulation. The building has a basement floor used for parking and ground floor, mezzanine floor, first floor, second floor, third floor used for shops and from fourth to six floors, it used for office purposes.

The building manager has kindly shared some vital information to aid in this research. According to him there are around 80 rented or rentable shops in the building till the third floor, and from three to four offices on each of the floors above. Each floor has four toilets for female and four toilets for male which fulfills more than the requirement.





Figure 3- 23 Floor plan illustration of Mafi City Mall

### 3.6.3 INDOOR ENVIRONMENT FINDINGS

With the collaboration of the management office of *Mafi* city Mall and personal observation sufficient information was acquired to understand the indoor environment of the building.

#### 3.6.3.1 THE TEMPERATURE OF THE BUILDING

From the feedback gathered from respondents the curtain wall, though weak heat insulator, is used wisely here because in proportion HCB wall is higher. The east facing frontage curtain wall is coupled with HCB making the thermal balance optimum.

From the data collected from respondents and the management office it is safe to the temperature of the work space is optimum for tasks to be carried out. This, they supposed, is due to the well studied use of curtain wall in collaboration with concrete (HCB).

#### 3.6.3.2 WINDOWS AND LIGHT

There seems to be enough light to enter every room and space. The use of sky light helps the building to eliminate the use of artificial light during the day time (fig 3.24).

#### 3.6.3.3 MICROBIAL GROWTH, VENTILATION AND DAMPNES

Due to the much exposed terrace on the sixth floor, leakage and seepage of water has occurred.



*Figure 3- 24 Leakage on roofs and terrace*

The building is founded up on a sub ground soil that naturally holds water within its particulates. Due to this character of the soil the basement parking area is continuously under readjustments. The water rises through the foundation and appears on the floor finish level of the basement

### **3.6.3.4 GREEN INFRASTRUCTURE**

As it is trend in many constructions, the site clearing starts with getting rid of any green infrastructure that may be thought to hinder the construction process. This is the case in this building. The site is clear of any plants as a result there are none to be seen to this day.

#### **3.6.3.4.1 GREEN ROOF**

The building has a flat roof that suggest green roof by itself. But there is no such structure supported on the flat roof.

#### **3.6.3.4.2 GREEN WALL**

Though some balconies do have greeneries, it is not safe to say it is enough.

### **3.6.4 ENERGY CONSUMPTION FINDINGS**

The management office of *Mafi City Mall* has indicated that they spend three to four percent of their income for energy. Even though they do not turn on artificial lights during day time (Places where they are indirect contact with the sky light) they still spend considerable amount of money on energy.

Because most of their rentable spaces are for boutiques, the boutique owners tend to redo or redesign their rented space according to their needs. They tend to cover the windows because natural light, they said, is not good for the displayed clothes in the boutiques. Thus, by using cheap wood and gypsum, they cover the windows and install different colored artificial lights. This adds to the energy consumption.

### **3.6.5 WATER RESOURCE CONSUMPTION FINDING**

The administration office of the building has claimed that they do not reuse, recycle or recollect water for uses of secondary priority.

### **3.6.6 WASTE MANAGEMENT FINDING**

Though they haven't established a permanent location for garbage that is collected from the shops and offices, the temporary location they use is the basement. As stated above, the basement is frequently attacked by water seepage. This combines with the organic and

inorganic waste matter kept in there temporarily causing foul smell sometimes. This is unfortunate because with the amount of organic substance the building produces so much could have been accomplished.

### **3.6.7 BUILDING MATERIAL**

The use of HCB and Curtain wall is in wise proportion when we come to *Mafi* City Mall. it is both attractive and functional. But in order to continuously function keeping these two important traits (aesthetics and function) other variables need to be addressed.

- Construction and workmanship
- Maintenance and continuance
- Improvement and development

These three conditions can enhance or hinder the life span of any building.

#### **3.6.7.1 DURABILITY**

The workmanship of the building does injustice to the building aesthetics and function as a whole. The foundation, due to faulty assumptions and unscientific measures has ceased to function regularly. The much exposed terrace of the sixth floor has interrupted the photo studio office found underneath it.

The maintenance of the building in general is medium rated. They tend to take trial and error type of approach when it all it really needs is a systematic approach to the existing problems.

Finally, because they are busy mending the problems at hand they do not have the finance or the time to invest on the building improvements.

This with the sub structure leakage due to the damp soil on which foundation is built upon it is safe to say the building needs attention. Or else its durability is compromised.

### **3.7 HAIMI HOTEL**

Area - about 1200m<sup>2</sup>

Function – Hotel

Ownership - Private

Location – Bole Medhanialem (Bole Sub City)

Woreda – 03

#### **3.7.1 BUILDING SITING AND ORIENTATION**

As one of the most recent buildings in the capital, *Haimi* Hotel is located at *Bole Medhanialem* road and can be spotted as one move from *Bole Medhanialem* to *Kas Anchiz*. This road is somehow oriented from a slightly slanted angle of North to South direction. From this, we gather that the building faces Western side on its front façade. Thus, the eight story building's longest side is oriented north to south.

The building gets the rise sun of the east from its rear. This side is mostly treated with smaller windows because it faces neighboring compounds (building code regulation). On the other

hand, the building has relatively larger windows in the front; the low afternoon sun enters the building uninterrupted.

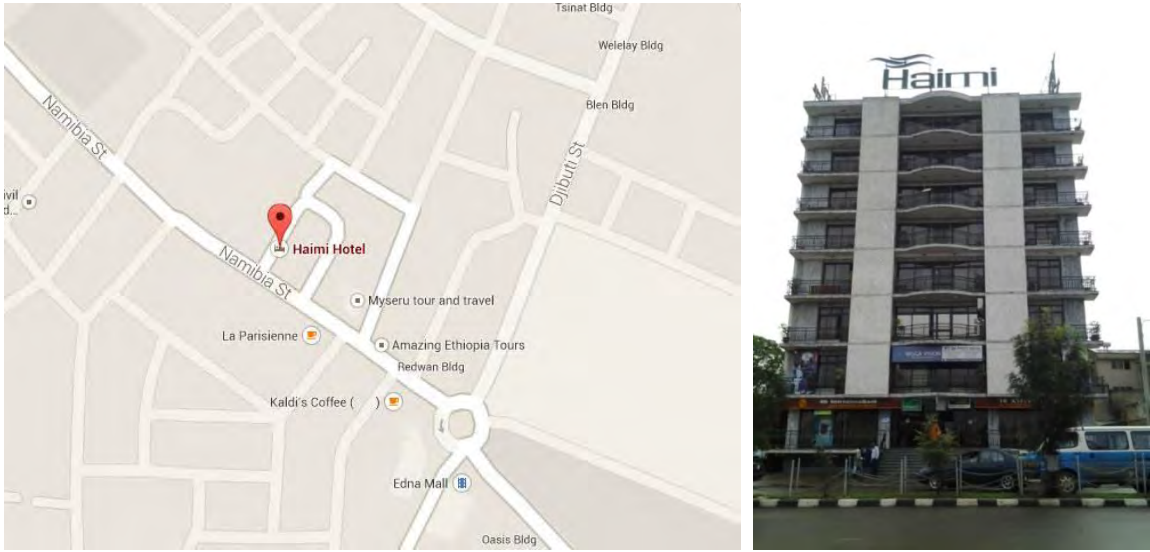


Figure 3- 25 Location map of Haimi Hotel

Source: Google Map

### 3.7.2 BUILDING FUNCTION DESCRIPTION

The building has a bank and a bar and the Hotel’s lobby in between them on the ground. On the first and second floor eye clinic and tour guide is available respectively. And from the Third floor up, the building serves as very stylish and elegant Hotel. The building has one stair case and an elevator. The building also has a fire escape stair case which is a mark of good design.



Figure 3- 26 Building green infrastructure



Figure 3- 27 Illustrations of floor plans of Haimi Hotel



Figure 3- 28 Hotel lobby on the ground, fire escape door, first floor lobby from left to right

### 3.7.3 INDOOR ENVIRONMENT FINDINGS

The building's indoor environment is the result of many variables such as orientation and windows and light and temperature. As the major concerns of Green Building indoor environment must be attacked toughly.

#### 3.7.3.1 TEMPREATURE OF THE BUILDING

The room temperature, gathered from questionnaire, is a very stable one that allows tasks to be carried out within the spaces.

#### 3.7.3.2 WINDOWS AND LIGHT

The building has enough light that enters through its medium sized windows. Though enough light enters every room, they still turn on artificial light. Below from left to right are pictures of the bed room area, the kitchen area and the collider of the building. As seen in the pictures, the building's interior is designed in away every room gets natural light. But still the use of artificial light is applied.



Figure 3- 29 Interior window location of the hotel and toilet free of microbial growth

#### 3.7.3.3 MICROBIAL GROWTH, VENTILATION AND DAMPNES

In the case of *Haimi* Hotel the building is designed in consideration of the toilet system among other things. As seen in the picture above it is easy to observe that the toilet is kept well cared for (fig 3-30).

#### 3.7.3.4 GREEN BUILDING

Every building has balconies in three of the four facades. On those balconies three seem to be greeneries on every balcony. A person sitting on the balcony will not only have the view of the

greeneries but also the unattractive sight of rotten roofs and other people's compound (fig 3-27).

#### **3.7.4 ENERGY MANAGEMENT FINDINGS**

The use of alternative energy source still eludes owners of buildings. *Haimi* Hotel does not have an energy source that could replace the regular one. Though the building has many activities that need energy (Gymnasium, Restaurant, cafeteria, Bed room services), it still depends on the fluctuating system of the country.

#### **3.7.5 WATER RESOURCE MANAGEMENT FINDINGS**

As stated above the building supports many functions. Of those functions there are almost none that do not use water. But still the buildings do not recycle water and also they don't use rain water or used water for secondary activities that do not necessarily need pure water. The building's toilets do not have double plumbing system that can guarantee in the reduction of water consumption.

#### **3.7.6 WASTE MANAGEMENT FINDINGS**

The waste is collected from every room and kept in a temporary storage. And then the building cleaners and janitors take it and place it in front of the building corner where door to door collectors can pick it up easily. Though they do not have enough space to create a compost site, they still could have recycled starting by sorting the garbage.

#### **3.7.7 BUILDING MATERIAL**

*Haimi* Hotel is built from concrete and finished with gray and white tile. For the hand rails of the building they used a black paint coated wrought iron. The black of the rail and the white of the tiles on the wall give the building a beautiful contrast. Also the black tinted medium sized windows add to this contrast.

##### **3.7.7.1 DURABILITY**

Concrete, by itself, is a very strong material discovered in the world of construction. And if coupled with other strong building materials like iron and aluminum it could prevail even more.

In the case of *Haimi* Hotel the combination is impeccable. And the building maintenance is one that could be an example for many others. Though built in recent years if kept maintained like this, *Haimi* hotel looks like it has more years ahead of it.

### **3.8 BEDLU HENTSA**

**ቤድሊ ክንፍ**

Area - 1000m<sup>2</sup>

Function – Apartment + shopping building

Ownership – Governmental Building

Location – Beherawi Theater

Woreda –

### 3.8.1 BUILDING SITING AND ORIENTATION

A lot of people think because there are many curtain-walled buildings rising from the ground overnight (it may seem like) there is development in a society. But to prove those people wrong and to show all of us that there is still quality in maintaining historical buildings, *Bedlu Hentsa* stands till this day head-to-head against the 23-story building of *Awash Bank* Head Quarters at *Beherawi's* main road. This building has withstood many eras during the roughly estimated 4 decades of its age. Built in the early 60's, the building seems to follow the late Art Deco style, period of Gaudí and Garibaldi. In fact, Architect Gaudí had a building with almost the same features as *Bedlu's* in Spain.

It is safe to say there is no building that resembles that of *Bedlu's* in the treatment of façade and attention of details except buildings that resemble the façade of *Bedlu Hentsa's* itself built in the same era (*Bank o De Roma* Building around Churchill Road).

The ground plus seven building gives its frontal face to the south direction. And the much wider right elevation to the south-west direction. Areas around the National Theater are growing more and more to be the CBD (central business district) of the city. With this comes the construction of huge head quarters of Banks and Business enters. This needs a lot of area by removing greenery. Due to such changes around it, *Bedlu Hentsa* has no green infrastructure on or near site.

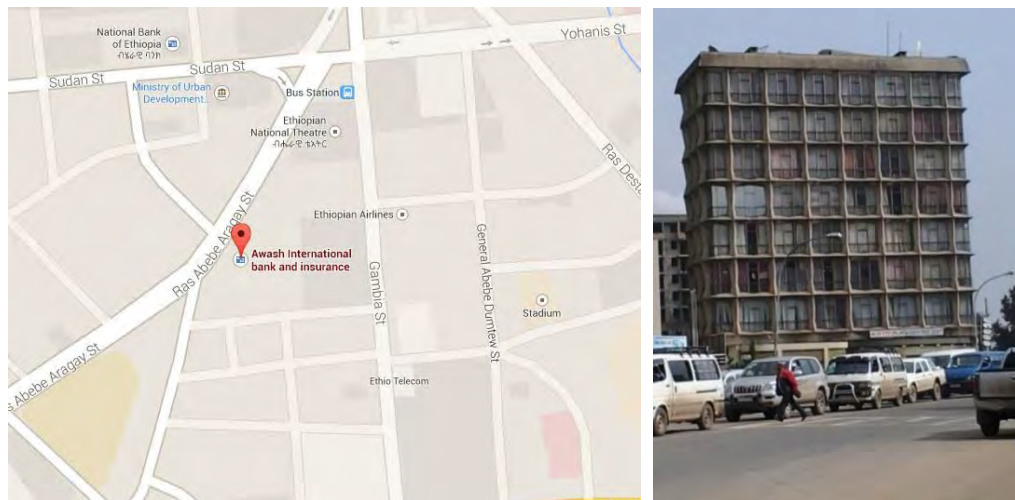


Figure 3-30 Location map of Haimi Hotel

Source: Google Map

### 3.8.2 BUILDING FUNCTION AND DESCRIPTION

The ground floor of this old building provides function like offices and administration purposes. In fact it has four shops including the ticket office of Ethiopian Airlines and a café. Though the building has sufficient parking lot in the back the building does not have a playground for children nor segregated garbage disposal area. There are two staircases including fire escape.

### 3.8.3 INDOOR ENVIRONMENT FINDINGS

The inner environment is one that is of significance while discussing Green Building. The collective facts of the location, building materials, orientations and so on give a certain meaning and outcome for the inner environment.

### 3.8.3.1 TEMPERATURE OF THE BUILDING

The respondents' answered that it gets warmer during the hot seasons of Addis Ababa. The shop owners stressed this concept as they face the lower sun rays in the afternoon and no system of shading could protect them.

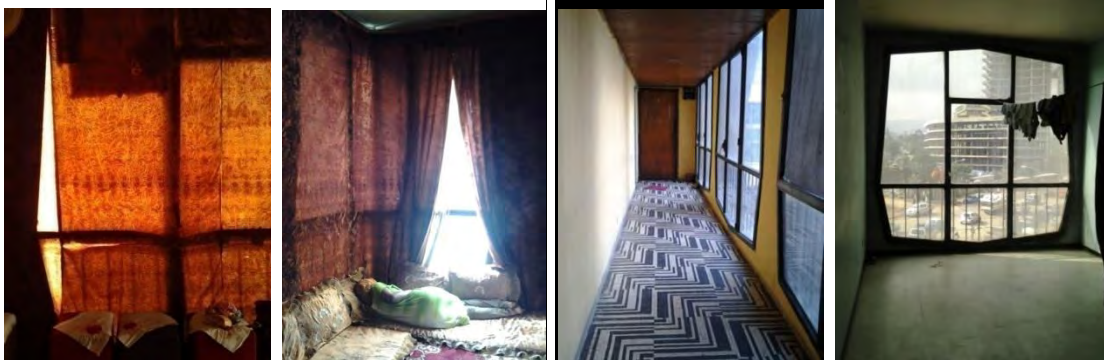


Figure 3- 31 Direct harsh sun rays entering the interior space window location of interior spaces

### 3.8.3.2 WINDOWS AND LIGHT

Having too much windows does not only let in light but the material (glass) has poor thermal capacity. And with building that faces the harsh sun, this is a bad combination (fig 3-32).

### 3.8.3.3 MICROBIAL GROWTH, VENTILATION AND DAMPNESS

If the people in the building open their windows a stream of heated sun rays will enter their houses unblocked. Thus, they will not open the building due to this reason the inner rooms are stuffed and unventilated with unpleasant smell.



Figure 3- 32 Dampness caused by leakage and dampening of garbage near the play area

Dampness is also a problem that is caused by low maintenance and design faults as seen in the pictures below. Especially on the third floor there is a series case of dampness and.

### 3.8.3.4 GREEN INFRASTRUCTURE

The building's surrounding has no greeneries on it. Plants are important to this building because they can shade it from the harsh sun.

#### **3.8.3.4.1 GREEN ROOF**

The building has no greeneries on the flat roofs.

#### **3.8.3.4.2 GREEN WALLS**

Balconies and façades, though it is very important, do not have the frame work or the treatment to support greens. During the summer time had the building supported greeneries it would have been shaded from the harsh afternoon sun.

#### **3.8.4 ENERGY CONSUMPTION FINDING**

As for Bedelu Hentsa it does not have any supplementary energy source. Not only they didn't use renewable energy but also their knowledge of bio gas is limited.

#### **3.8.5 WATER RESOURCE FINDINGS**

Water is very scarce around this area. The building experiences this first hand because it does not have water tank for reservoir. But still they do not consider using rain water or reusing or recycling water.

#### **3.8.6 WASTE MANAGEMENT FINDINGS**

Waste is collected and damped on the back yard inappropriately (fig3-33). This is wrong for two reasons,

1. Health issue
2. Aesthetic issue

#### **3.8.7 BUILDING MATERIAL**

The building is built from concrete. Concrete is a very strong material that has a long life span in the history of Ethiopian building materials.

##### **3.8.7.1 DURABILITY**

It is oblivious that the building material is of strength and durability. It has lasted the past forty years functioning and giving service. But the questions are

1. How long will it continue to function
2. What could be done to further its age of function

### **3.9 MINISTRY OF TRADE**

Area -----

Function – Office Building

Ownership – Governmental

Location – Kir Kos Sub City

Woreda- 15

#### **3.9.1 BUILDING SITING & ORIENTATION**

The ground plus eight governmental building is one of the oldest office buildings that could be exemplary for its strength & durability. The building is located in front of the road leading from

*Kas-anehiz to Mexico* facing the beautiful garden of Hilton hotel. The building faces north direction.

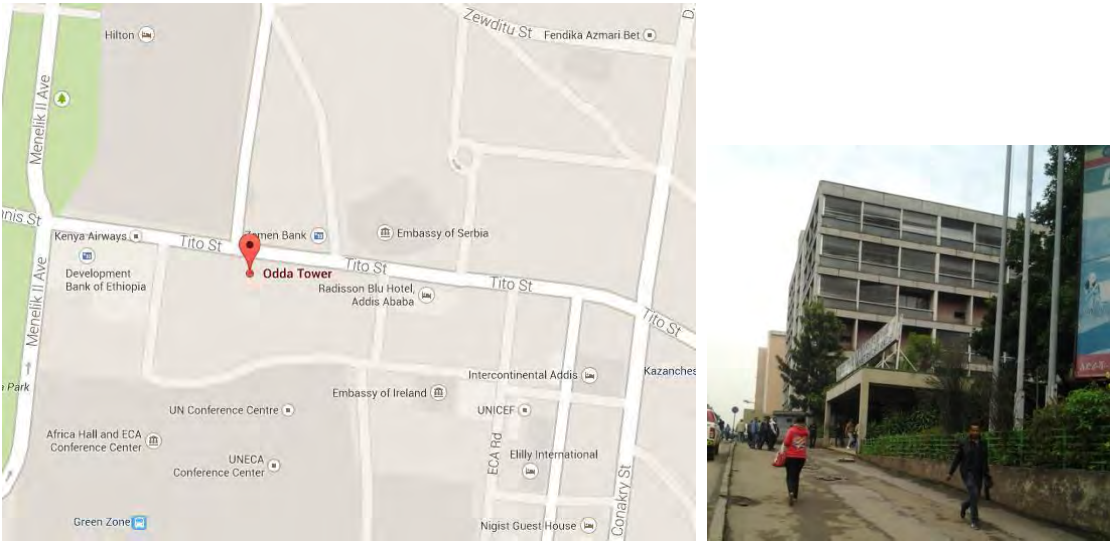


Figure 3- 33 Location of Ministry of Trade

Source: Google Map

**3.9.2 BUILDING FUNCTION & DESCRIPTION**

The first basement is accessed directly the right side ramp of the building. But it can also be accessed with internal stairs even though that is not suitable for disabled people. The function of this basement is for parking only. The lower second basement is used as a garbage disposal it is in unhealthy way this is disposed. On the ground the national bank of Ethiopia is located. As one move further in he/she finds three elevators & one stair case. And also its hard to pass without mentioning that the corridor & stair case both are artificially lighted & are not ventilated.



Figure 3- 34 Entrance of the building (left) and rough presentation of typical floor plans of Ministry of trade (right)

### 3.9.3 INDOOR ENVIRONMENT FINDINGS

#### 3.9.3.1 TEMPERATURE OF THE BUILDING

There are some out comes due to the fact that the building faces the southern direction. Respondents in the spaces that face northern direction claim that the building is very cold all year round. But respondents that face the southern direction said that it gets warm during the summer time & regular during winter times. When very hot the occupants cannot open the windows due to the glare of the next building

#### 3,9.3.2 LIGHT & WINDOWS

Stated in the above section that reviews the architectural, functional lay out, the stair & toilets do not have windows that can be used to light them up. Artificial lights are used. On the contrary the office spaces have large windows that let in enough light but can't protect users from the glare of the newly built buildings on the next site. Glare seems to be a problematic barrier in the building.



Figure 3- 35 The use of artificial light during day time

#### 3.9.3.3 VENTILATION, DAMPNES & MICROBIAL GROWTH

Since the toilet does not receives natural light due to the absence of windows it is suitable for microbial growth to occur on the wet surfaces of the toilet. Also leakage & faulty installation of pipes are witnessed. And the corridor as a whole has a damp smell to it.



Figure 3- 36 Microbial growth and dampness in the toilet

### 3.9.3.4 GREEN INFRASTRUCTURES

The building's greenery is one of the defining features of the area. The properly maintained and kept green area adds up to the beauty and the sustainability of the total location. The greenery includes *Zembaba*, lawn (grass) and more.



Figure 3- 37 Green infrastructure around the building

### 3.9.4 ENERGY CONSUMPTION FINDING

Even though the building is governmental it is not immune to the current fluctuation of power(light).but still nothing has been done to prevent loss of data in computers & machines due to this fluctuation of power.

### 3.9.5 WATER CONSUMPTION FINDINGS

There are two toilets on each of the ten floors that mean twenty wet spaces depending on water to be cleaned. The building has a tank reservoir for case of water loss. But when tank water is also finished there is no other permanent back up.

### 3.9.6 WASTE MANAGEMENT FINDINGS

The second basement, as stated above serves as an informal garbage disposing spaces. now, this floor support garbage's that are

1. not sorted
2. both wet & dry
3. Composed of recyclable &non- recyclable garbage's.

This results in foul smell.

### 3.9.7 BUILDING & MATERIAL

The building material, just as the rest of the strong buildings is concrete. But one has to take a closer look at the floor finishes and wall finishes.

Carpet - dusty and adds to the stuffy smell of the corridors. Also have particles that are light and easily volatile that could cause breathing infections.

Paint - dirtied by long years of usage, has volatile particles that could cause breathing problems.

### 3.9.7.1 DURABILITY

It is a known fact that the building is very strong and still has decades of further functional life. Despite of the finishing materials described in the above section (carpets & paints). But if a step is taken to fix such toxic material it can have even more years to survive.

### 3.10 SHEGER HOUSE

Area - 4000m<sup>2</sup>

Function – Shopping mall and office building

Ownership - Private

Location – *Bole Medhanialem* (Bole Sub City)

Woreda – 03

#### 3.10.1 BUILDING SITING AND ORIENTATION

The eight story building is a well know structure supporting many shops, the famous la Parisian café and many more offices. It is located on the road that connects *Kaz Anchiz* and *Bole Medhanialem*. This road is oriented from North to south with somehow a slight slanting. The building's front façade faces the North East direction having the advantage of morning sun that is proven to give needed energy boost to all living organisms.

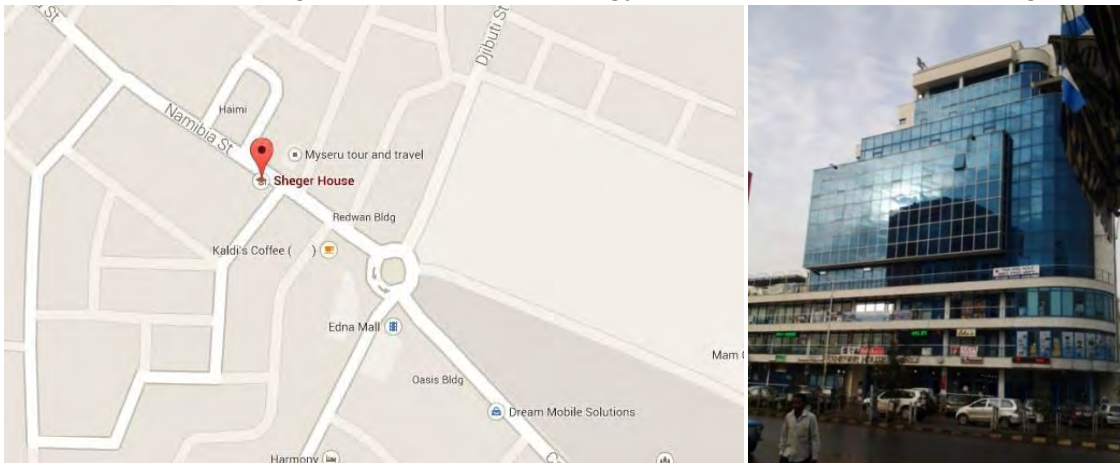


Figure 3- 38 Location of Sheger House

Source: Google map

#### 3.10.2 BUILDING FUNCTION AND DISCRIPTION

Having three entrances on the ground, the *Sheger House* building uses one of the entrances for bank access only. The famous café *la parizian* is also located on this floor. Though the building has basement floor, it does not use it for parking which is the case in many other buildings. The basement is occupied by the night club *Yougovia*. In total there are 19 shops on the ground that range from small to large. On the first floor almost 14 shops are available. Second floor there are 16 shops that function well. And the third floor is owned by Dr. Sahele Selassie Araya Dental Clinic.



Figure 3- 39 Interior spaces of the Sheger House, open down, sky light, shop collider and office collider (from left to right)

After the fourth floor the building becomes an office building. Each floor has seven to eight offices (fig. 3.41). The building has one elevator and a regular stair. Also fire escape is available. There is a wooden stair that connects the ground floor to the first floor. As shown in the above pictures, this stair is located in the middle of the open down. The sky light is located on the roof of second floor. This brings light into the three floors down.

### 3.10.3 INDORR ENVIRONMENT FINDINGS

The building has many design facts that lead to certain conclusion in terms of light, dampness, ventilation, temperature etc.

#### 3.10.3.1 TEMPERATURE OF BUILDING

Respondents found in the left of the building claim to experience a cold and chill indoor environment due to the excessive use of curtain wall. And respondents in the right wing of the building have explained that they experience a bit warmer indoor air quality. This statement is designated in the below diagram that shows that the blue arrow is the side of the building that is cooler and the red one is the warmer side. The doors are those that show the entrance to those offices that have explained the above statement.



Figure 3- 40 Temperature difference of the building

#### 3.10.3.2 WINDOW AND LIGHT

*Sheger* Building though there are enough windows that let in light, occupants still turn on the light.

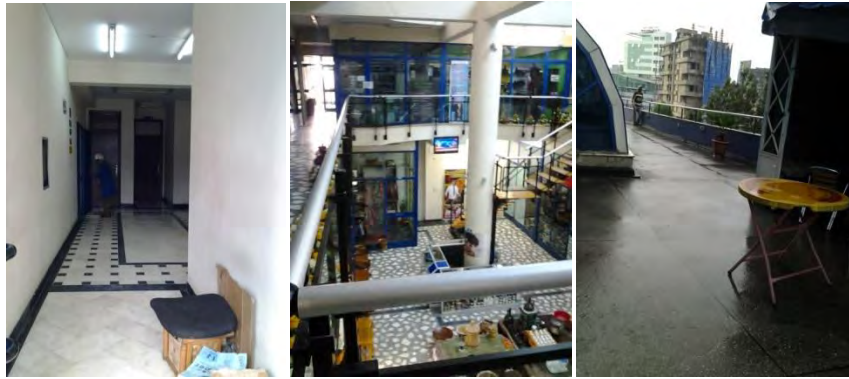


Figure 3- 41 The use of artificial light during day time on the left and terrace on the fourth floor on the right

The collider that leads to the offices does not receive natural light thus it is lighted in an artificial manner. This consumes more energy and is very costly. The main aim of a good design is using the opportunities the site provides and turning them into advantages. If a building has enough windows it should be able to use them to full advantage.

### **3.10.3.3 MICROBIAL GROWTH, VENTILATION AND DAMPNES**

The second floor roof slab is exposed to the outside environment. This leads to the exposure of rain and sun. The offices directly below the floor have experienced a mild case of dampness and leakage. When one goes from the third floor to the fourth he/she may notice that the location of the toilet is somehow shuffled to the left. This has caused more pipes to be used as an extending system and also the area underneath the fourth floor toilet susceptible to leakage. It is a sanitary design fact that when drainage lines do not follow a regular pattern they tend to consume more pipe lines (costly) and also leakage is most likely to happen.

### **3.10.3.4 GREEN INFRASTRUCTURE**

There is no green infrastructure witnessed on or around the building. It's such a shame because the building has spaces for such systems both inside and around it.

#### **3.10.3.4.1 GREEN ROOF**

The second floor roof extends into unoccupied large terrace that could be used as a green roof system. This system not only produces plants it can also solve the problem of leakage that has occurred on the lower floor.

#### **3.10.3.4.2 GREEN WALL**

The building's balcony does not have any plants and this is also a waste. The building is not using what already has at its disposal.

### **3.10.4 ENERGY CONSUMPTION**

Almost every artificial light in this building is turned on during the working hours of the day.

In addition to the regular electronics, those occupants that occupy the right wing of the building cool their office by the use of mechanically ventilating machine. This is due to faulty design lay out resulting in additional cost for amendment.

### **3.10.5 WATER RESOURCE MANAGEMENT**

Water is consumed in many of the activities. The building uses clean water for toilets and washing items. The company cars also use clean water for washing.

### **3.10.6 WASTE MANAGEMENT**

The waste management of *Sheger* House is just like the rest of big buildings seen in Addis Ababa. First each shops and offices collect garbage from their spaces and then put it in the basement. Then the door to door collectors would take the collected garbage.

### **3.10.7 BUILDING MATERIALS**

The building is built from HCB and curtain wall. The two building materials could work well if they are managed and constructed according to a well studied design.

#### **3.10.7.1 DURABILITY**

It is a well known fact our capital is swarming with curtain walled buildings that require management application every now and then. Curtain walls are mostly applicable in cities where they do not get enough light. Our city does not have such problems. It receives thirteen months of sunshine. Many of our buildings apply curtain walls due to their cost. They are cheap relatively. Though there is a wide application of curtain wall is seen in the capital, their installation is still imperfect. This causes the shortening in the life span of the material.

### **3.11 TOMMY TOWER**

Area – 2000m<sup>2</sup>

Function – Office Building

Ownership – Private

Location – Bole Sub City

Woreda-

#### **3.11.1 BUILDING SITING & ORIENTATION**

On the road to the newly built African avenue one can't help to notice the fully glazed building of Tommy tower. The building is erected immediately next to African bank building facing the northern (slightly slanted) direction. The building has the total of nine stories including the ground.

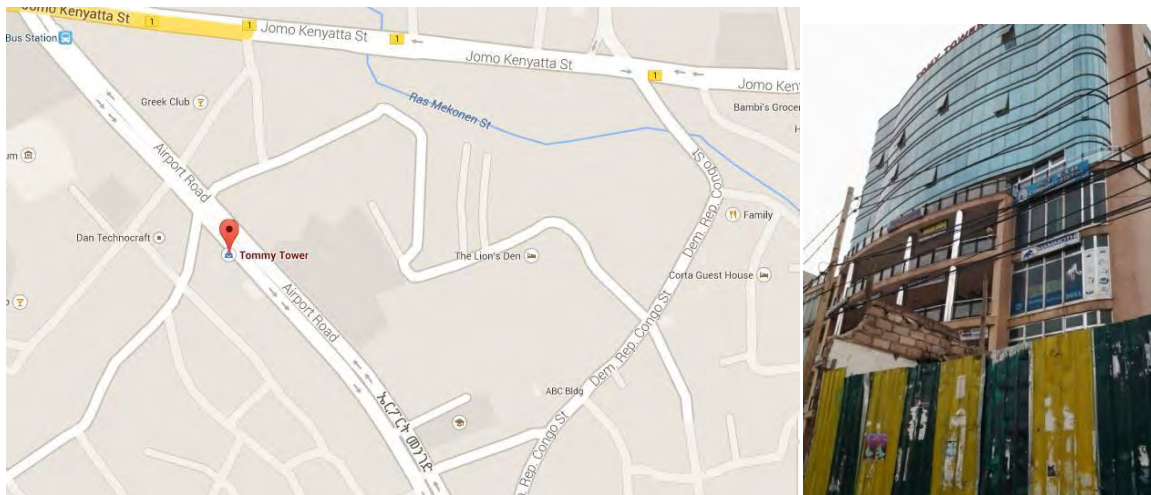


Figure 3- 42 Location of Tommy Tower

Source: Google Map

### 3.11.2 BUILDING FUNCTION & DESCRIPTION

The ground floor supports nine shops including a large furniture store & *Kaldi's* Coffee (previously). The building fully glazed, is sufficiently lighted. As we move to higher floors (1<sup>st</sup>-3<sup>rd</sup> floor) we find shops ranging from kiosk to very large size. These are ten in number. But on the fourth floor there is only one rentable space. The upper floors are office spaces ranging from 5-7 in number. There are two stairs including fire escape and there appears to be a shift in toilet passion on the ninth floor which may cause drainage problem on lower floors.

### 3.11.3 INDOOR ENVIRONMENT FINDINGS

#### 3.11.3.1 TEMPERATURE OF THE BUILDING

The building, since built from curtain walls and is north facing resulted in being very cold all year round.

#### 3.11.3.2 LIGHT & WINDOWS

Building is much lighted (sufficiently). These types of building can be exemplary when it comes to windows & lighting. Since there is no high raised building in front of it there is no glare. If there had been glare, the respondents would have been vulnerable.

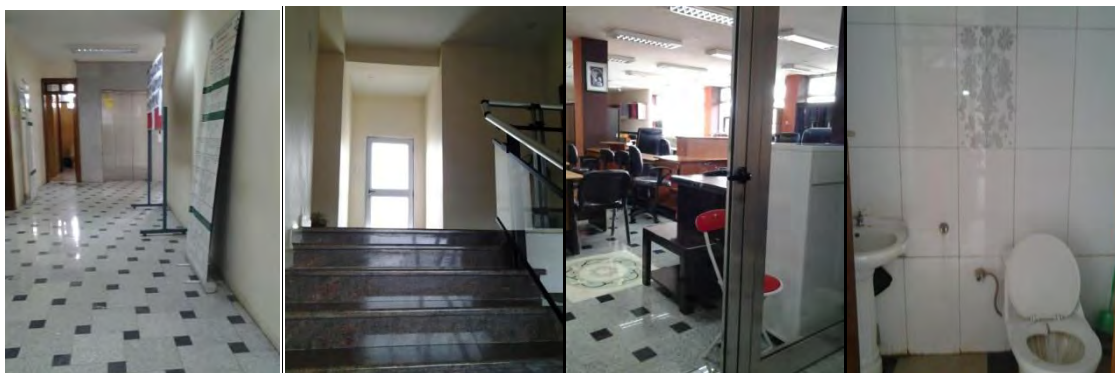


Figure 3- 43 Interior spaces of the building, lobby of the top floor, lighted stair case, shop space on ground floor and ventilated toilet

### **3.11.3.3 VENTILATION, DAMPNES & MICROBIAL GROWTH**

Since the building is new, it is very early to check. (There is too much ventilation).

### **3.11.3.4 GREEN INFRASTRUCTURES**

There are no green infrastructures that could be considered to be functional in or around the building.

### **3.11.4 ENERGY CONSUMPTION FINDING**

There are no precautions taken when power is off for days. The trend in our country has not changed when it comes to renewable energies.

### **3.11.5 WATER CONSUMPTION FINDINGS**

Same holds true as it is in energy in water consumption. Recycling water & reusing it has not been applied in this building. For example-each floor has two toilets each releasing six lit per a press. Multiplying that by number of floors we find that  $2*6*9 = 108$  lit per usage. And on average each toilet may be used twice a day. This will result in 216 lit/day every day and this is clean water.

### **3.11.6 WASTE MANAGEMENT FINDINGS**

The regular door to door collection is applied in Tommy Tower.

### **3.11.7 BUILDING & MATERIAL**

The curtain wall & HCB is the main building material of the building. Floor finish of the building is the one element that should be focused on because it is the element that adds to the cooler indoor element.

## **3.12 NEGA CITY MALL**

Area – about 1500m<sup>2</sup>

Function – Mixed Use Building

Ownership – private

Location – *Kir Kos* Sub City

Woreda – 15

### **3.12.1 BUILDING SITING AND ORIENTATION**

In the today Addis Ababa, *Kas- anchiz* can be considered a district where large city malls and well known Hotels could be found. Hotels like Radisson Blue and Intercontinental are located in the same area. *Nega* City Mall is also located in the same district as those famous buildings. Area commonly known as Super Market is where this building is located, to be specific.

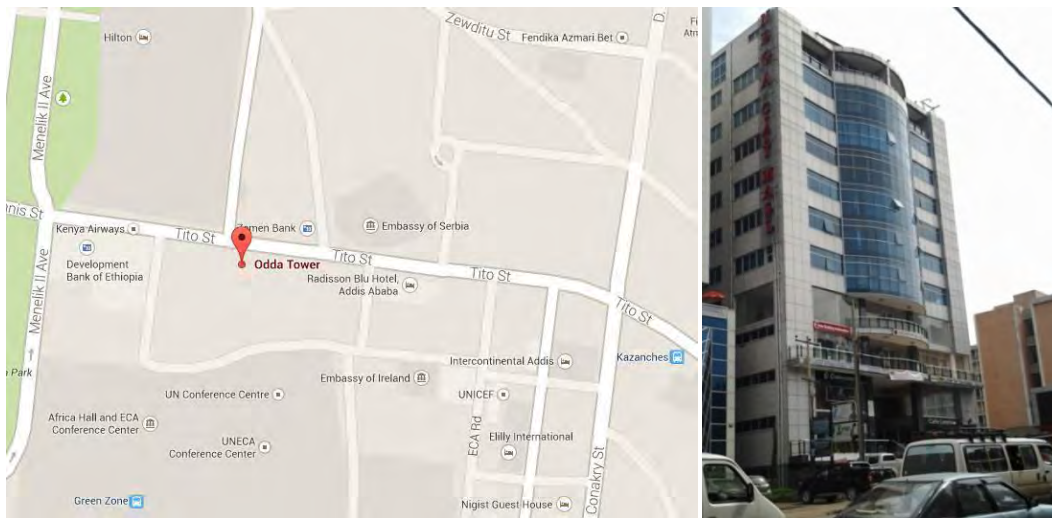


Figure 3- 44 Location of Nega City Mall

Source: Google Map

Following the road from *Flowuha* to *Kas-anchiz*, the ground plus nine building can be viewed standing next to the *Odda* tower.

### 3.12.2 BUILDING FUNCTION AND DESCRIPTION

The building has both front yard parking and basement parking that shows a very well thought architectural design. And as one enters the lobby he/she overwhelmed by the richly lighted lobby, which also tells the consideration put into the design. The semi basement of the building supports bank.

A person taking coffee could easily see or have a visual contact with the upper floors due to the open down. Also the light that enters through the lobby can easily diffuse to the upper floors. The ground floor and the mezzanine floor each have 20 shops. The above floors also on average have 23 to 25 shops. From 4<sup>th</sup> to 9<sup>th</sup> floor the office range from 11 to 12 on each floor. Function like toilets and stairs are easily accessible and clearly located with disable access. The number of toilets is proportional to the rest of the building which shows an appropriate consideration taken for the building. Both toilets and stairs are lighted well.

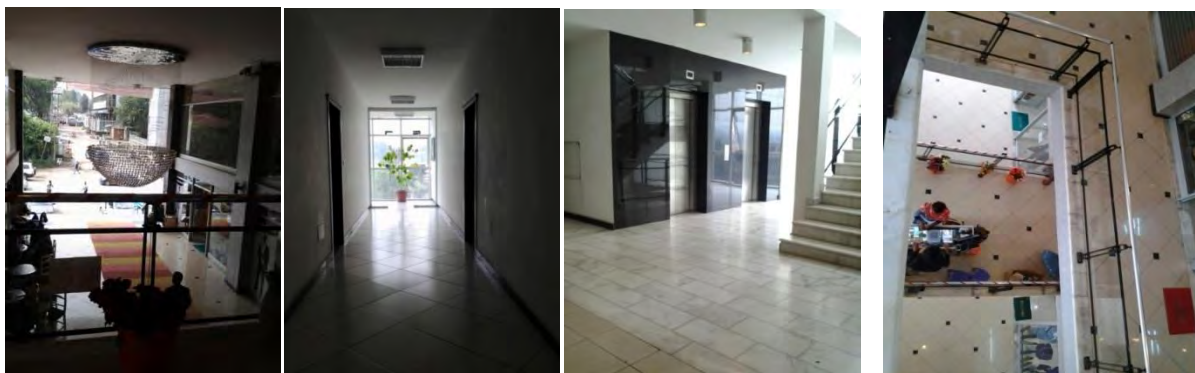


Figure 3- 45 Interior spaces of Nega City Mall, lobby of the building, lobby of the office level, elevator area and open down (left to right)

### **3.12.3 INDOOR ENVIRONMENT FINDINGS**

The building has its own character that is the collective result of all the designing features including orientation.

#### **3.12.3.1 TEMPERATURE OF THE BUILDING**

The appropriate use of windows and thermal masses has resulted in the appropriate stabilization of temperature within the building.

#### **3.12.3.2 WINDOWS AND LIGHT**

Function like toilets and stairs are easily accessible and clearly located with disable access. The number of toilets is proportional to the rest of the building which shows an appropriate consideration taken for the building. Both toilets and stairs are lighted well. The building's lobby, shops, café and circulations are all lighted naturally. The day time provides endless supply of light for the inner environment.

#### **3.12.3.3 MICROBIAL GROWTH, VENTILATION AND DAMPNES**

The regular unmaintained toilet we see in most of our city's building is not seen in this building. But still if not maintained well the result will be same the rest.



*Figure 3- 46 Microbial growth free toilet*

#### **3.12.3.4 GREEN INFRA STRUCTURE**

The building has no green infrastructure that could be considered useful and functional. This is the only downside of the building.

#### **3.12.4 ENERGY CONSUMPTION FINDING**

The building has no alternate means of energy supply.

#### **3.12.5 WATER CONSERVATION FINDINGS**

Consumers of the building use clean water for the toilets, washing items and also cars. The means of reusing recycling and collecting still eludes them.

#### **3.12.6 WASTE MANAGEMENT FINDINGS**

Waste, as many of mixed use buildings happen to do, is collected in each functional space and then put in the basement for door to door collectors to collect. One can imagine the amount of garbage taken out from a thirteen story building (basement + semi basement + ground floor + ten upper floors including mezzanine floor).

### 3.12.7 BUILDING MATERIAL

The building is of concrete and curtain wall.

#### 3.12.7.1 DURABILITY

Built in recent times (three or four years), a lot can't be said about the durability of this building. But since we know what shortens the life span of we can estimate the life span of this building.

1. Maintenance
2. Repairing
3. Protecting
4. Follow up

The above actions can elongate the life span of any buildings. One of the causes of damage to the building is people. And people damage buildings when they lack some sort of necessity. If most of the necessity is already presented people do not have a reason to damage a building In order to mend any problem.

### 3.13 FRIENDSHIP CITY CENTER

Area – 5000 Sqm

Function – Mixed Use

Ownership – Private

Location – Bole Sub City

Woreda – 02

House Number – 5591

#### 3.13.1 BUILDING SITING AND ORIENTATION

The building is located in bole sub city. It is one of the recently built structures in Addis Ababa. The ground plus nine building is oriented to face the slanted southern direction. The building site is a very good location for mixed use building.

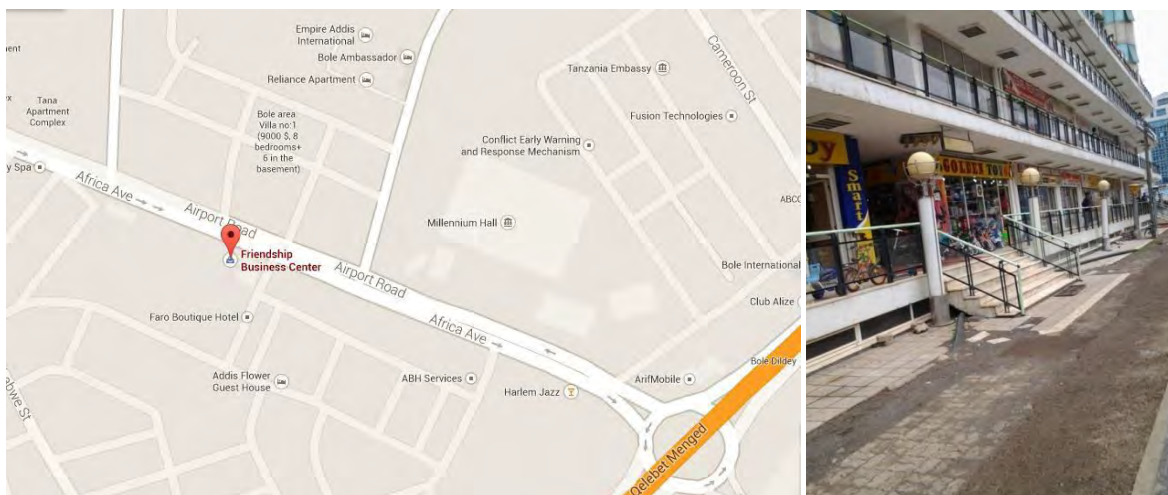


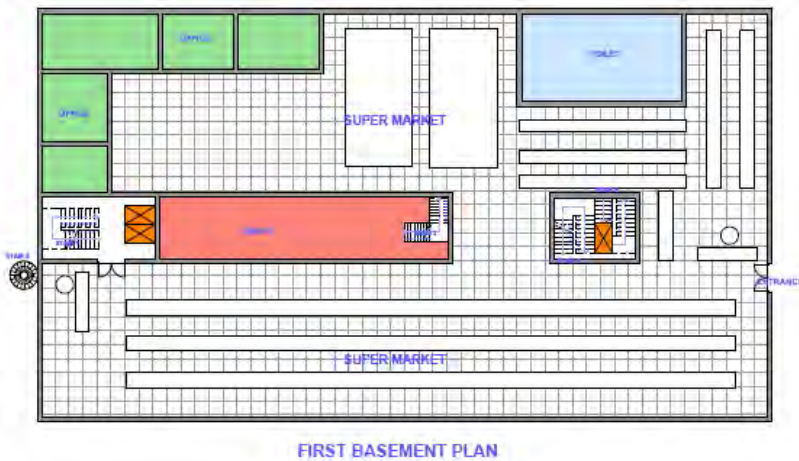
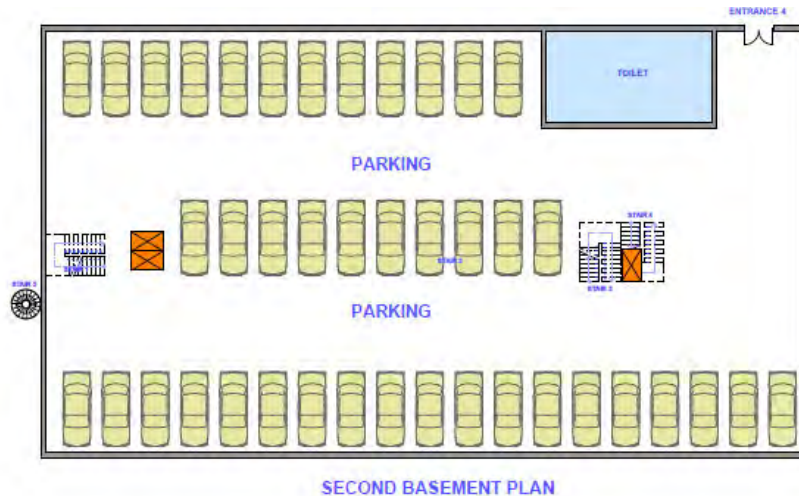
Figure 3- 47 Location of Friendship City Center

Source: Google source

### 3.13.2 BUILDING FUNCTION AND DESCRIPTION

The ground plus nine building has two basements that can be both accessed from the outside. As seen in the floor plan shown, the basement show area can be accessed only from stair case A. the second basement in the building could be accessed from stair case B. the first basement which is a super market could be accessed from stair case only.

There are two entrances to the ground floor and they are composed of 4 steps. The ground floor has 33 shops. And the first floor has 30 shops which also includes the large Awash Bank. The second floor has 36 shops. The building's toilet is artificially lighted as can be seen in the below figure.



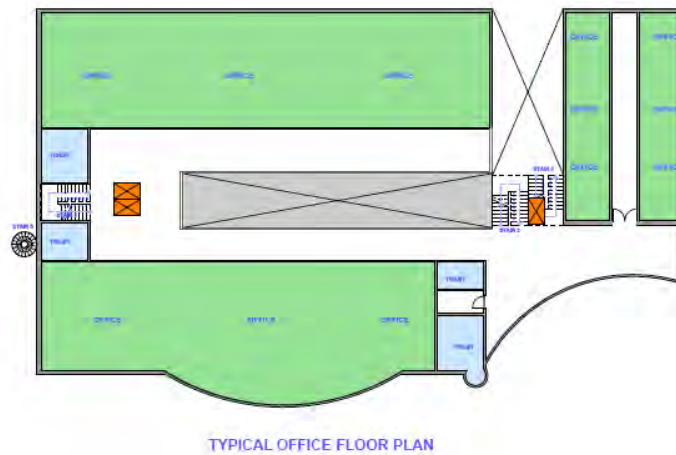
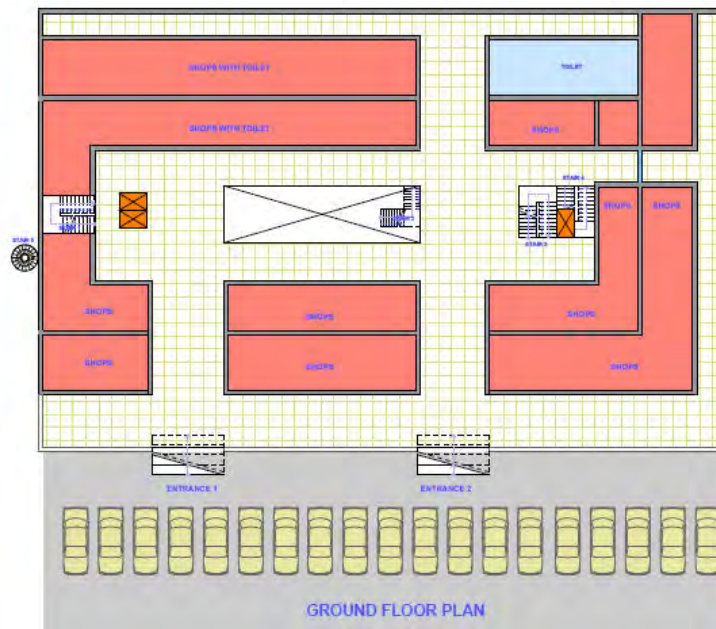


Figure 3- 48 Illustration of floor plans of Friendship City Center

### 3.13.3 INDOOR ENVIRONMENT FINDINGS

#### 3.13.3.1 TEMPERATURE OF THE BUILDING

The curtain wall has a huge effect in the indoor air quality. The respondents claim that it gets a lit bit warmer during the afternoon. Temperature is higher when the harsh sun enters through the sky light.

#### 3.13.3.2 WINDOWS AND LIGHT

The building's toilets do not have the proper windows that could let in the natural light necessary for one see the function that takes place in the space. Also some of the inner shops do not have windows, thus they use artificial lights for the working hours of the day. In the above floors the right side toilet does not have enough light. These are also important because it is related with ventilation. But the sky light aided the lighting situation significantly. Though there is effect of glare due to the sky light, it has also helped in naturally lighting the lower spaces.



Figure 3- 49 Interior space of the building, sky light and toilet (from left to right)

### 3.13.3.3 MICROBIAL GROWTH, VENTILATION AND DAMPNESS

It is obvious that without light and window a space will inevitably become congested. The respondents claim that the toilet smells sometimes and also has leakage problem (fig 3.51)

### 3.13.3.4 GREEN INFRASTRUCTURE

Though it has flat roof perfect for Green Roof the building has no greenery on the roof. And also the curtain wall that can support Green Wall has no greenery.

### 3.13.4 ENERGY CONSUMPTION FINDINGS

The building uses no renewable energies. The respondent's knowledge about bio gas and renewable energies is surprisingly low. It is very disappointing.

### 3.13.5 WATER CONSUMPTION FINDINGS

The building uses clean water for car wash, toilet and other secondary activities that do not necessarily need clean water. In this era where water stress is abundant, it is quite clear that the current trend of water consumption is unsustainable and 'ungreen'.

### 3.13.6 WASTE MANAGEMENT FINDINGS

The backyard at basement level is where waste is disposed. The composition ranges from plastic to organic. The offices mostly dispose of paper and plastics. The shops mostly dispose of plastics and the restaurants and cafes organic matter. They do not sort, remanufacture, reuse or recycle the waste matter.

### 3.13.7 BUILDING MATERIAL

As discussed in the above sections (repeatedly), the unnecessary usage and installation of curtain walls has led the material to be a weak building material.

#### 3.13.7.1 DURABILITY OF MATERIAL

The weak installation has proved to have cracks and regular fixing of the material. As most people tried to make the indoor air quality to their satisfaction (it is originally uncomfortable due to glare and low thermal resistance character of curtain wall) they tend to take uneducated measures hindering the durability capacity of the material.

### 3.14 DH GEDA TOWER

Area - about 3000m<sup>2</sup>

Function – Shopping mall and office building

Ownership - Private

Location – Bole Road (Bole Sub City)

Woreda – 02

#### 3.14.1 BUILDING SITING AND ORIENTATION

Owned by *Ato Dugma Hunde Geda*, the Ground plus eleven building is located on the main street that leads from *Bole* to *Bole deldey* (bridge). The building front façade faces the slightly slanted south west direction. As shown in the map below, the building is located on Africa Avenue. There is no sign of tree or vegetation that proves to be providing any function for the building itself.

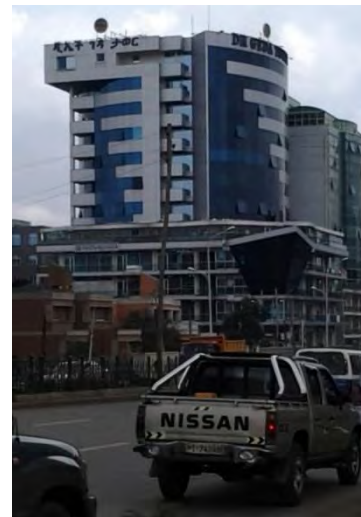


Figure 3- 50 Location of DH Geda

Source: Google map

Its iconic larger than life sculpture is one of a kind and gives its location a rather familiar feeling that is known by all passer bys.

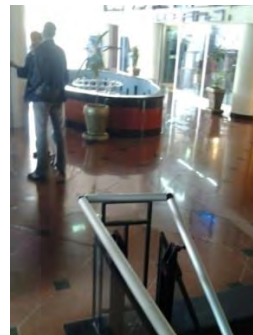
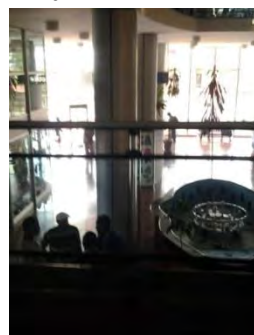


Figure 3- 51 DH Geda Building lobby

### 3.14.2 BUILDING FUNCTION AND DESCRIPTION

Designed by Architect *Mesfin Mulugeta*, the thirteen story building has many features that make it stand out. Its sculpture being one of those defining characters, the other is its huge diamond shaped glass volume hanging from the first floor. This volume solely functions as a food court.

The basement function as parking space in addition to the space in front of the building which is where most customers park when they are in a rush or when they want to have a cup of coffee from the famous *Kaldi's Coffee*.



Figure 3- 52 Illustration of floor plans of Friendship City Center

As one enters the lobby the enormous fountain pool welcomes his/her eyes (fig 3.55). The ground has nine shops including *Kaldi's Coffee*. The mezzanine floor has seven shops. The first floor has ten shops that are rented. Balcones are integrated from the first floor to fourth floor. The second and third floors have twelve to fourteen rentable shops. The open down

starts from the fourth floor showering the lower floors with natural light. This is a good call taken by the Architect since it's known that a sky light is the best way to let sufficient light into an enclosure. The upper office floors have six to eight offices on each story. With its two stairs well lighted naturally, the DH Geda building also has sufficient number of toilets for both male and female.

### **3.14.3 INDOOR ENVIRONMENT FINDINGS**

A lot could be said basing our findings on the functional lay out, orientation, siting, opening direction and numbers and so and so. The systematic research used for such reports must be undertaken thoroughly. This is to assure what have been collected and interpreted can be depended upon. The data collected from respondents is one way of deducing on a finding. The other is personal observation and cross checking that observation with certain standards.

#### **3.14.3.1 THE TEMPERATURE OF THE BUILDING**

“Though the plan is very clean and does not create any ambiguity, ” says Ato Dawit, who owns an underwear store in one of the kiosks on the lobby, ‘it is very difficult to run a business on this particular spot where the cross ventilation meets causing a breeze that is chilling.’”

#### **3.14.3.2 WINDOWS AND LIGHT**



*Figure 3- 53 Toilets in the building stair case and open down windows*

The pictures seen above are the stair, the open down and lobby area respectively. It is clear that there is sufficient light that seem to reach every corner of the building.

#### **3.14.3.3 MICROBIAL GROWTH, VENTILATION AND DAMPNES**

The building exhibits (collected information from respondents) no microbial growth or dampness.(fig 3.55).

#### **3.14.3.4 GREEN INFRASTRUCTURE**

The site has been cleared during construction so there is no green infrastructure seen at present time.

##### **3.14.3.4.1 GREEN WALL**

Though building's balconies have a little of potted plants on them they are not enough to shade the large the highly glazed building causes. Since more than 85% of the building is covered with curtain wall the building is bound to have glare. One way of preventing or protecting users of a building from glare is having a green wall. This in turn will help in the trap of UV rays also.

#### **3.14.3.4.2 GREEN ROOF**

The building has a flat roof, perfect for a green roof to sustain on it. But as it has been witnessed in many of the capital's buildings, it has no structure remotely related to a green roof.

#### **3.14.4 ENERGY CONSUMPTION FINDINGS**

Respondents claim that they do not use renewable (alternate) energy or they do not recycle such green energies. Their knowledge about bio gas is limited and very scarce to apply in the building condition. The building function varies in a way that energy is highly consumed in a daily basis. And most of the boutiques use artificial lights for display and restaurants use machines and stoves. This function increase the use of energy.

#### **3.14.5 WATER RESOURCE MANAGEMENT**

Water for the fountain, water for toilets, water for washing the company cars are all clean water. No recycling, no reusing. This adds to the cost of continuing function.

#### **3.14.6 WASTE MATERIAL MANAGEMENT FINDINGS**

Door to door collection is applied when it comes to waste matter management. Then those collectors dump the waste elsewhere. Not really managing anything. Most of the waste produced is food matter and paper. Both are decomposable organic matters that could be reused to serve for many services.

#### **3.14.7 BUILDING MATERIAL**

The building is built from HCB and curtain wall. As stated above in previous sections, the two building materials could work well if they are managed and constructed according to a well studied design.

##### **3.14.7.1 DURABILITY**

It is a well known fact our capital is swarming with curtain walled buildings that require management application every now and then. Curtain walls are mostly applicable in cities where they do not get enough light. Our city does not have such problems. It receives thirteen months of sunshine. Many of our buildings apply curtain walls due to their cost. They are cheap relatively.

### **3.15 MEDHANIALEM MALL**

#### **መድሃኒያላሌም ጥል**

Area - about 5000 m<sup>2</sup>

Function – Shopping mall and office building

Ownership - Private

Location – *Bole Medhanialem* (Bole Sub City)

Woreda – 03

##### **3.15.1 BUILDING SITING AND ORIENTATION**

The buildings got its name from the church in front of it across the street. Holy Savior Church which is known as *Medhanialem Bet Christian*. As a matter of fact, the whole area is named

after this church built in the form of a Gothic style. This building stands in the side along with, *Sheger House*, *Edna Mall*, *Mafi City Mall* (a little further away). It is also oriented in the same direction as *Mafi City Center*, which is its frontal façade in the East direction.

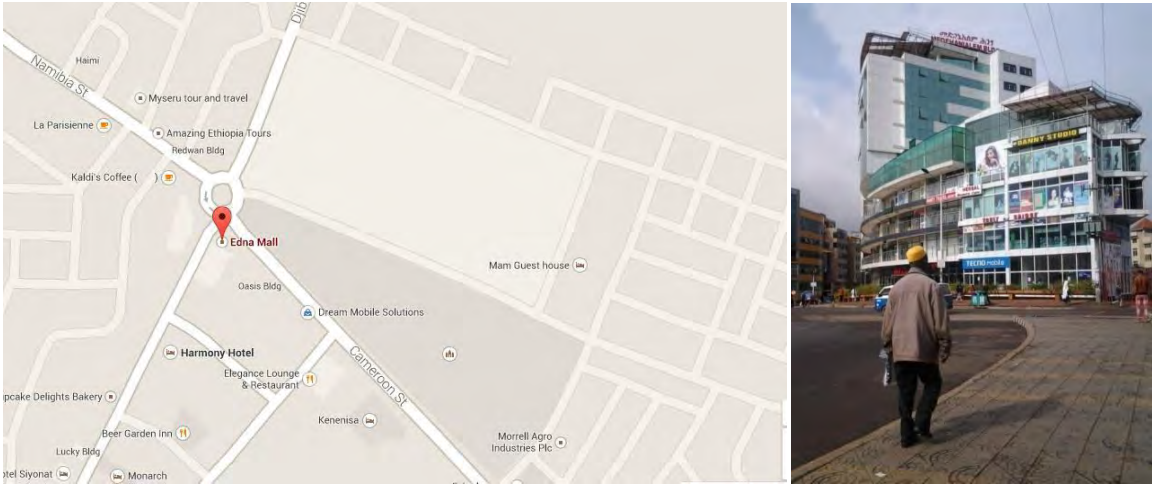


Figure 3- 54 Location of Medhanialem Mall

Source: Google Map

**3.15.2 BUILDING FUNCTION AND DESCRIPTION**

The ground floor supports 5 huge shops. One is techno mobile display (show) room, second is a well known fast food café called MY BURGER, the other is a coffee shop named Caravan, and the rest are large cloth and jewelry shops.

As we move in, the lobby is very wide and relatively darker. But the easily accessible lifts and stairs make it is simple to experience the whole building. The intricate spaces and plans are very complicated but without purpose. The building has many spaces and pockets that are simply unreadable and unfriendly. The basement access is, for instance, found not directly under the stair leading to the ground floor but after we step down a stair of 4 steps and then a pathway leading to the hallway to the basement.



Figure 3- 55 Lobby, sky light and basement access of Medhanialem mall

The first floor supports almost 35 shops and does not seem to change all through the third floor. The huge show room on the fourth floor is generously lighted by the curtain walls of the façade and also the sky light.

The surprising fact of observation was that even though there was a huge sky light that is located at the roof of the fifth floor the building's corridors and shops still use artificial light during day time. But this and more issues will in fact be discussed under the next section. But one can't help mentioning such conditions in relation to faulty architectural designs.

The mostly unoccupied upper floors of *Medhanialem* Mall seem to promise renters sufficient square meter areas but with difficulty of accessibility. The intentionally and intricately formed rooms either have missed their target of being interesting or exciting. The ratio of circulation and usable space has been tempered with in this building. The open down seems to have take a lot of space than necessary. But likely the open down is up to the fourth floor. The upper floors have enclosed circulations. With 25 offices on average, each floor has more or less the same system of space formation.

### **3.15.3 INDOOR ENVIRONMENT FINDINGS**

Such matters like light, windows, ventilation, dampness and microbial growth within and enclosed structure is discussed under this section.

#### **3.15.3.1 TEMPERATURE OF THE BUILDING**

Most of the rear side of the building experiences the harsh sun. This is a disadvantage because this is accompanied by lower sun rays that are very difficult to be shaded from. The rooms that are exposed to such rays of the sun must be designed wisely. In many similar cases, Green Buildings do apply Green infrastructures in order to reduce temperature.

One of the occupants of the office, Ato *Hayelom Berhe*, has kindly offered to help in the research program. He stated that due to the orientation and the building material of the building, during peak working hours, he experiences glare and uncomfortable warmth. Because of much exposed glazing to the sun, heat is greatly observed and contained. This problem causes discomfort.

#### **3.15.3.2 WINDOWS AND LIGHT**

Curtain wall is our city's second leading building material. Most of our buildings are built with curtain walls. These large scaled windows actually function as large in let of light. As lightly discussed above, though there are windows available, due to faulty allocation and design, users of the building still use artificial light during day time (fig 3.58).

#### **3.15.3.3 MICROBIAL GROWTH, VENTILATION AND DAMPNES**

The inner walls of the panoramic lift are exposed to wet surface (caused by an identified reason). These walls are comfortable enough to support microbial organisms that cause mild to serious cases of diseases.

### **3.15.4 ENERGY CONSUMPTION FINDINGS**

There are no alternative sources of energy to support the vastly different functions of the building.

### **3.15.5 WATER RESOURCE CONSUMPTION FINDINGS**

The toilets and basins of each floor use clean water that is not recycled or reused. And though they often experience stress in water supplies, they do not feel the need to look for a system to reduce such shortcomings.

### **3.15.6 WASTE MATERIAL MANAGEMENT FINDINGS**

The building collects all its waste at its basement. After that door to door collectors come and collect it from the basement.

### **3.15.7 BUILDING MATERIAL FINDINGS**

As repeatedly stated above, most of the buildings in our city are built with curtain walls. This in the Western has a great function. Due to the lack of enough sun light they have to collect whatever they can with openings and glazing. This is quite unnecessary in our country because as we broadcast in multimedia '*our country has 13 months of sun shine.*'

#### **3.15.7.1 DURABILITY**

The lift case of this building needs immediate attention or it will compromise the durability of the building as a whole. The failure of one element can bring about the collapse of the total structure. It was also observed that most of the installation of the curtain wall appears to be clumsy and uneducated. This, too, can also be the reason for the reduction of productive years of the building.

### **3.16 ADAM'S PAVILION**

Area - about 5500 m<sup>2</sup>

Function – shops + offices

Ownership – Private

Location – Sar Bet, Road from Mexico to Sar Bet (Kir Kos Sub City)

Woreda \_

#### **3.16.1 BUILDING SITING AND ORIENTATION**

The building is located in Kir Kos Sub City. It faces the south west direction. The building is easily located from the round about that connects the two major roads. (From *Mexico to Besrate Gebreal and Kera to Tor hayloch*) There is a noticeable change in the atmosphere as one moves from the building to the baring lot and from the parking lot to the asphalt. The parking area and the front of the building have a noticeably higher temperature. This incident is known as urban heat island.



Figure 3- 56 Location of Adam's Pavilion

### 3.16.2 BUILDING FUNCTION & DESCRIPTION

Adam's Pavilion has stood on its location for 8 years now. Oriented with its longest side east to west this building has frontal parking space.

The building design concept is designed to resemble a ship. This 8 story building is comprised of ground; mezzanine & 7 floors divided into shopping, office & restaurant functions. The first three stories are used for shops, restaurant & café. The rest upper floors are rented out for offices. This categorizes the building as mixed use building.

This building has 65 rooms that are for rent. From these 65 rooms the 3<sup>rd</sup> floor is totally occupied by garden view restaurant which has kitchen, 2 toilet, and dining area & bar area. Part of ground floor & mezzanine floor is rented by the famous *Kaldi's* and the rest of the floors are shops plus the upper 4 floors are offices. The building is built from curtain wall and in its rear side from HCB.

### 3.16.3 THE INDOOR AIR QUALITY FINDINGS

As stated above the building is oriented with its longest side east to west. The afternoon sun (10:30 – 12:00) comes through the fronted façade which is treated with curtain wall.

#### 3.16.3.1 TEMPREATURE OF THE BUILDING

The temperature on the rear side of the building is relatively lower than one at the front of the building (where *Kaldi's* coffee and Commercial Ban of Ethiopia is located)

#### 3.16.3.2 WINDOWS & LIGHT

The interior corridors are designed to be lighted by the sky light on the roof of 3<sup>rd</sup> floor. But seen in the picture the corridor lights are turned on all day & through the night the building hours. Most of these shops & café pass through these hot times by lowering their metal shutters. This in turn forces these places to put on their light because lowering their shutters creates dark interiors.

The building facade that faces the northern side (built of HCB) has different sizes of windows. These rooms, until third floor have only top windows. But above 3<sup>rd</sup> floor, the windows get larger. This side of the building experience a relative drop in temperature because these side does not get enough light and heat and the small windows do not help he effect.

### **3.16.3.3 MICROBIA GROWTH, VENTILATION AND DAMPNES**

As gathered from questionnaires & interview with management office, there are no serious cases of microbial growth or dampness. But due to the high heat of the afternoon that comes through the larger portion of the buildings curtain wall employees repeatedly responded they found it hard to breath.

### **3.16.3.4 GREEN INFRASTRUCTURE**

The third floor of the building is occupied with 'Green Garden Restaurant' and this floor has most of the green infrastructure that the building accounts for.

The floor unlike the rest of the floors experience lower temperature during rise of outdoor temperature high glare and heat afternoon is blocked by the greenery through the action of transpiration the leaves expire H<sub>2</sub>O that absorbs heat. This can't be said for all of the floors. Because these are on green infrastructure as other floors.

### **3.16.4 ENERGY CONSUMPTION FINDINGS**

The building in general does not use other source of energy. The respondents' knowledge of renewable energy ranges from poor to medium.

The 65 rooms each have lamps varying from spot light to fluoresce shops use display lights & restaurants use fluoresce and chandeliers. But during interviews with management office it is discovered that most lamps are cost efficient that have helped to reduce electric bill by 20%.

The management admitted that they used to pay up to 70,000 birr per month before switching to cost efficient light bulbs put after that they pay 17,000birr per month. The rooms and spaces that are found on the northern side use their lamps for the average of 11 hours a day. Also materials like, printers, refrigerator, iron etc are within hooked up all day.

### **3.16.5 WATER RESOURCE MANAGEMENT**

Because of the availability of gymnasium on the 2<sup>nd</sup> floor addition consumption of water is inevitable. (I.e. bath, sauna and showers). This Adds up 2 toilets per floor. The building does not recycle or reuse.

### **3.16.6 WASTE MANAGEMENT FINDING**

The building uses communal system disposing garbage. The garbage is placed in front of the building. Unsorted and mixed.

### **3.16.7 BUILDING MATERIAL**

Curtain wall is a very low thermal resistant material which is suitable for cold areas oriented in northern direction so the light and heat can enter easily. But in Adam's case it is placed on the harsh sun direction.

## **3.17 BOLE APARTMENTS**

### **BLOCK .985**

Area –m<sup>2</sup>

Function – Apartment building

Ownership –Governmental

Location – Bole Sub City

Woreda-

### 3.17.1 BUILDING SITING & ORIENTATION

The beautiful sets of buildings that form the outskirts of Bole Road are found in front of the famous *Shoa* super market. This group of colorful buildings has been standing in their original location for the past three decades. Faced with south western direction, these buildings are few of the main apartments that were built during that era.

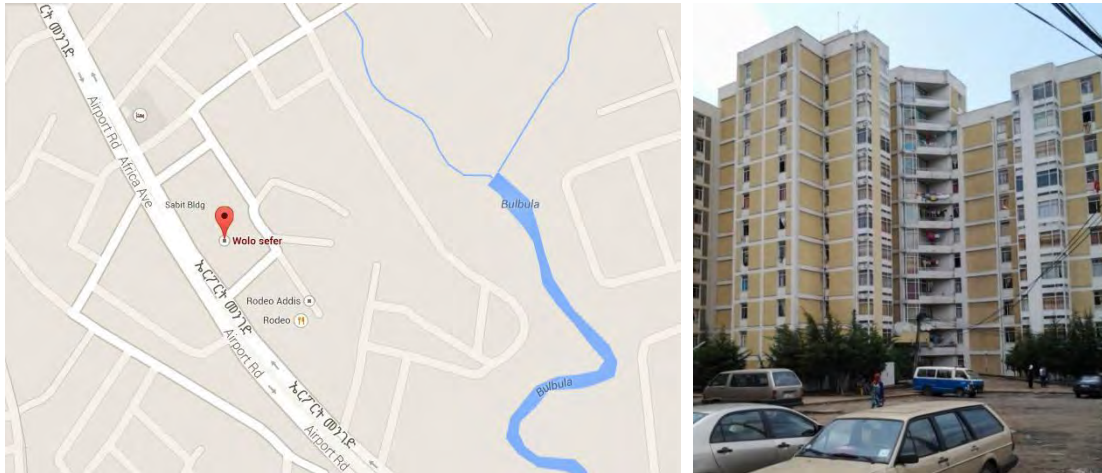


Figure 3- 57 Location of Bole Apartments

Source: Google Maps

### 3.17.2 BUILDING FUNCTION & DESCRIPTION

Block 985 of these apartments has a semi basement, basement and eleven stories above the ground floor. The building's backyard is accessed after one has stepped down four or five steps, a slaughter space & unfortunately as a playground for children. The park doesn't serve as parking; the basement supports both rooms of apartments & the extension of garbage disposal. This mix of function has become unhealthy and unattractive. People live next to the toilet leakage that has been laying there for months.

The un-segregated backyard space has been the reason for many of the residents' children's sickness. The manhole & septic tank have long before stopped functioning, resulting in the foul smell of the environment.

The building is comprised of two & three bed room apartments. It is very sad to realize that the circulation lights do not work properly. So if people come late at night they have to use a lamp (portable) in order to see easily. And also during day time due to the placement of stairs, natural ventilation & light is not available. The smell from the slaughter space on the backyard is sensed all the way to the second floor, especially during holiday seasons. It's also unfortunate to realize that this fourteen-story building does not have any working elevators from the available 3, and safety is an issue when children are playing in the unprotected pit of the elevator. The electricity of the building is placed on the backyard and it has been attacked by termites & pests, resulting in its malfunction. This is due to the architectural poor design of

placement of sensitive items (objects) and the electricity sometimes causes contacts when children play with it.



Figure 3- 58 Some worn out facilities in the apartment and the entrance of the apartment

On the entry level it is said to observe that toilet discharge is just laying there in front of the apartment's doors. During the field work of this particular buildings research people were more than willing to express their aggravation & anguish towards the building function.

These include, no access for the disable & mothers expecting a child, no segregation of function for garbage disposal & slaughter, no function septic tank (septic tank is full and has been leaking), no natural light in the circulation, children play area is unavailable, placement of electrical equipments, Parking problems, no proper managerial office and etc.

### **3.17.3 INDOOR ENVIRONMENT FINDINGS**

#### **3.17.3.1 TEMPERATURE OF THE BUILDING**

Because of the building material, respondents claim that the inner temperature is more or less stable. When it is cold outside the rooms are warmer & when it is hot outside it is cooler. But these that occupy apartments facing the main road are a bit challenged with afternoon sun & glare when opening windows to cool their apartments.

#### **3.17.3.2 LIGHT & WINDOWS**

As stated above repeatedly, the corridors & circulation area does not have natural light reaching them. This causes discomfort the positive side of the building when it comes to windows & light is that every room has windows.

#### **3.17.3.3 VENTILATION, DAMPNES & MICROBIAL GROWTH**

These are some of the problems the people living in block 985 faces daily. These & many more problems cause the people to have a serious cause of sicknesses.



Figure 3- 59 Unmanaged green infrastructure microbial growth and dampness within the apartment

### 3.17.3.4 GREEN INFRASTRUCTURES

The back yard has green garden. It is right next to the garbage which makes it not functional and children cannot experience (fig 3-63).

### 3.17.4 ENERGY CONSUMPTION FINDING

Without adding the energy stress the country is currently in, the building electrical system can easily be considered an almost total failure. This is due to, as repeatedly mentioned, different placement of electrical equipments leading to exposure to pests & termites. So the backyard can easily be designed to support a renewable energy (green energy). By the simple act of separating wet & dry garbage's & wastage.

### 3.17.5 WATER CONSUMPTION FINDINGS

Even though the water stream condition is known throughout the city, people living in the building still didn't learn to store or recycle water. And use clear water for washing cars & others secondary activities that do not need clear water to be accomplished.

### 3.17.6 WASTE MANAGEMENT FINDINGS



Figure 3- 60 Garbage disposing system of respondents

### 3.17.7 BUILDING & MATERIAL

Durability is dependent on building material but it is not the only component that is a determinant in the life span of a building. Certain factors like maintenance & facilities may seem insignificant but still determine the active duration of a structure.

### 3.18 DEMEBEL CITY CENTER

Area – 8000 m<sup>2</sup>

Function – Office Building

Ownership – Private

Location – Bole Sub City

Woreda- 20/21

House Number – 1146

#### 3.18.1 BUILDING SITING & ORIENTATION

Located at bole road, Dembel City Center is a mixed use building which has two basement, ground floor, mezzanine floor and twelve floors above that serves as shops & offices. The building has been as iconic signature on that area. The building faces the eastern direction.

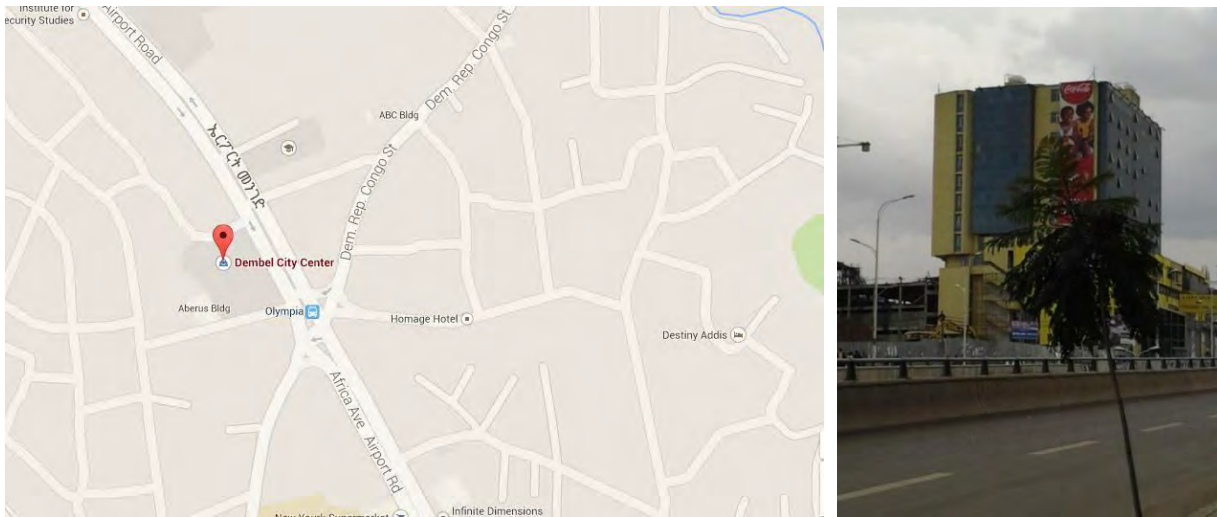


Figure 3- 61 Location of Dembel City Center

Source: Google Map

#### 3.18.2 BUILDING FUNCTION & DESCRIPTION

The building has two public entrances. One entrance to the basement which serves as parking and one straight to the inner functions of the building.

As one enters through the front entrance there is a flight of stair made up of eight steps. Though this may prove to be weak design plan for disabled people they still enter through the basement. There are about 60 shops on the ground both are ventilated & lighted artificially since they are located among shops & corridors. As one moves through the circulation he/she finds the huge dome structure, flense the name *Dembel Dome*. This dome continues till the second floor of the building. The shops function of the building continues till fourth floor then the rest is office floors. Dembel has, in total three main stairs, four elevators & two fire escapes.

From the information gathered from administration office of the building the building has around 300 shops total and 70 offices as a whole.

### 3.18.3 INDOOR ENVIRONMENT FINDINGS

#### 3.18.3.1 TEMPERATURE OF THE BUILDING

Dembel is one of exemplary building that marked the being of modern architectural steps in our capital. It was the first large scaled shopping center that was, in its time, very grand & luxuries.

Even its building material was something un-experimented before & radiated the sense of globalization & modernism. Though, the system of using glazed wall (Curtain Walls) on the building was a somewhat new concept in our country at that time. It really didn't take a person's to perceive the outcomes of Applying such materials in later years.

One of those out comes is indoor heat island in particular and urban (outdoor ) heat are directly in contact with the space that has the glazing experience intolerable heat during day time. As respondent's claim, since the building is curvy & the glare from own curtain wall make it difficult for users to open their windows for the fear of going blind. The dome of Dembel also traps heat causing green house effect.

#### 3.18.3.2 LIGHT & WINDOWS

Spaces that demand light & windows in this building do not have or have insufficient number of windows, spaces like toilets & circulation. Spaces that want a less or amount of light for function to sustain within then in this building have too much windows in them.

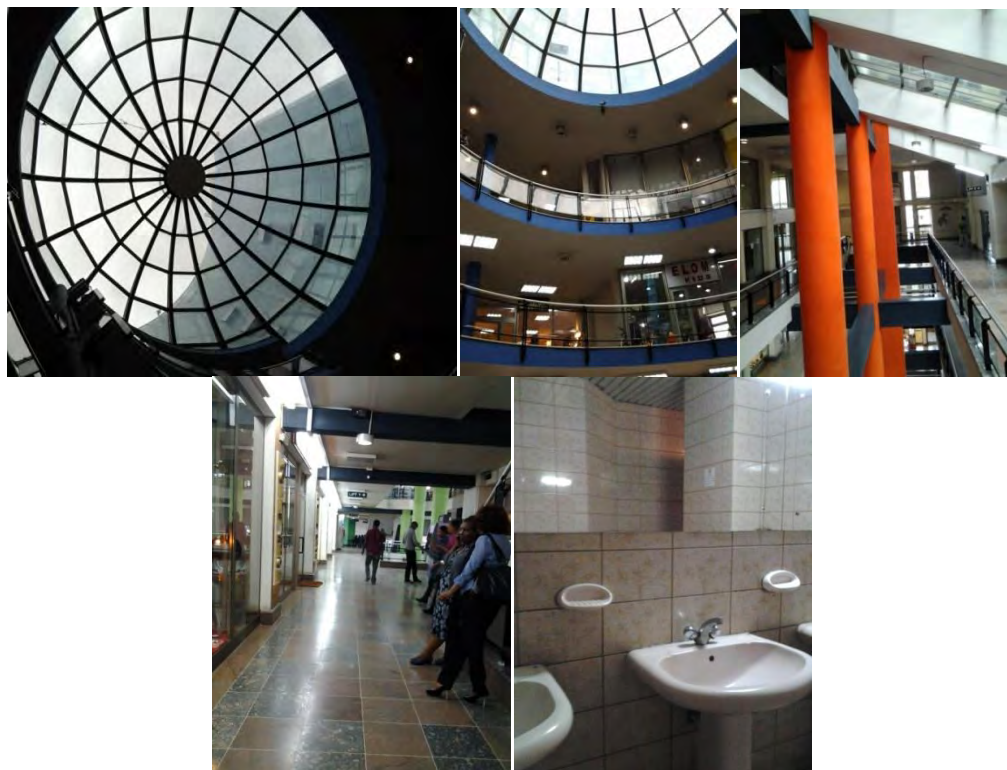


Figure 3- 62 Interior space of Dembel City Center, the Dome of the building, the sky light, circulation and toilet (from left to right)

### **3.18.3.3 VENTILATION, DAMPNES & MICROBIAL GROWTH**

This shows if terraces & balconies are left without being treated & protected they will failed to function properly. Also the toilets of this ground building are being to have stuffed smell due to the lack of windows.

### **3.18.3.4 GREEN INFRASTRUCTURES**

The building has a very scarce green infrastructure.

### **3.18.4 ENERGY CONSUMPTION FINDING**

The energy used by fans, ventilators & shafts to cool or ventilated Dembel City Center adds to the amount of energy consumption. Even the system used by this building to pump water to upper floors consumes more energy than many buildings in the city.

### **3.18.5 WATER CONSUMPTION FINDINGS**

The building takes no consideration to preserve & wisely use the scarce resources water even at some floors of the building the leakage of clean water is seen. But no action has been takes to contain such mischarge.

### **3.18.6 WASTE MANAGEMENT FINDINGS**

The regular curb side collection of waste is applied just like the rest of the building in Addis Ababa, organic (food) – 45%, paper45% and others -10%.

### **3.18.7 BUILDING & MATERIAL**

The building is built 35% from concrete & the rest from curtain wall & glazing so most of its floor finish is PVC & ceramic tile & some custom made tiles. Most of the wall finished is paint. The combination of finishing & building materials has their own result & effect on its durability.

#### **3.18.7.1 DURABILITY**

Since the building built with curtain walls at it large side considering the installation & character of the material itself, durability may be questioned. Durability means functioning properly. But if the heat is intolerable, the building is being to faille all ready.

## **3.19 FLAMINGO APARTMENTS**

Area – 5000m<sup>2</sup>

Function – Apartment building

Ownership – Government

Location –Kir Kos Sub City

Woreda- 09

House Number – 506/102

### **3.19.1 BUILDING SITING AND ORIENTATION**

On the same road with 'Red Terror martyr' Museum, Flamingo Apartment building was built in the early 70s. This building, just like the Museum gives its front to the slightly slanted Northern direction.

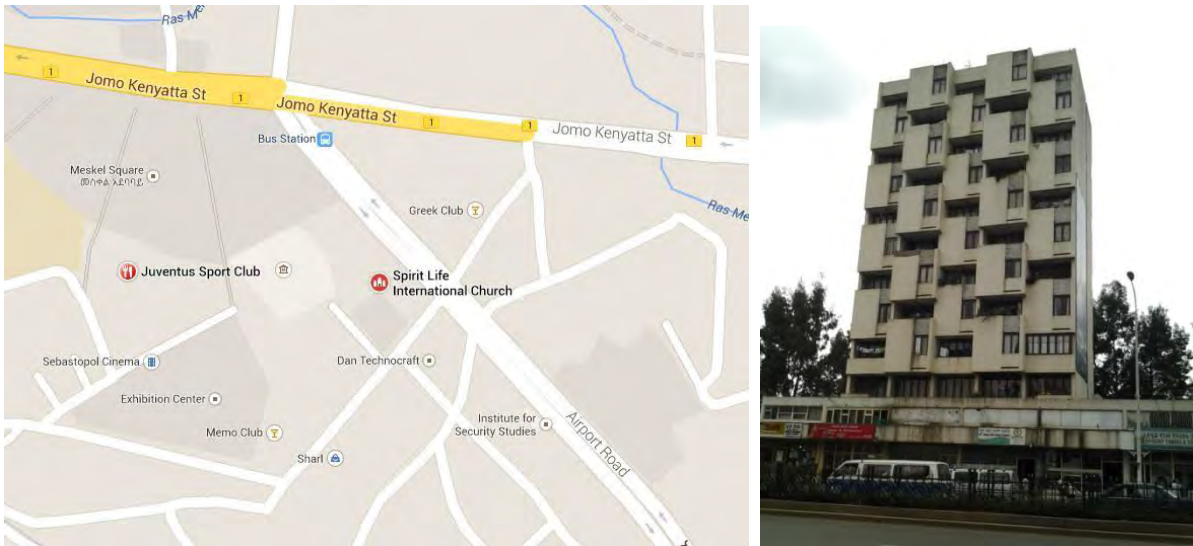


Figure 3- 63 Location of Flamingo Apartments

Source: Google Map

### 3.19.2 BUILDING FUNCTION AND DESCRIPTION

There are two entrances. One serves for those who would use the shops and the second one for the apartment users. The building starts to function as an apartment starting from the ground (Back side). There are two apartments on each floor. The ground plus ten building has a back yard for parking and waste disposal.



Figure 3- 64 Back yard of the building

Source: Google Map

### 3.19.3 INDOOR ENVIRONMENT QUALITY FINDINGS

#### 3.19.3.1 TEMPERATURE OF THE BUILDING

Respondents claimed that the indoor air temperature is quite suitable for them.

#### 3.19.3.2 WINDOWS AND LIGHT

Every space has window that is suitable and sufficient for performance.



Figure 3- 65 Interior space of the apartment building

### 3.19.3.3 MICROBIAL GROWTH, VENTILATION AND DAMPNES

There is a mild case of leakage (dampness) in wet areas of the building (kitchen & bath), which are both floor to floor and room to room seepage. But it is no surprise considering the fact that the building is one of the older buildings in the capital.

### 3.19.3.4 GREEN INFRASTRUCTURE

The building has a large backyard which incorporates green trees that provide shade for parked cars.

GREEN WALLS - some balconies have Green plants on which added the building beauty.

### 3.19.4 ENERGY CONSUMPTION FINDINGS

No supplementary system is used to support the regular energy types. Though most respondents do have enough knowledge on the subject, none have collaborated to actualize it.

### 3.19.5 WATER CONSUMPTION FINDINGS

Since the whole building serves as an apartment one can imagine how much water is consumed per usage. Since the building is ground plus ten, it is easy do calculate the amount. If we do have a hint of the consumption, it will force as to look for an alternative means to save more water.

### 3.19.6 WASTE MANAGEMENT FINDINGS

During the site visit to the building, respondents were asked if they had any idea on how to make compost from waste. Surprisingly enough they had medium to high ranging amount of knowledge. But in this building case, it was bringing it on to the ground that seems to be the problem. All the toilet waste is collected in the septic tank.

### 3.19.7 BUILDING MATERIAL

As described in the above section, the building is built from concrete. This played a huge role in its strength indoor air quality and etc.

#### 3.19.7.1 DURABILITY

The building has stood at its location for the last 30 years (approximately). Though only this does not prove a building is durable, the facilities functioning does. But having all the functioning fixtures and all the external and internal treatments and finishes, that is one seeks

when designing a building. This building, as respondents claim, has most of its fixtures and also all the treatments used are sustainable and durable

### 3.20 ARADA

Area -

Function – shops + Apartments

Ownership - Government

Location – Piassa (Arada Sub City)

Woreda –

House Number-

#### 3.20.1 BUILDING ORIENTATION AND SITING

The building is situated in the middle of the iconic and oldest area of Piassa. Even the Sub City where it is located is named after this very building. The longest side of this building is exposed to the afternoon sun. The deep verandas and the horizontal balconies are the defining character of this ground plus 12 storied building. The longest side of the building is oriented east to west making the whole building face the southern direction.

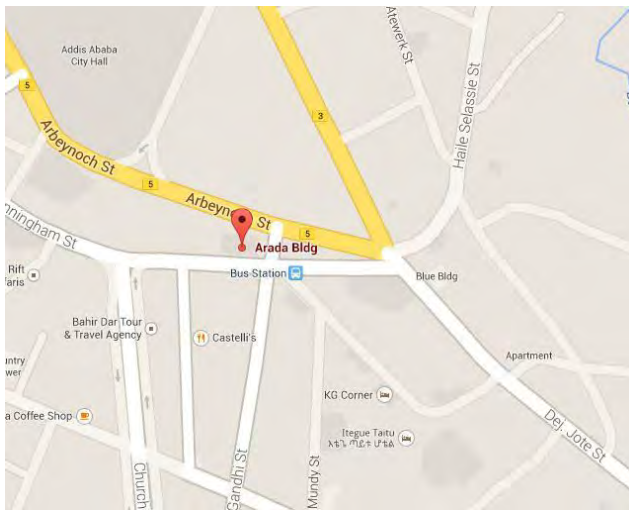


Figure 3- 66 Location of Arada Building

#### 3.20.2 BUILDING FUNCTION & DESCRIPTION

As we approach the building we notice that it is built on a sloppy ground. It is slopping both on the longest direction and shortest direction. The arrows show that there is a gentle slope upwards both as we move from the side that is close to Churchill road to the upper and also from back to the front.



Figure 3- 67 Building slope

This has a suggestion of split level design in which the sloppiness of the building is balanced by the addition of stairs and ramps. Though ramps are not seen on near the building entrances it has been noticeably tried to balance the level difference by addition and subtraction of stairs. The building has six entrances, to the bank, the main tower and the rest four entrances to the shopping sections

The four external stairs lead to the entrance to the shops. The basement is access able to one coming from Churchill Road and as he/she moves up ward the road lifts upward making the floor basement. And as we reach the opposite direction we notice there is a stair that could equalize the floor level to the road level.



Figure 3- 68 Access, stair and parking space of Arada building

The ground has 26 shops on the side which faces the Churchill road and 17 on the opposite side giving us the total of 43. The first floor, counting from the side that faces Churchill road, has 20 shops. And the second floor, still counting from the side that faces Churchill road but only a ground floor when counting from the opposite side, has another 20 shops. The tower has its own stair and elevator shaft as shown blow.

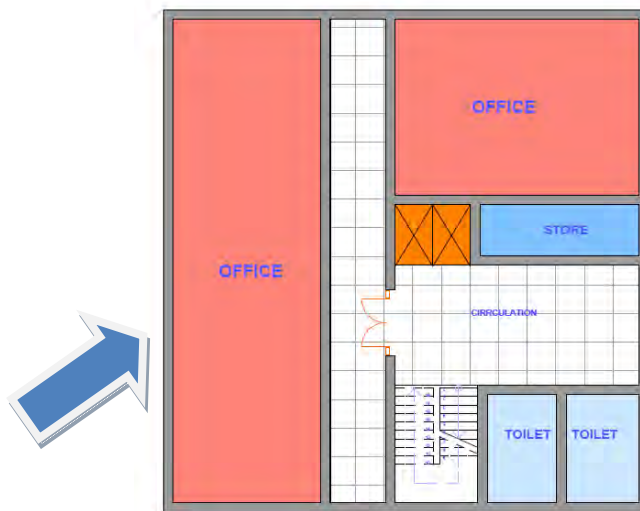


Figure 3- 69 The illustration of office floor

### 3.20.3 THE INDOOR ENVIRONMENT QUALITY FINDINGS

#### 3.20.3.1 TEMPREATURE OF THE BUILDING

The side that faces harsh sun rays experiences a relatively hotter indoor temperature. The balconies though faced with afternoon sun, are functional because they provide a deep volume that protect the shops from direct contact with the heat.

#### 3.20.3.2 WINDOWS & LIGHT

Though the building is considered to be built in the olden days, it is still an iconic structure in the way it's lay out is designed. Every office space in the tower is provided with windows that are functional. But due to habit the occupants of the building still turn on light during day time. Also some modifications the users of the building have done created pockets and gorges that are a bit difficult to light naturally.

Despite the careful lay out plan, the tower's toilet still lack windows that provide light.



Figure 3- 70 Windows of the interior space and unventilated toilet

### **3.20.3.3 MICROBIA GROWTH AND DAMPNESS**

Some spaces formed due to users' modifications have left these areas without proper ventilation. And some also due to negligence in planning (tower's toilet), they have been left without windows and without ventilation. This has resulted in a space unventilated and that has a foul smell.

### **3.20.3.4 GREEN INFRASTRUCTURE**

There is no greenery seen on the building that account as a functional structure that could provide services those other functional green infrastructures could provide.

### **3.20.4 ENERGY CONSUMPTION FINDINGS**

There is no renewable energy used in this building. And also the knowledge of such energies is very low and the application a very distant future.

### **3.20.5 WATER RESOURCE MANAGEMENT**

The recycling of water is a complete foreign idea to most of the respondents. Double plumbing, though technically very easy for application, is unfamiliar concept.

### **3.20.6 WASTE RESOURCE MANAGEMENT**

No system of garbage sorting is applied. The most dominating part of the garbage are paper, organic matter and plastic.

### **3.20.7 BUILDING MATERIAL**

The building is built from concrete. It has a high thermal resistance which makes it a good material to use in areas where the weather is warm. It does not get hot quickly it also does not release the heat it has trapped rapidly. This makes it cool during the day time and warmer in night time. During the day time the surrounding environment is warm but as we enter the building it will seem cooler and during the night time the environment is chiller and the building releases the heat it has trapped. But combined with glazing this character can be altered. That's why the respondents answer was different.

#### **3.20.7.1 DURABILITY**

The building's age could be a testament for its material's strength and durability. Most of its facilities work better than buildings built in recent times.

### **3.21 MALEDA APARTMENT**

Area – m<sup>2</sup>

Function – Office Building

Ownership –Government

Location – Arada Sub City

Woreda –

House Number –

### 3.21.1 BUILDING SITING AND ORIENTATION

With its grand green garden in front of it, Maeda is located on 4 Kilo road next to St Mary church. The building is oriented in North direction.

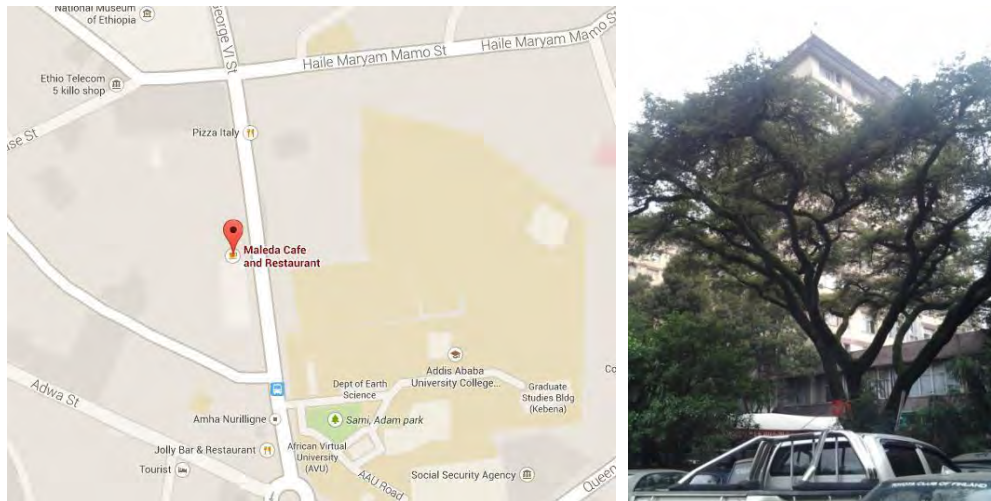


Figure 3- 71 Location of Maleda Apartment

Source: Google Map

### 3.21.2 BUILDING FUNCTION AND DESCRIPTION

The building has shops, restaurants (café) and offices on the ground and first floor and apartments on its upper floors on its front side. And the apartment starts from the ground in the back side. There are four apartments on each floor that are of one bed room and two bedroom types.

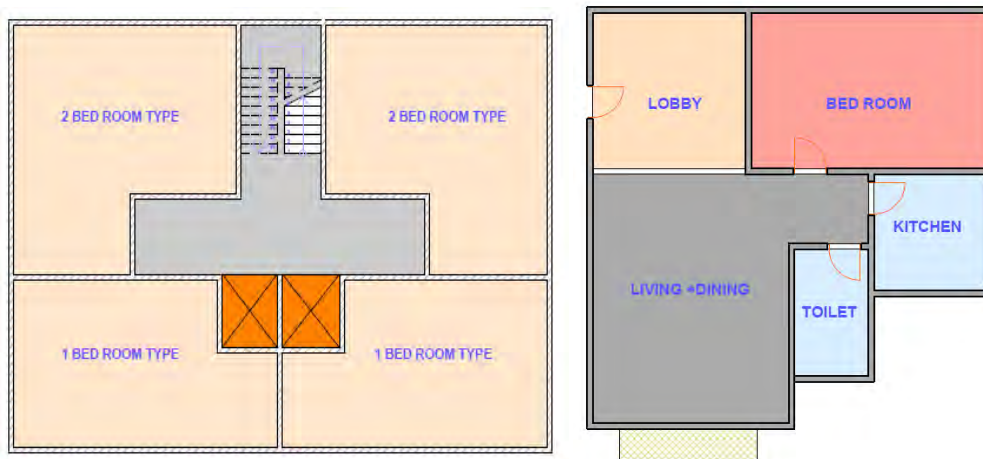




Figure 3- 72 Illustration of floor plans, stair case and entrance to the building

### 3.21.3 INDOOR ENVIRONMENT QUALITIES FINDINGS

The orientation of building, building material and floor plan lay out has resulted in certain indoor environment conditions.

#### 3.21.3.1 TEMPERATURE OF THE BUILDING

Those that face the south west direction have responded that they are faced with unbearable heat during the afternoon. They cannot even stay in the living room during the day time. And also the glares that inter through the windows are another problem of heat.

#### 3.21.3.2 WINDOWS AND LIGHT

The interior spaces have sufficient windows that allow enough light. There is enough natural light that allows for tasks to be accomplished with in the defined space. Though *Maledas'* Apartments are equipped with the proper windows, the office floors below have weak exposure to natural light. But It should be stressed that the area under study is the apartment section of the building.



Figure 3- 73 Windows of the apartment and floor drainage causing dampness and kitchen fixture leakage causing damage

#### 3.21.3.3 MICROBIAL GROWTH, VENTILATION AND DAMPNES

Floor drainage backs up the water and lets in dirty water making the room smell of foul smell due to the used water. Also, the kitchen fixtures have damp surfaces below them caused by dampness (fig 3-78).

### 3.21.3.4 GREEN INFRASTRUCTURE

The site has enough green space composed of wide canopied trees. But those trees are not tall enough to shade the G +12 building from the glare windows have created.



Figure 3- 74 Green infrastructure around the building and garbage bin of the building

But the residents lack green infrastructure of their own other than the public space provided outside the building.

### 3.21.4 ENERGY CONSUMPTION FINDINGS

The residents do not use other means of energy other than sun energy (to dry cloth). The concept of renewable energy is new.

### 3.21.5 WATER CONSUMPTION FINDINGS

The use of rain water is not applied. Residents do not recycle or reuse water. Most of the water used is for toilet which is a secondary activity that does not necessarily need clean water.

### 3.21.6 WASTE MATERIAL MANAGEMENT FINDINGS

The building's organic, plastic and metal waste is disposed in communal garbage near the building compound. This unsorted and un-recycled garbage may contain items that could be resold and reused resources. But they are simply thrown into one big pile randomly.

### 3.21.7 BUILDING MATERIAL

The building is built from HCB and mortar.

#### 3.21.7.1 DURABILITY

The building has been standing at its location for almost more than 3 decades.

## CHAPTER IV: ANALYSIS OF FINDINGS

This chapter will first compare the building qualities according to the criteria described under methodology. The analysis of qualities of the assessed buildings will be done simultaneously in order to make the comparison easier. Then in the second part of the chapter the assessed building will be compared to the Green Buildings standards accordingly. Then the gaps between the findings and the Green Building will be addressed.

### 4.1 COMPARISON AMONG ASSESSED BUILDINGS

The criteria used to compare assessed buildings were: Building functions, indoor environment (temperature, windows and light, efficiency of respondents, green infrastructure, and microbial growth), energy consumption, water consumption, waste management and building material.

Under this section the assessment of the buildings will simultaneously be done along the comparison. The assessment will help in understanding the character of buildings and will make the comparison easy. Immediately under each criteria the description of the best and worst exemplary building under each specific criteria will be mentioned,

#### 4.1.1. BUILDINGS' FUNCTION

This section would help us to know the different functions that were consider for sampling. This, as stated above, is important so as to know what type of building consumes how much Energy and produces how much waste and also the composition of waste itself.

*Table 4 1 Function of the assessed buildings*

Function of buildings assessed	
Apartments	19.4%
Office buildings	9.5%
Mixed use	57%
Institutes	4.7%
Hotels	4.7%
Restaurants	4.7%

*Source: sample building survey*

#### 4.1.2. INCOME STATUS OF PARTICIPANTS

This will help to calculate participants' expenditure for Energy and water. Their answers will be almost precise considering the fact that they will answer with reference to their income. These numbers will be in terms of percentage.

Table 4 2 Framing technique for income status of participants

Status	Average income per month (birr/month)
High income	More than 15,000 birr/month
Middle income	3,000 – 15,000 birr/month
Low income	Less than 3,000 birr/month

According to the table above the result of the income status was as follows.

Table 4 3 Income status of participants

Status	Average income per month (birr/month)
High income	62.2%
Middle income	26.7%
Low income	11.1%

Source: sample building survey

#### 4.1.4 NUMBER OF ROOMS

Number of rooms in an office (shop) or apartment will guide us to know how much each room consumes energy in relation to sun direction, window opening etc. also, knowing the average number of rooms will help us understand in general how many of the rooms have functioning windows. This in turn will aid the investigation of each subdivision of Green Building including indoor environment quality, waste management and also resources used in each room.

Table 4 4 Number of rooms

Type of function	Average number of rooms (kitchen and toilet are considered)
Residence	5 rooms
Others	3.17 rooms

Source: sample building survey

Note: this table shows that a single shop (office) takes an average of 3.45 rooms from the total building. A residence flat takes 5.42 rooms (including toilet and kitchen) in the average from the total building.

#### 4.1.5 GLARE FROM INTERNAL AND EXTERNAL ENVIRONMENT

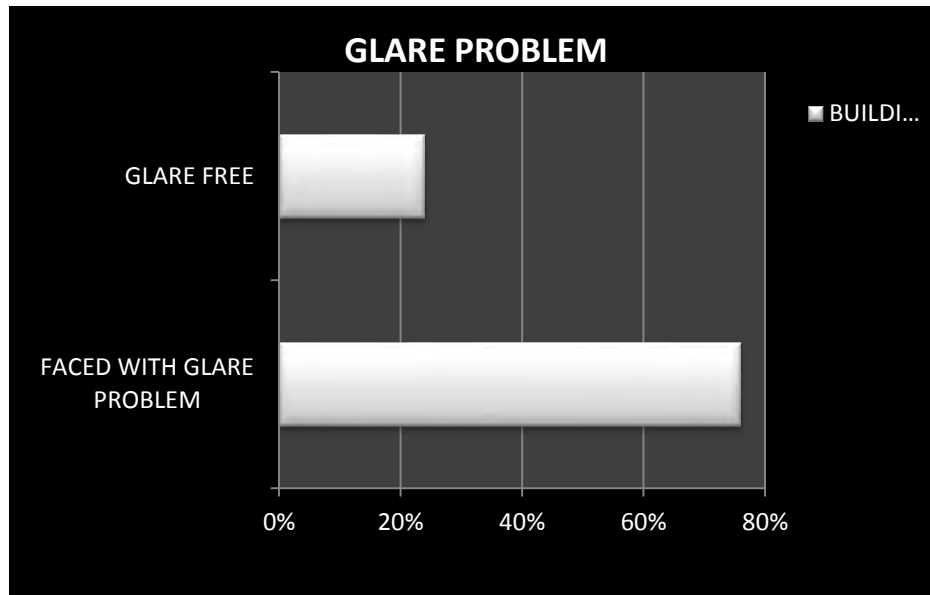


Figure 4- 1 Number of buildings faced with glare from external and internal environment  
Source: sample building survey

- ❖ Buildings like 'Ras Shell' are not faced with such problems because of the large over hand roof protecting them from glare. From the data collected about surveyed buildings, Adam's Pavilion could be the leading example of Glare Attacked building.



Figure 4- 2 Overhang of Ras Shell

#### 4.1.6 THE GENERAL INDOOR ENVIRONMENT QUALITY INFORMATION OF THE SAMPLED BUILDINGS

As indoor air quality is one of the issues addressed in Green Building, the data collected from the sampled buildings included questions about temperature, light, windows' quality, ventilation, dampness etc.

##### 4.1.6.1 INDOOR TEMPERATURE OF SAMPLED BUILDINGS

This particular topic has strong relationship with the building material of the building itself. If the building material has high thermal resistance the building will have no problem coping up

with the outdoor environment. Also if the building material has a low thermal resistance it will have difficulty coping with the outdoor temperature.

Table 4 5 Building Materials

Building material	% of assessed buildings
Hollow concrete block (HCB)	33.3%
Brick	14.3%
Curtain wall –(glassed wall)	47.7%
Stone	4.76%

Source: sample building survey

Table 4 6 Temperature drop and rise

a) warm seasons ( Mid Meskerem- Early Ginbot)

Materials	Temperature rise		No Temperature change		Temperature fall	
	Day time	Night time	Day time	Night time	Day time	Night time
HCB(hollow concrete block)					✓	✓
Brick walls			✓			✓
Curtain walls	✓					✓
Stone façades			✓	✓		

b) cold seasons ( Mid Ginbot - Mid Meskerem)

Materials	Temperature rise		No Temperature change		Temperature fall	
	Day time	Night time	Day time	Night time	Day time	Night time
HCB(hollow concrete block)					✓	✓
Brick walls			✓			✓
Curtain walls					✓	✓
Stone façades			✓	✓		

Source: sample building survey

Note:

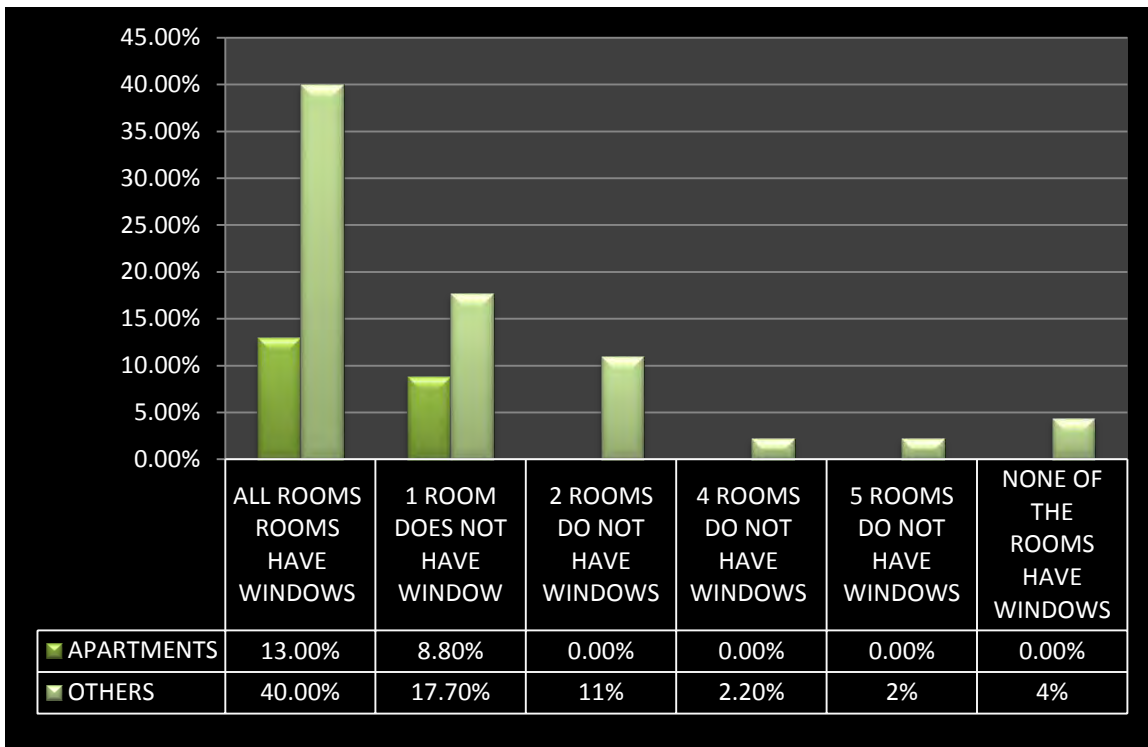
- ✓ 'Temperature fall' refers to the considerable drop of temperature in a certain room with the reference to the outdoor atmosphere temperature. ( $T_r < T_a$ )

- ✓ 'Temperature rise' refers to the considerable rise of temperature in a certain room with reference to the outdoor atmosphere temperature. ( $T_r > T_a$ )
- ✓ 'No temperature change' refers to a balance in temperature of the room and the outer atmosphere. ( $T_r = T_a$ )
- ✓ Where  $T_r$  is temperature of the room and  $T_a$  is the temperature of the outer atmosphere.
- ❖ From assessed buildings those that have a slightly lower indoor temperature with reference to the outdoor environment are the Red Terror Museum, Stairs and Tommy Tower. Those buildings that respondents claim to have an optimum temperature of indoor environment are Ras Shell and Haimi Hotel. On the contrary, buildings that have a higher indoor temperature compared to the outside environment are Adam's Pavilion, Sofonias and Bedlu Hentsa.

#### **4.1,6,2 WINDOWS & LIGHT**

The two concepts windows and light are two separate criteria. Rooms that do have windows may not necessarily have natural light entering them. And naturally lighted rooms may have sky lights instead of windows. That is why windows and light are considered separately.

##### **4.1.6.2.1 WINDOWS**



Knowing the number windows that are available in a house hold will help us in identifying which  
*Figure 4- 3 Number of rooms that have windows*

*Source: sample building survey*

rooms are well ventilated and lighted. The concept that is tried to be addressed here is, if rooms are well lighted and ventilated; the users of those rooms will have very good performance and efficiency. Rooms with windows are comfortable work environment and easily adoptable to live in.

#### 4.1.6.2.2 LIGHT

Even if we have windows in all our rooms the next question we should be asking is, do those windows let in enough light to allow any task to be done in a room?

Though it is assumed that any room that have windows lets in light, the reality is, most windows designed in AA buildings are without function and built facing wrong direction. This creates a bold problem when it comes to creating functional spaces with in an enclosed structure. Some of the problems that can be observed while surveying selected buildings are:

- windows facing next building's wall closely:
- windows facing another building's curtain walls causing glare to enter:
- small windows that do not allow enough light to enter:
- windows that face the direction of south west without proper shade which lets harsh sun to enter which in turn makes the room unbearable to stay in:

- windows facing a land fill site that let foul smell to come into the room:
- windows that let too much light and wind in inhabiting occupants from doing their task properly:

A well functioning window is a window which allows enough light so that occupants would not have to turn on artificial light in day time.

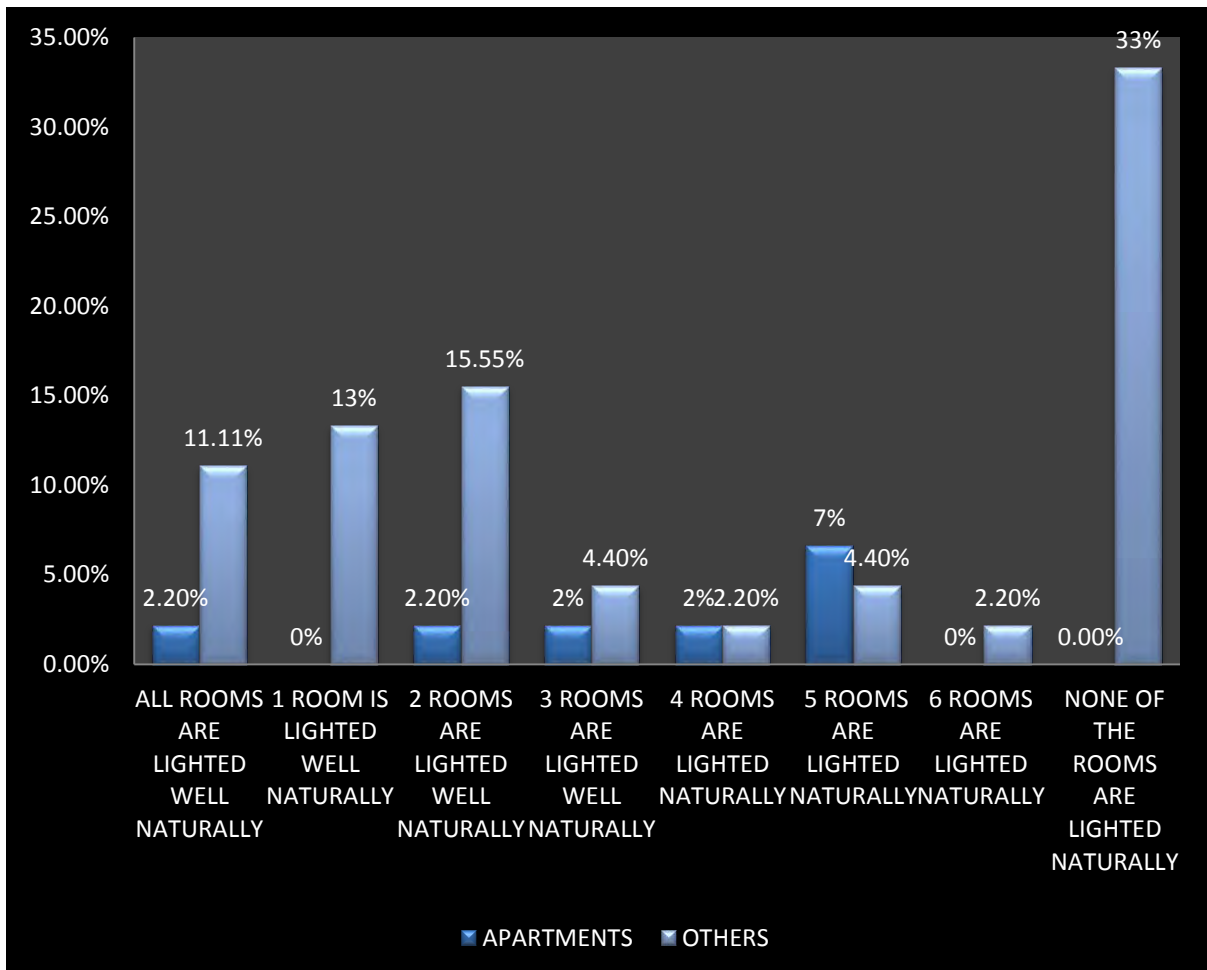


Figure 4- 4 Graph showing functional windows

Source: sample building survey

- ❖ From the assessed buildings, stairs, Ras Shell and Mafi have proved to have the most functional windows. Maleda Apartmens, Bedlu Hentsa and DH Geda are found on second place. On third place Bank o De Roma, Flamingo and Bole Apartments and Nega are found.
- ❖ When it comes to their space being naturally lighted the worst are Adam's Pavilion and Ministry of Trade.

#### 4. 1.6.3 DAMPNES AND MICROBIAL GROWTH

Also important to indoor air quality is the control of moisture accumulation (dampness) leading to mold growth and the presence of bacteria and viruses as well as dust mites and other

organisms and microbiological concerns. Water intrusion through a building's envelope or water condensing on cold surface on the building's interior can enhance and sustain microbial growth.

Table 4 7 Table showing dampness and microbial growth in percentage

Criteria	Percentage from total
Dampness	71.1%
Microbial growth	23.8%
Ventilation	19%
No problems	4%

Source: sample building survey

- ❖ Buildings like Nega City Mall, Tommy Tower and Haimi Hotel stand out when it comes to microbial and dampness free environment.
- ❖ From surveyed buildings those that were found to be at worse stage when it comes to microbial attacks are, Ras Shell, Ministry of Trade and Bedlu Hentsa.

#### 4.1.6.4 ORIENTATION OF BUILDINGS

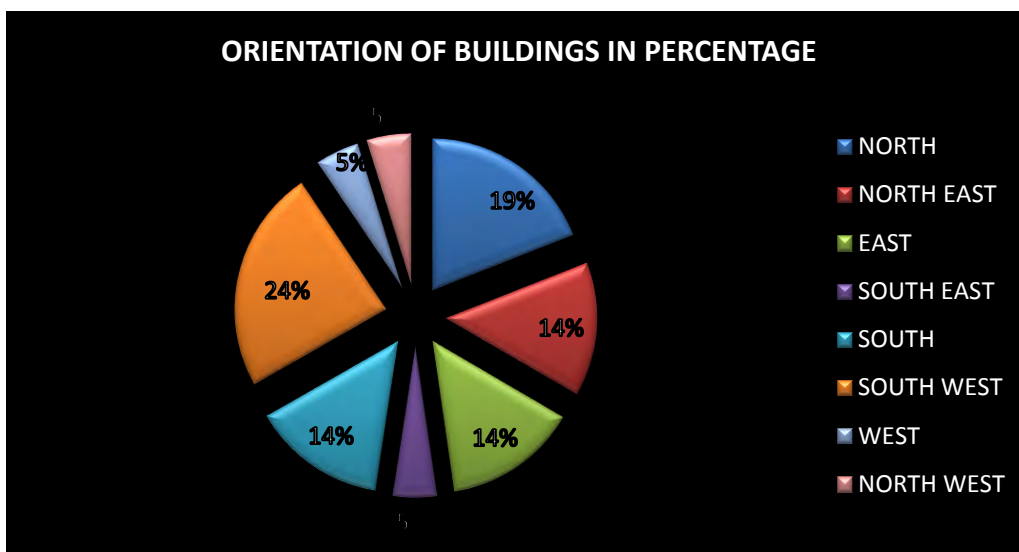


Figure 4- 5 Orientation of Buildings Surveyed

Source: sample building survey

The fact that from the surveyed buildings, 14% of them face south direction has so much to do with the indoor air quality because orienting a building in a certain direction has its own result. 23.8% from the total surveyed buildings face South West direction. Buildings that face North West and North East both are 7% from the total surveyed buildings. Also, buildings facing west and North West directions are 4.7% from the total surveyed. Buildings facing South East direction add up to 4.7%. Those that face south west direction (23.8%) had have a proper shading device intact because this side is known to be harsh sun side with low sun rays that are hard to shade cause heat.

In our country, the time considered an afternoon harsh sun time is roughly on average from 8:45 to 11:45 local time. At this time buildings that face south west direction having big glazing on their façade need trees or louvers to shade them from such heat and light.

Half of the 23.8% buildings that face the south west direction were not shaded and the face that faced the direction was built with mostly curtain wall or large glazing that lets in all the heat and light (plus glare) into the work space and living space.

- ❖ *Most of the surveyed building, in general, does not have green trees used for shading purpose But those eastern facing buildings have the full advantage of morning sun, which is healthy.*

#### **4.1.6.5 EFFICIENCY OF EMPLOYEES**

In an office environment employees' efficiency is one of the most important issues that are considered to have a direct impact on the productivity of the company as a whole. And this efficiency is in turn related to the emotion and comfort of the employees.

If employees are comfortable and stable, it is known they will produce more. And this comfort and stability has so much to do with indoor environment quality. If the indoor air quality is balanced employees will be more efficient.

*Table 4 8 Showing reduction of efficiency of employees*

From morning to evening	Average Efficiency in percentage
Does not change	33.33%
It decreases	66.66%
It increases	0%

*Source: sample building survey*

- ❖ *People working in buildings like Stairs and Ras Shell do not experience decrease in efficiency.*
- ❖ *On the other hand respondents that work on buildings like Adam's Pavilion, Bank O De Roma and Bedlu Hentsa experience decrease in efficiency,*

#### **4.1.6.6 GREEN INFRASTRUCTURE**

The respondents were asked if they have any green infrastructure in their house hold or office area.

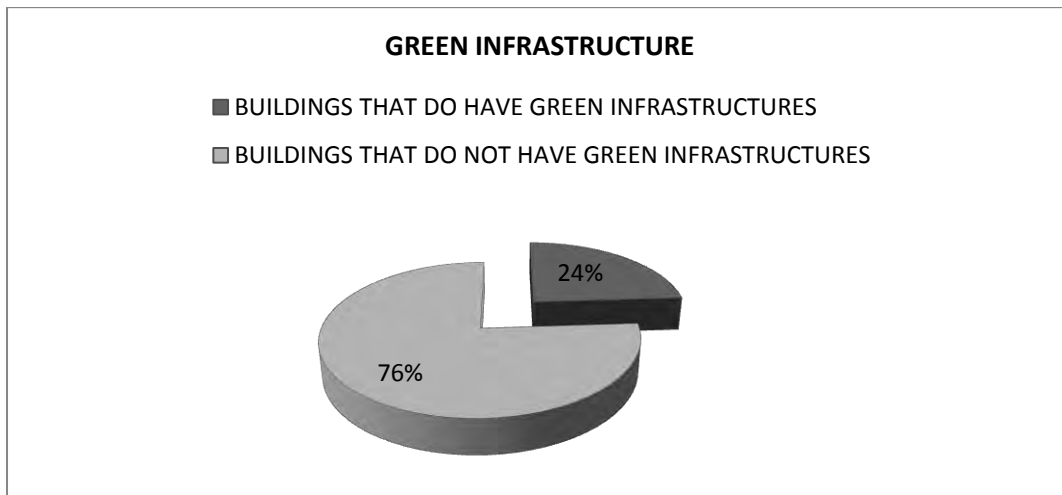


Figure 4- 6 Green infrastructure of the surveyed building

Source: from surveyed data

❖ Buildings like Maleda, the Museum and Flamingo Apartments have better green infrastructures in their compounds relatively.

#### 4.1.7 ENERGY CONSUMPTION FINDINGS

The criteria considered when it came to Energy were, if the respondents found in the assessed buildings used renewable energies, if they know what they are (their knowledge about renewable energies), if they use energy efficient equipments and how much they use energy consuming materials during the hours of the day.

##### 4.1.7.1 USE OF RENEWABLE ENERGY

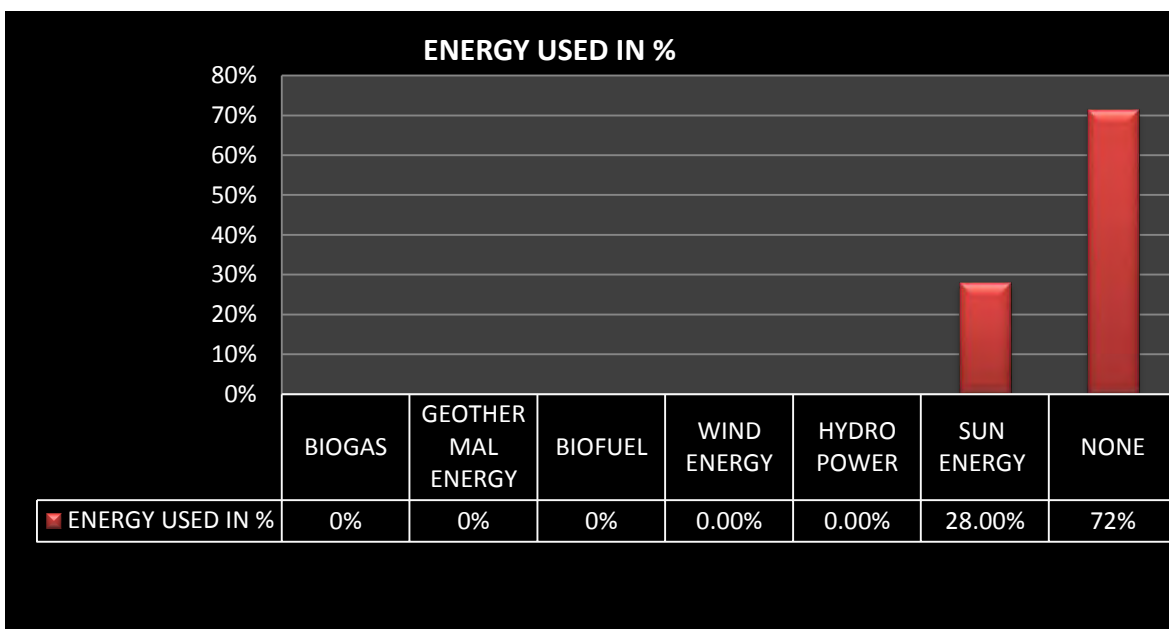


Figure 4- 7 Number of respondents that use about renewable energy

Source: sample building survey

- ❖ *People that live in apartments (Maleda, Bole and Flamingo Apartments) use sun energy for drying their cloth.*

#### 4.1.7.2 KNOWLEDGE ABOUT RENEWABLE ENERGIES ESPECIALLY BIO GAS

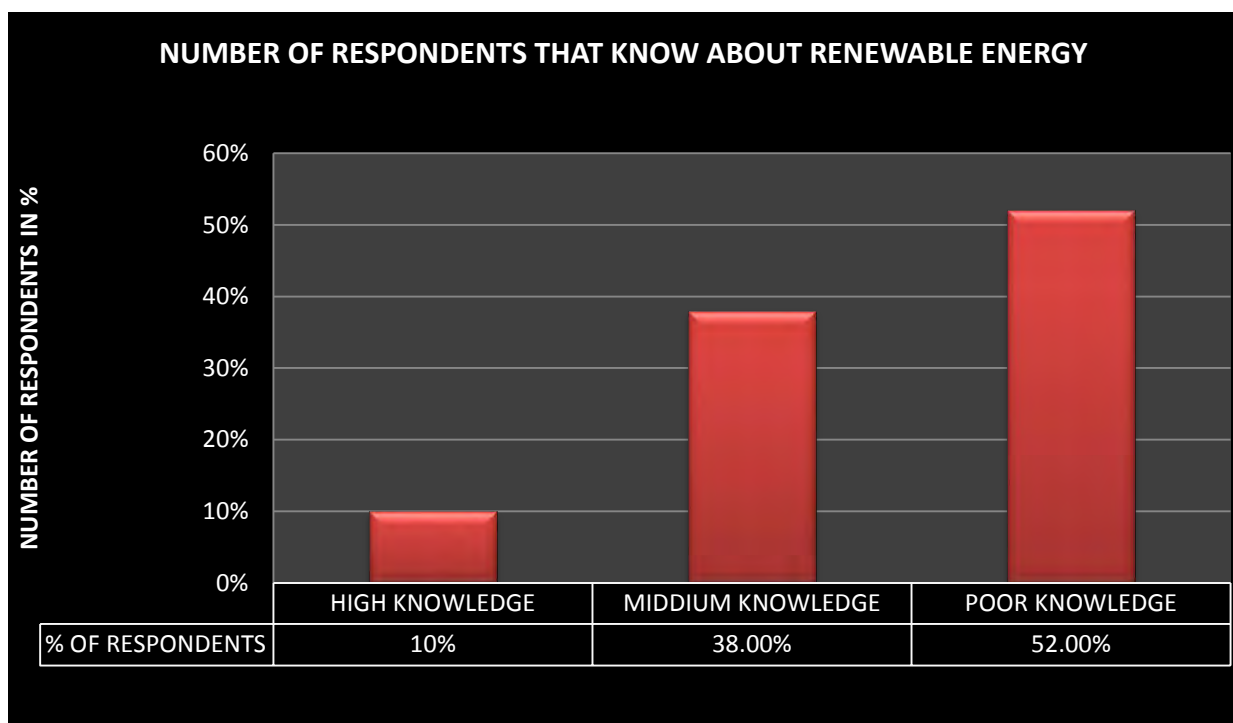


Figure 4- 8 Number of respondents that use about renewable energy  
Source: sample building survey

- ❖ *Respondents that work in offices seem to have a better knowledge about renewable energy.*

#### 4.1.7.3 ENERGY EFFICIENT ITEMS

Table 4 9 Energy efficient lamps used in percentage

Energy efficient items	Respondents that use the items
Yes	46.66%
No	28.8%
Use mixed	24.4%

Source: sample building survey

It is known that there are so many items that could be considered as energy efficient objects, for instance, lamps, refrigerator, iron etc. But the respondents only used energy efficient lamps. And because they could not afford to buy the lamps for every room they use only 2-4 lamps in the average. This, they have responded, makes insignificant difference in the electric bill

because assuming a house hold of five having only 2 energy efficient lamps, the cost will not vary as much because there are 3 more energy inefficient lamps in the same house hold. (Note: this deduction came from the survey not from personal insight.)

#### 4.1.7.4 ENERGY CONSUMPTION OF ITEMS

Table 4 10 Percentage of respondents that use items listed below

Items	Average number of items	Average Hour used within 24 hr of the day
Lamps	9	8 hrs
Computers	1	11.8 hrs
Printer	1	10.7 hrs
Refrigerator	1	24 hrs
Boiler	1	5.6 hrs
Sterilizer	1	12 hrs
Drier	1	12 hrs
Stoves + Mitad	0.95	12hrs
Washer	1	5 hrs
Scanner	1	11.6hrs
Charger	1	30 min
TV/ radio	1	5.5 hrs
Iron	1	1 hr
Microwave	1	10.2hrs
Blander + Grinder	1	1 hr
Cash register	1	8 hrs

Source: sample building survey

#### 4.1.7.5 ELECTRIC BILLS OF RESPONDENTS

When asked to presume what amount of their income is spent on electric bill, respondents' answers varied in wide range, because as their livelihood their income also was ranging from low income to high. One's very high bill is other's payable bill. Thus, it is easy how the task was very hard.

Table 4 11 Classification of respondents depending on income level and electricity bill

Status	Average payment form income in %	Bill paid for electricity usage in% from total income
High	More than 3% from total income	23.33%
Middle	2%-3% from total income	33.33%
Low	Less than 2% from total income	33.33%

Source: sample building survey

#### 4.1.8 WATER RESOURCE FINDINGS

under buildings' water consumptions the criteria taken under consideration were amount of water used per day, usage of rain water, water usage for secondary activities (toilet, garden and car wash) and of course the bills for water consumption.

##### 4.1.8.1 AMOUNT OF WATER USED PER DAY

When asked the amount of water they spend in a day, respondents' answers were vague and careless. This, by itself was answer enough that indicated people do spend water unconsciously and without foreseeing the impact it has on the environment and also on the next generation.

Table 4 12 Amount of water used per day

Functions	Average Amount of water used roughly
Food	132lit
Drink	72.25lit
Washing items	110lit
Bathing	360lit
Toilet	359lit
Car wash	100lit
Plants	50lit
Washing hands	50lit
Cleaning room	28.5lit
Summation	1161.75lit

Source: sample building survey

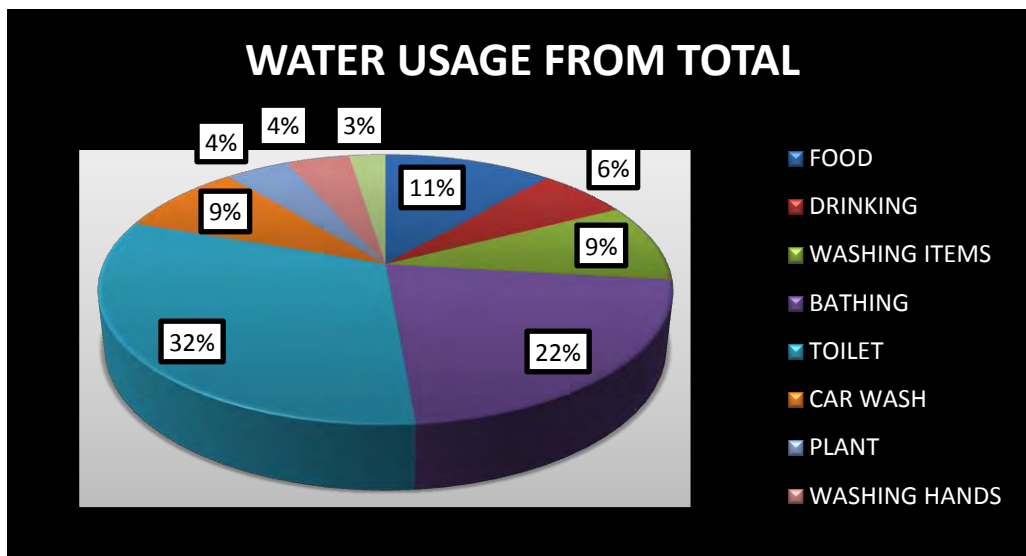


Figure 4- 9 Amount of water used in the surveyed buildings  
 Source: sample building survey

From the chart above we can understand that the most water is used for toilet and bathing. This secondary activity does not necessarily need clean water. But as we will see in later section respondents mostly use clean water for most activities described above.

#### 4.1.8.2 USAGE OF RAIN WATER

Though the question of collecting rain water does not come like a new subject to inhabitants and workers in Addis Ababa. Most are aware that rain water can be used for many functions.

Table 4 13 Amount of water used per day in shops and offices

Do you use rain water?	
Yes	4.7%
No	95.3%

Source: sample building survey

❖ Few respondents in Maleda Apartment claimed to use rain water.

#### 4.1.8.3 WATER USAGE FOR TOILET, GARDEN AND CAR WASH

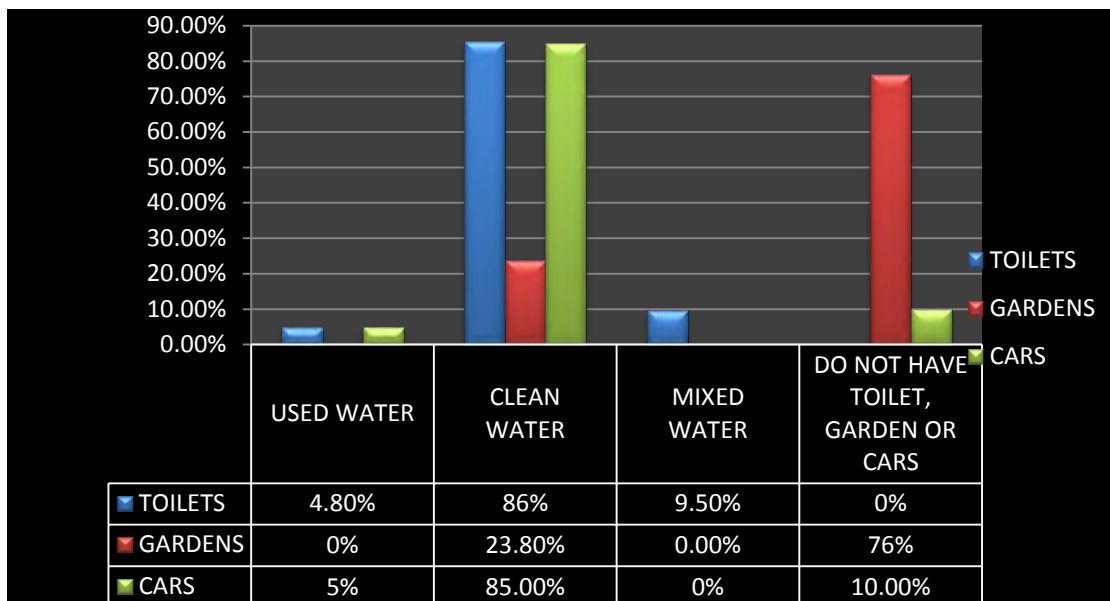


Figure 4- 10 Water usage for toilet,garden and car wash

Source: sample building survey

- ❖ Those who used mixed and used water for toilets are in apartments such as Bole Apartment and Maleda.

#### 4.1.8.4 WATER BILLS OF RESPONDENTS

Table 4 14 Water usage bills

Status	Average payment form income in %	Bill paid for electricity usage in% from total income
High	More than 3% from total income	24%
Middle	2%-3% from total income	38%
Low	Less than 2% from total income	38%

Source: sample building survey

#### 4.1.9 WASTE MANAGEMENT FINDINGS

Those who had communal garbage disposing system had to walk average of 10 meters to the garbage bin to dispose their waste, so the habit of leaving waste as a mess around their work and living area was observed during surveying due to tiresomeness of walking all the way to disposal bin.

#### 4.1.9.1 COMPOSITION OF WASTE MATERIAL

The type of waste material is divided into metal, ash, dust, plastic and organic. The composition of these elements differs from shops to apartment, from apartments to offices and from shops to offices. Buildings that have higher content of organic material in their waste can decompose their waste if they had a compost site. Buildings with higher composition of plastic can resell the waste to factories that recycle the plastic. Metal can also be used to produce other materials if recycled.

##### 4.1.9.1.1 COMPOSITION OF WASTE MATERIAL IN SHOPS

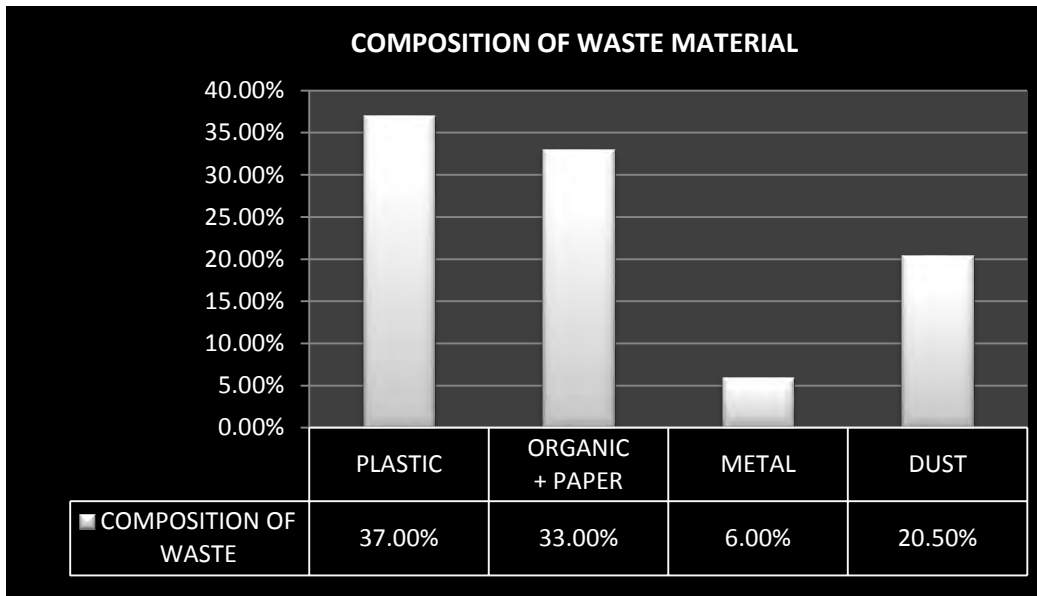


Figure 4- 11 Composition of waste material in shops

Source: sample building survey

#### 4.1.9.1.2 COMPOSITION OF WASTE MATERIAL IN OFFICES



Figure 4- 12 Composition of waste material in offices

Source: sample building survey

#### 4.1.9.1.3 COMPOSITION OF WASTE MATERIAL IN APARTMENTS

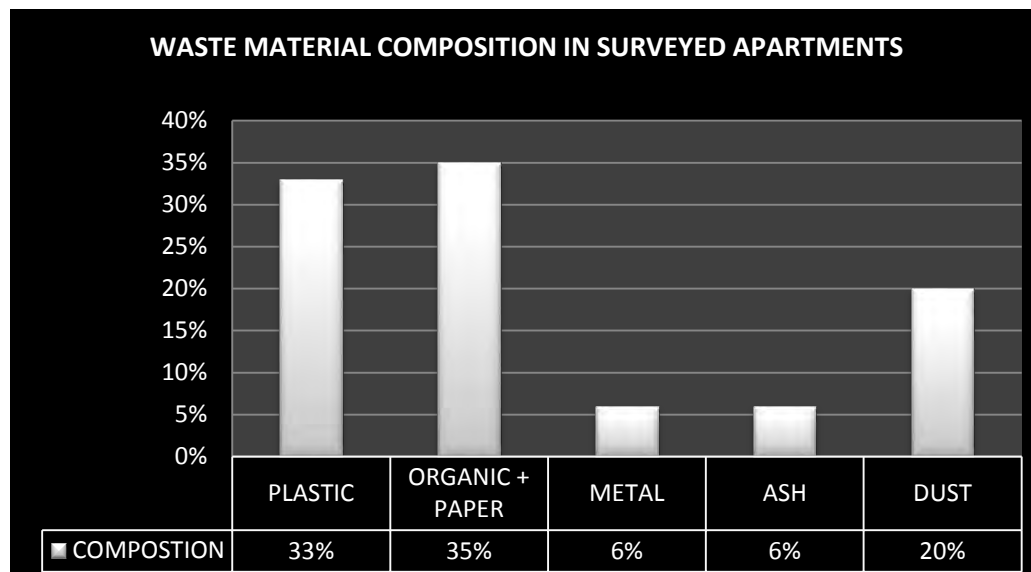


Figure 4- 13 Composition of waste in apartments

Source: sample building survey

#### 4.1.9.2 AMOUNT OF GARBAGE DISPOSED

Since it was difficult for both respondents and the research conductor to weigh every garbage disposed, respondents were told to roughly estimate the garbage they dispose off in terms of Kurtu plastic bag as a measuring device. The average every respondent dispose of every day has been calculated to be 1 Kurtu.

#### 4.1.9.3 SORTING OF GARBAGE

It is easy to gather from section 3 table of questions and answers of respondents) that almost all of the buildings do not sort garbage.

#### 4.1.9.4 TOILET WASTE COLLECTION SYSTEM

Table 4 15 Toilet waste collection system

Type of toilet waste collection	
Sewerage System	9.5%
Drain to river	0%
Drain to open space	0%
Closed system/ septic tank	90.5%

Source: surveyed building data

#### 4.1.9.5 COLLECTION OF GARBAGE

Most of the building's garbage is collected through curb side collection. Buildings like DEMBEL and the Red Terror Museum have been witnessed to burn most or all of their waste. Some of small sized buildings (G+1 to G+3) use door to door collection.

#### 4.1.9.6 BUILDING MATERIAL AND FINISHING

Buildings built from concrete and stone were found to be durable. For instance *Ras Shell*, *Bedlu Hentsa*, *Ban o De Roma* and *Maleda* are all built from concrete and they have lasted more than three decades. These buildings are said to be durable relatively. The same cannot be said about buildings built from curtain walls because of installation problems and weather conditions.

#### 4.2 COMPARISON BETWEEN ASSESSED BUILDINGS & GREEN BUILDING

This section will address the gap between green buildings and surveyed buildings. By using criteria of testing for indoor environment quality, energy consumption, water consumption and also waste management.

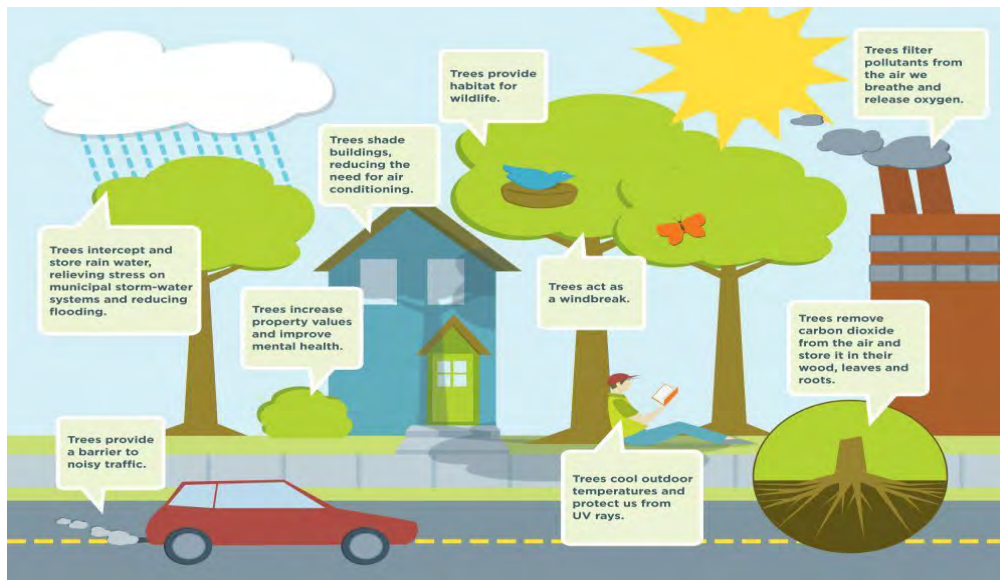


Figure 4- 14 The use of greeneries in urban areas

#### 4.2.1 TESTING FOR INDOOR ENVIRONMENT QUALITY

This category includes temperature, windows and light, microbial growth, dampness and ventilation and green infrastructure.

##### 4.2.1.1 INDOOR TEMPERATURE QUALITY

This sub division will include the indoor temperature of the green building and the existing condition of the surveyed buildings and the gaps between the two (green building and surveyed buildings).

##### 4.2.1.1.1 INDOOR TEMPERATURE OF GREEN BUILDINGS

In 2006, a formal statistical analysis of 24 of studies was completed to assess the average relationship between temperature and performance of work. The authors primarily analyzed office studies and laboratory studies that simulated office work, although three of 24 studies were performed in classrooms. Their analyses are the source of table 5.1.2 illustrating a best estimate of how office work performance varies with temperature. The graph in table 5.1.2 shows that performance is maximized when the air temperature is approximately 71 °F. As the indoor air temperature rises above or falls below 71 °F, work performance decreases. The equation for the curve in Figure 1, resulting from the statistical analysis, is

$$P = -5.5893 + 0.2394 \cdot T_F - 0.002824 \cdot T_F^2 + 0.00001068 \cdot T_F^3$$

Where;

- P is performance relative to the maximum value
- TF is room temperature, °F.

The equation should not be used for temperatures below 59 °F or above 89 °F.

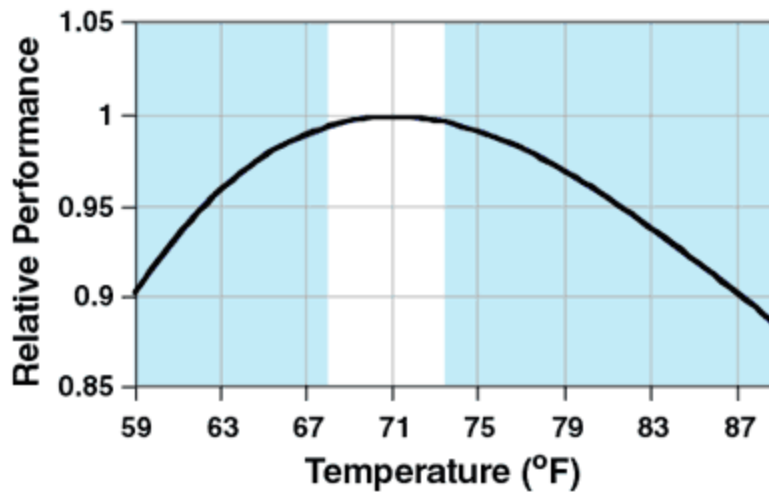


Figure 4- 15 Room temperature and productivity

Source: Lawrence Berkeley national laboratory

Table 4 16 Estimated value of work performance changes from a 1°F shift in temperature toward the optimum for performance<sup>1</sup>.

Temperature Change	Estimated Increase in Performance (%)	Annual Economic Benefit per Worker @ \$100K per Worker	
<b>increasing temperatures</b>	67 to 68 °F	0.43	430
	68 to 69 °F	0.30	300
	69 to 70 °F	0.17	170
	70 to 71 °F	0.05	55
<b>decreasing temperatures</b>	76 to 75 °F	0.43	430
	75 to 74 °F	0.35	350
	74 to 73 °F	0.26	260
	73 to 72 °F	0.16	160

Source: Lawrence Berkeley national laboratory, 2009

The design of Green Buildings starts with orientation of the building itself. This, as stated above, helps moderate the indoor building environment. Orienting a building in a certain direction can aid in the consumption of energy or add to the consumption of energy needed to regulate the indoor air temperature.

In the case of Green Buildings orientation of buildings plays an important role in assuring the reduction of energy consumption used to regulate temperature. Every green Building that is considered functional is oriented along sun direction that has maximum advantage of sable temperature. The heat retention properties of tall buildings and urban materials such as

concrete and asphalt are the primary causes of urban heat island effect. It should be noted that a Green Building is said to be functional if the structure is comfortable enough for occupants to function well.

Section 01 81 13, "Sustainable Design Requirements," includes general requirements for managing and protecting indoor air quality during construction. In order for people to function properly concepts like building material, orientation and many other scopes must come together to give a sensible indoor environment where comfort is first priority. From the many concepts described above temperature is one of the most critical terminologies we come across whenever we try to better indoor air quality.

Room temperature is a colloquial expression for the typical or preferred indoor (climate-controlled) temperature to which people are generally accustomed. It represents the small range of temperatures at which the air feels neither hot nor cold, often approximated at 20°C or 70°F. In more rigorous scientific contexts it may denote the range between 23 and 25.5 °C (73.4 and 77.9 °F) with an average of 24.3 °C (75.7 °F).

**4.2.1.1.2 THERMAL RESISTANCE OF BUILDING MATERIALS AND TEMPERATURE**

Building elements, particularly those in the shell of a structure give protection from the outside environment, and extreme conditions such as, heat and cold. The measures of how effectively the shell of a building maintains an equable temperature for the benefit of occupants is in part gauged via the thermal resistance of the shell. In mathematical terms the Thermal Resistance of an element is the inverse of its Thermal Transmittance.

The Thermal Resistance of a building element or the materials used provide for the flow of heat (always from a hot to cold temperature) to be impeded. This impedance is measured in terms of the total R-value for a building element, which equates to the sum of the component R-values of the various materials, including the inner and outer air surfaces and any air-spaces that make up the composite building element.

- Calculation of Thermal Resistance (R) of a Wall

To calculate the Thermal Resistance (R-value) of a wall, the following equation is used:

$$R = \frac{1}{U} = \frac{1}{h_i} + \frac{1}{h_o} + \left( \frac{1}{a_1} + \frac{1}{a_2} + \dots + \frac{1}{a_n} \right) + \left( \frac{d_1}{k_1} + \frac{d_2}{k_2} + \dots + \frac{d_n}{k_n} \right) \text{ m}^2\text{km}^{-1} \dots \dots \dots \text{ (Howard harries, 2004)}$$

Where:

R = total Thermal Resistance of the wall

U = Thermal Capacity

hi = coefficient of heat transfer for inner surface of wall

ho = coefficient of heat transfer for outer surface of wall

a1...an = air-spaces coefficient of heat transfer

d1...d n = thickness of each successive layer of materials

k1 ...k n = thermal conductivity of n layers or different material of elements (W/mK)

#### **4.2.1.1.3 GOOD THERMAL RESISTANT MATERIALS' VALUE VS THE MATERIALS USED ON THE SURVEYED BUILDINGS**

Though there are no identical values throughout the world stating a particular materials' thermal resistance value is best, it is fair to apply values countries similar to our city's weather condition have applied. Building materials with larger thermal resistance (R-value) are suitable for this country's weather condition because they do not let heat escape easily and also do not allow heat to penetrate into their spaces easily.

Now, when we come to the building materials used in surveyed buildings we find HCB, glass, stone and red brick.

Brick

*R = 0.76 m<sup>2</sup>K/W making it a very good thermal resistant material*

Stone

*R = 0.66 m<sup>2</sup>K/W making it a very good thermal resistant material*

Glass

*R = 0.03m<sup>2</sup>K/W which makes it relatively weak thermal resistant material.*

HCB

*R = 0.56m<sup>2</sup>K/W which makes it relatively material. (Ernest Neufert, 1999)*

#### **4.2.1.1.4 INDOOR TEMPERATURE OF SURVEYED BUILDING**

##### *Buildings Built With Stone Masonry*

This material has high thermal resistance of 0.66 m<sup>2</sup>k/W. this means this building material does not let heat escape or let in heat easily. Ocupants in these buildings experience cool temeprature during day time and since the masnory releases heat during night time, the ocupants do feel warmth.

These buildings, 4.7 % of them out of the total surveyed, claim to have a 'nice' atmosphere with in the building inclosure.

##### *Buildings Built With HCB Walls (Most Of Their Parts Built From HCB)*

These buildings' building material has relatively low termal resistance of ..... m<sup>2</sup>k/W. during interivews with ocupants of buildings built with HCB walls they stated they experience tempeare fluctuation along with seasonal changes. But the average character of such buildings collected from interviews indicated these buildings experience temperature fall with reference to the standard room temeprature that is 71<sup>0</sup>F.

This leads to the conclusion that these buidings (33.33% of them) need the necessary additional energy to stabilize the temeprature needed to perform the activities.

### *Buildings Built With Curtain Walls*

Buildings that have more glazing in proportion to their solid walls or are built with curtain wall mostly experience the same character of temperature when it comes to indoor air quality. Occupants experience temperature during day time (mid day through late afternoon) and temperature fall during night time (from 12:30 till dawn) during warm season and general temperature fall during night and day time in cold season.

It is obvious to anyone who spent time enough time in AA that most buildings in general are built with HCB and Curtain wall. These two building materials, as calculated in the above section, are found to be low thermal resistant materials creating mild to high problems for the occupants. These leads to the deduction that 47% of the buildings that are assessed in particular and most of the buildings in AA in general have uncomfortable indoor air quality.

#### **4.2.1.1.5 GAPS BETWEEN GREEN BUILDINGS AND SURVEYED BUILDINGS IN TERMS OF INDOOR TEMPERATURE**

##### GREEN BUILDINGS

- Use natural ventilation and orientation to balance indoor temperature quality so as to have maximum performance. (Lawrence Berkeley national laboratory, 2009)
- Uses proper window to room ratio in order to have proper cross ventilation to occur with in the room. (William Fisk, Olli Seppanen, 2007)
- Selection of building materials that are in accordance to the thermal condition of the site is given significant consideration. (The Indoor Environmental Quality (IEQ))

##### SURVEYED BUILDINGS

- 47% of the assessed buildings face temperature rise or fall from the room temperature. (source: sample building survey)
- Most buildings do not follow the proper window to room ratio so that they could have proper ventilation and temperature balance. (source: sample building survey)
- Most buildings are built with HCB and Curtain walls that have weak thermal resistance. (source: sample building survey)

#### **4.2.1.2 WINDOWS AND LIGHT**

The windows' orientation and size of Green Buildings are quite different from the building surveyed.

##### **4.2.1.2.1 WINDOWS AND LIGHT OF GREEN BUILDINGS**

The LEED IEQ category addresses design and construction guidelines especially: indoor air quality (IAQ), thermal quality, and lighting quality. Section 01 81 13, "Sustainable Design Requirements," of the LEED specification clearly specifies the guidelines of nature of light in accordance with the function that takes place in a particular space.



Figure 4- 16 Natural light filling a dining room

It is said that windows are the eyes of a building. They are eyes that let in the light and view. This is quite true. Living conditions like bed rooms, living rooms, kitchens, toilets need windows for ventilation and sufficient light. Also, working conditions like shops and offices need windows in order to perform and manage the task at hand. It is true that there are mechanical means of ventilating and lighting a room. But those systems consume energy and are costly for countries such as ours. It is repeatedly heard that our country has 13 months of sunshine. This is a resource by itself. We can easily manipulate this resource in order to have sufficiently ventilated and lighted rooms in particular and buildings in general.

When we come to the existing situation of the buildings assessed, it is somewhat difficult to distinguish functional windows from non functional windows because in some buildings even if the windows let in enough light inhabitants still put on artificial lights during day time. Thus, the functionality of the windows available depended on the characters of the inhabitants.

#### **4.2.1.2.2 FUNCTIONAL WINDOWS AND LIGHT**

Human dependency on light and the positive effects of natural light on our health and performance becomes apparent only when we are deprived of light or exposed to excess quantities of light.

Studies by the Research Foundation of Lighting and Health in the Netherlands have shown that roughly 70% of the populations feel minor depressive mood swings. They also confirmed that additional light at the workplace relieves these symptoms which, in turn, has a positive effect on well-being, and hence on performance. (Ulrike Brandi, 2000)

Scientists call the chronic form of winter depression Seasonal Affective Disorder (SAD); approximately 3 % of the population is affected. It can be successfully treated with a light therapy during the dark winter months.

The lack of day light is second only to air-conditioning; which is the leading cause of SBS, Sick Building Syndrome. The World Health Organization coined the term in 1983 to describe the negative effects of the built environment that are not related to a specific physical illness. A study by A. and G. Ca proved that the typical symptoms of SBS - headaches, fatigue, and

numbness irritation of the eyes - increase in portion to the use of artificial lighting. Ailments increase the further the work place is located towards the centre of the room, while higher levels of daylight have shown to improve performance. In addition to the phenomenon of psychological, glare suggests that artificial lighting, even if it is installed to standard specifications, cannot replace the quality of daylight.

#### 4.2.1.2.3 WORK SPACE

Light in the workplace, whether in the administration or production sector, should provide a healthy, safe and comfortable working environment. In consideration of these three factors, the following daylight and artificial lighting criteria for good and efficient visual performance can be listed:

- illumination
- uniformity (at the place of work) - luminance conditions in the field of vision
- Avoidance of glare
- light distribution (in interior spaces)
- color properties of light (Ulrike Brandi's list, 2000)

A functional window is in lay man's terms windows that allow enough light so that the person in the room is not pressured to put on artificial light during day time. Furthermore, these are some of additional checkpoints that are used in architectural view;

- Windows that face next building's wall with specified setback:
- Windows that face another building's curtain walls with proper shading device intact:
- Windows that follow the proper calculation of window to room ratio:
- windows that face the direction of north to north east that allow sufficient light in the room:
- windows that avoid facing a land fill site that let foul smell to come into the room:

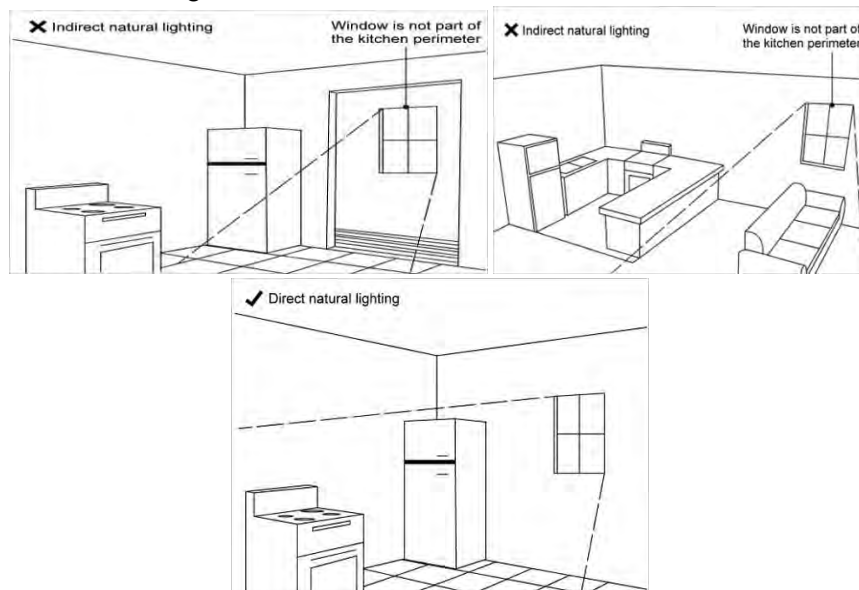


Figure 4- 17 Windows should be part of the perimeter wall of the room being, Windows should be part of the perimeter wall of the room being and Effective natural lighting is close to task areas

- The description above shows that even if some apartments/shops/institutes do have windows, since the window is not in the work area like the office/kitchen or class room area it does no good.
- Whereas the correct manner should have been like as the following diagram;

#### 4.2.1.2.4 DEFINING NATURAL COLOR OF ITEMS

The vegetables on the left are in natural light and the ones in the right are under artificial lighting.



Source: Geoff Milne, 2013

Figure 4- 18 The color rendering index rates the portrayal of color

Contact with the outside world; since the windows do not have sufficient light passing through them, it is very difficult for occupants to maintain contact with the outside world.

- **Clarity of structure;** since the natural color is biased, it is difficult to have a clear definition of structure.
- **Unwanted heat from light bulbs during daytime** (summer time mostly)

#### 4.2.1.2.5 SUFFICIENT LIGHT IN A ROOM FOR SUFFICIENT PERFORMANCE

*At an illumination level above 2000 lx the secretion of melatonin (sleeping hormone) may be suppressed or postponed. While an illumination level of 500 lx, commonly found in offices, does not affect physical well-being.* (Ulrike Brandi, 2000)

In the previous chapter it was found that the average number of lamps is 9. Taking the average watt of typical incandescent lamp of 60 makes the total of luminous value of

*9 lamps of 60 watts each = 60 x 9 = 540 watts*

*540 watts = 243,000 lx average*

This is well above the needed lx.

Usually, though the function of a building determines the amount of light required, sometimes buildings or areas of buildings will demand a high level of light to serve the visual needs of the occupants, whilst other areas may be satisfied by lower levels. Suggested levels are found in publications such as the codes of practice of the different Illuminating Engineering Societies. Examples might be as follows:

- High Bay storage 20 lux
- Boiler house 100 lux

- The nave of a church 100–200 lux
- Living room in a home 100–300 lux
- School teaching place 300 lux
- Offices, computer stations 300 lux
- Offices, general 500 lux
- Precision assembly, electrical 1000 lux
- Hospital operating theatre
- (over limited area) 15 000–30 000 Lux

\*Taken from the Code for Interior Lighting, CIBSE UK, 1994

#### 4.2.1.2.6 WINDOW TO ROOM RATIO

The standard window size that allows sufficient task to be done in a room is as follows. (Ernest Neufert, 1999)

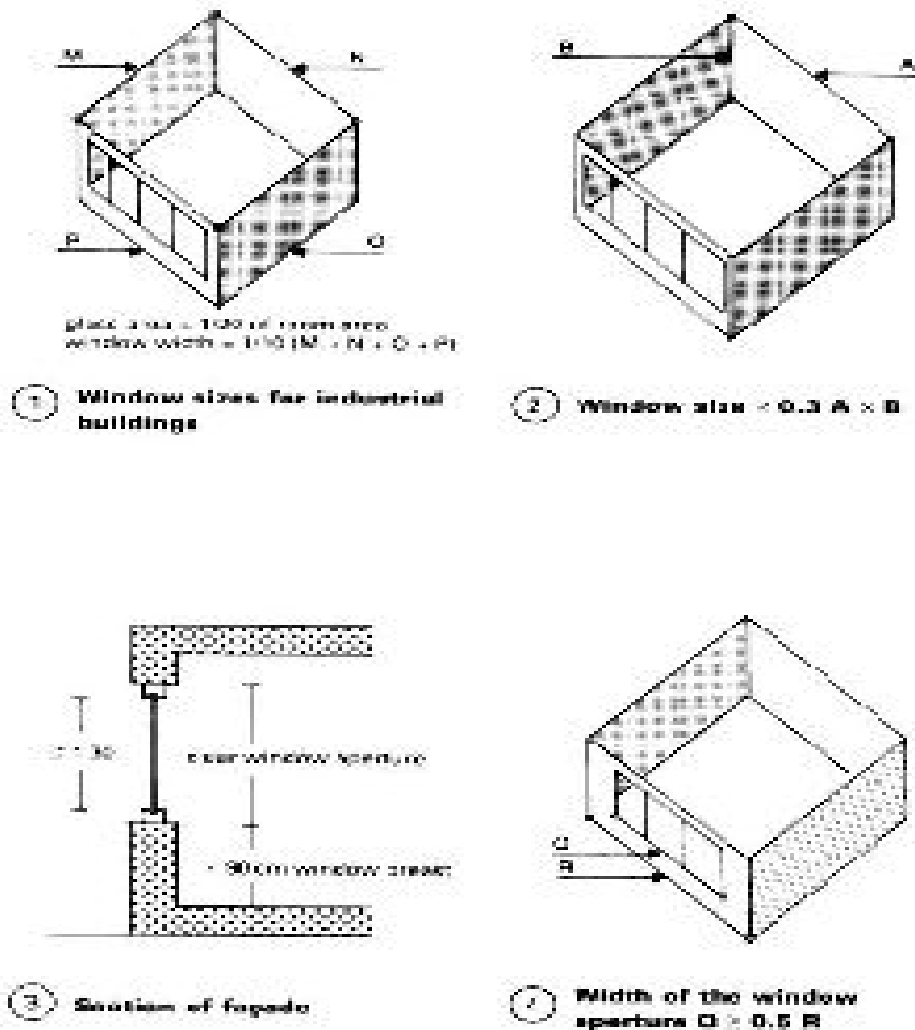


Figure 4- 19 Window to room ratio

**Source: Ernest Neufert, 1999**

Every working area needs windows leading to the outside world. The window which transmits light must be at least 1/20 of the surface area the floor in the work space. The total width of all windows must amount to at least 1/10 of the total width of all walls, i.e.  $1/10(M+N+O+P)$  (Ernest Neufert, 1999)

For workrooms which are 3.5m or more high, the light transition surface of the windows must be at least 30% of the outside wall surface, i.e.  $\geq 0.3 A \times B$

For workroom with dimension similar to those of living room, the following rules must be considered

- minimum height of glass surface, 1.3m
- height of the window breast from the ground  $\geq 0.9$
- the total height of all windows must be 50% of the width of the workroom, i.e.  $Q=0.5R$  (Ernest Neufert, 1999)

Those that are considered to be a successful and energy efficient Green Buildings use natural light sufficiently so as not to use artificial light during day time. One of the purpose of Green Buildings is creating a high performance luminous environment through the careful integration of daylight and electrical light sources that will improve on the lighting quality and energy performance of a structure.

#### **4.2.1.2.7 WINDOWS AND LIGHT OF SURVEYED BUILDING**

This graph by itself (fig 4.12) shows that though rooms in the apartments and or shops do have windows, they windows may or may not be functional when it comes to letting in enough light.

#### **4.2.1.2.8 GAPS BETWEEN GREEN BUILDINGS AND SURVEYED BUILDINGS IN TERMS OF WINDOWS AND LIGHT**

##### **GREEN BUILDINGS**

- Try to provide each room with natural light in order to have properly function occupants (The Indoor Environmental Quality (IEQ))
- Uses proper window to room ratio in order to have proper light to enter room. (William Fisk, Olli Seppanen, 2007)
- Windows that face another building's curtain walls with proper shading device intact (Ernest Neufert, 1999)
- windows that face the direction of north to north east that allow sufficient light in the room: (Ernest Neufert, 1999)
- windows that avoid facing a land fill site that let foul smell to come into the room: (source: sample building survey)

##### **SURVEYED BUILDINGS**

- are faced with glare problems from the outside or inside environment that has caused them not to open their windows during day time
- Those who do not have glare problem are faced with the wrong orientation of windows that let in direct harsh sun rays.
- Some windows face the direction of rooms that have foul smell or land fill site that let in bad smell when opened.
- Some room to window ration is not respected
- Self created spaces (done by users) have left spaces that are without windows and without natural light.

#### **4.2.1.3 MICROBIAL GROWTH, VENTILATION AND DAMPNES**

When the materials in a building become sufficiently damp to cause material damage or visible mold growth we often say that the building has a dampness problem or we characterize the building as a damp building. There are many causes to dampness, seepage between ill constructed details of window and doors letting water to seep into indoors, nature of the area where the building is built etc.

The dampness and mold growth may occur on visible interior surfaces in the building, including within basements or crawl spaces, or be hidden inside walls and air conditioning systems. Building dampness problems arise from a range of sources including, but not limited to, water leakage through roofs and walls, plumbing system leaks, groundwater entry, damp construction materials, high indoor rates of moisture generation, entry of humid outdoor air coupled with insufficient dehumidification, water vapor condensation on cold surfaces of windows and walls, and floods.

##### **4.2.1.3.1 IMPACTS OF BUILDING DAMPNES ON INDOOR AIR QUALITY**

When building materials or furnishings are damp for a sufficient time period, mold and bacteria will often colonize the materials. The molds and bacteria can produce microscopic airborne particles, some containing allergens or chemicals with the potential to induce inflammation in the respiratory system. Molds and bacteria are also sources of odorous volatile organic compounds in the indoor air. High indoor relative humidity in damp buildings also can increase the number of house dust mites present indoors and these mites are an important source of indoor allergens. Many building materials also emit chemicals into indoor air and increased dampness in these building materials may also lead to increases in emission rates of gaseous non-microbial chemicals, for example formaldehyde.

It is found that more than 95% of the buildings assessed face microbial growth and dampness problem throughout their systems. And only 4% were found with no or minimal problems. Those buildings that do have problems of microbial growth and dampness include;

- ❖ Leakage in toilets,
- ❖ Seepage between openings,
- ❖ Rotten wood in ceilings,
- ❖ Dampness due to improper ventilation of rooms ,

- ❖ Algae and fungi growth because of dampness and heat in certain rooms.
- ❖ Condensation of water created due to small openings that allow water to condense and rot the building material.
- ❖ Foul smells created by harmful microbes

#### **4.2.1.3.2 MICROBIAL GROWTH, VENTILATION AND DAMPNESS and HEALTH**

In 2004, the Institute of Medicine (IOM) of the National Academy of Sciences completed a major review of the available scientific literature pertaining to the health consequences of building dampness and mold. In 2009, the World Health Organization (WHO) completed a similar review 2011 published and update to the review by the WHO. The conclusions of each of these reviews are similar, with the later reviews identifying a few more health effects as associated with dampness and mold. Based on the review of Mendell dampness and mold in homes is associated with increases in several adverse health effects including upper respiratory symptoms, cough, wheeze, difficulty breathing, asthma exacerbation, development of new asthma, bronchitis, allergic rhinitis (allergy-caused inflammation of the nasal passages with runny nose or congestion), and eczema.

#### **4.2.1.3.3 BUILDINGS ALONG MAIN ROAD AND VOCs**

Indoor volatile organic compounds, or VOCs, are carbon-containing organic chemicals present in indoor air. They come from a large number of indoor sources including building materials, furnishings, consumer products, tobacco smoking, people and their activities, and indoor chemical reactions. Pollutants from attached buildings such as garages may also enter indoor living spaces. Outdoor air is also a source of indoor VOCs. Since our study area sample frame is buildings that have high land value that follow main road and main road is where cars are highly circulating. This is additional causes to VOCs to the indoor environment of sampled buildings.

Initial evidence is appearing that concentrations of some specific VOCs may be related to the occurrence in buildings of a broader set of symptoms, such as respiratory symptoms, headaches, and fatigue, sometimes called Sick Building Syndrome symptoms. Also SVOC are found to be emitted from interior materials like regular refrigerator, flooring like vinyl and paints. (Lawrence Berkeley national laboratory, 2009)

#### **4.2.1.3.4 MICROBIAL GROWTH, VENTILATION AND DAMPNESS AND GREEN BUILDINGS**

Green buildings do not take the matter of microbial growth easily. The sampling and analytical methods for speculating fungi have evolved significantly in the last decade. Based on consultations with EPA researchers, this specification calls for DNA detection using quantitative polymerase chain reaction (QPCR). The QPCR method is more reliable and consistent than conventional morphology using visual identification, which is highly dependent on the experience of the technician.

Indoor Air Quality seeks to reduce volatile organic compounds, or VOCs, and other air impurities such as microbial contaminants. Buildings rely on a properly designed ventilation

system (passively/naturally or mechanically powered) to provide adequate ventilation of cleaner air from outdoors or re-circulated, filtered air as well as isolated operations (kitchens, dry cleaners, etc.) from other occupancies. .

More detailed requirements for testing indoor air prior to occupancy, and for testing products that are to be installed, are included in Section 01 81 09, “Testing for Indoor Air Quality” of the LEED requirement guide specifications.

Section 01 81 09 is intended to define terms and lay out general procedures and requirements for testing to ensure adequate indoor air quality prior to occupancy of a new or refurbished facility. The scope of this document is limited to testing procedures and performance thresholds for those tests, including both testing of indoor air prior to occupancy, and testing of products and materials to be used in construction.

Ideally, product and material selection decisions would be based on a comprehensive, reliable *life-cycle assessment* to determine the most environmentally preferable choice for each application. Such a selection process is not feasible for most construction and renovation projects at this time. However, the Building for Environmental and Economic Sustainability software tool from the National Institute for Standards and Technology contains information that makes such comparisons feasible for at least one product category—carpets.

During the design and construction process choosing construction materials and interior finish products with zero or low VOC emissions will improve IAQ. Most building materials and cleaning/maintenance products emit gases, some of them toxic, such as many VOCs including formaldehyde. These gases can have a detrimental impact on occupants' health, comfort, and productivity. Avoiding these products will increase a building's IEQ. LEED, HQE and Green Star contain specifications on use of low-emitting interior. Draft LEED 2012 is about to expand the scope of the involved products. BREEAM limits formaldehyde emissions, no other VOCs.

The basic feature described in Green Building is appliance. These appliance are particularly selected so as they are low VOC emitting materials. These materials in Green Building lower the risk of occupants' infection with microbes and create a comfortable environment that generally enhances performance. With the aid of orientation that improves ventilation, suffocation and foul smell caused by micro organisms, is avoided. With proper ventilation dampness could be avoided also.

#### **4.2.1.3.5 MICROBIAL GROWTH AND DAMPNES OF SURVEYED BUILDING**

During the survey, though most people did not know the connection between dampness, microbial growth and discomfort, they felt uncomfortable and mostly developed mild type of sickness nonetheless. As described in table below the realistic condition of surveyed buildings are considerably serious. Since those respondents questioned spend most of their time in the building they are highly exposed to discomfort.

*Table 4 17 Showing percentage of respondents suffering from indoor microbial growth and dampness*

<b>sickness</b>	<b>% of</b>	<b>frequency</b>	<b>Symptoms</b>	<b>Causes</b>
-----------------	-------------	------------------	-----------------	---------------

**population**

<b>No Sickness</b>	22%(no sickness but only mild discomfort)	-----	-----	-----
<b>Cough</b>	-----	Every 5-6 month	cough with phlegm; cough without phlegm; day or night cough; dry cough; morning cough; long-	Foul smell coming from damp rooms caused by bacteria and virus
<b>Allergy</b>	-----	Rarely	runny nose or congestion	Caused by inflammation of the nasal passages
<b>Asthma Exacerbation/development</b>	-----	During the cold seasons	Difficulty in breathing, eye irritation, ear irritation, nose irritation, Discomfort in chest area	Foul smell coming from damp rooms caused by bacteria and virus
<b>Cold</b>	-----	Every 3-4 month	runny nose or congestion, fever	Foul smell coming from damp rooms caused by bacteria and virus
<b>Wheeze</b>	-----	Not that frequent	including shortness of breath and asthma; wheeze/breathlessness; wheezing or whistling in the chest	Stuffiness, Irritated Dust and microorganisms
<b>Difficulty Breathing</b>	-----	Not that frequent	Mild pain in the chest area and difficulty breathing	Stuffiness, Irritated Dust and microorganisms

**General  
discomfort**

-----

Always

Decrease in  
performance and  
general unhappiness

Toilet  
leakage and  
unpleasant  
smell etc.

---

*Source: surveyed building data*

#### **4.2.1.3.6 GAPS BETWEEN GREEN BUILDINGS AND SURVEYED BUILDINGS IN TERMS OF MICROBIAL GROWTH, VENTILATION AND DAMPNES**

##### **GREEN BUILDINGS**

- Personal temperature and airflow control over the HVAC system coupled with a properly designed building envelope will also aid in increasing a building's thermal quality.
- Green buildings try to decrease the effect of microbial growth and dampness by detail inspection and eliminating the use of materials that release toxic chemicals like carpet, and replacing them with hardwood, vinyl, linoleum tile or slate flooring. (The Foundation of American)
- The buildings try to avoid condensation in small areas by creating vents in possible pockets for microbial growth allowing it to have ventilation and preventing dampness.

##### **SURVEYED BUILDINGS**

- Most of the buildings have leakage problem or have items that release formaldehyde. (source: analysis of findings)
- Occupants of these buildings face problems of microbial growth created by dampness. (source: sample building survey)
- Most of the occupants face health problems when they do not even know it is caused by the dampness and microbial growth. (source: sample building survey)

#### **4.2.1.4 ORIENTATION OF BUILDINGS**

Orientation of buildings says a lot about the indoor living and working quality of the interior of the buildings.

##### **4.2.1.4.1 ORIENTATION OF BUILDINGS AND THEIR MEANINGS**

Design for orientation is a fundamental step to ensure that buildings work with the passage of the sun across the sky. Knowledge of sun paths for any site is fundamental in design building facades to let in light and passive solar gain, as well as reducing glare and overheating to the building interior. It is important to remember that the position of the sun in the sky is dynamic, changing according to time of day, time of year and the site's latitude.

##### ***NORTH-FACING ROOMS***

The main living spaces such as living, family and dining rooms should be north facing where possible. North-facing rooms:

- Are accompanied by prevailing winds
- Are mostly protected the strong sun rays
- Receive good natural light

### *EAST-FACING ROOMS*

East facing rooms are most suited as kitchen and breakfast areas as they can benefit from early morning solar gain throughout the year and will be cooler in the late afternoon when evening meal preparation takes place. They:

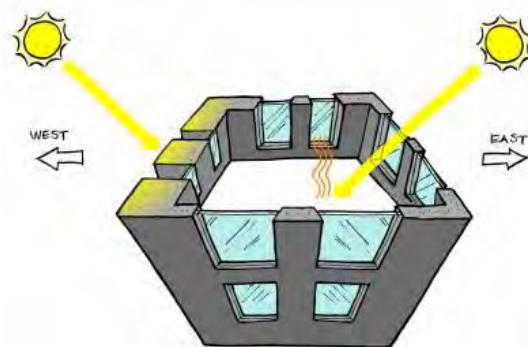
- have good morning light
- have solar gain in the morning throughout the year to provide initial warming
- Will be cooler in the late afternoon.
- Bedrooms that face east will be cooler in the late afternoon and evening, making them more comfortable for summer sleeping. Early risers generally appreciate east sun in spaces they will use first thing in the morning such as breakfast bars.

### *WEST-FACING ROOMS*

As west-facing rooms get low-angle, late afternoon sun, they usually require some shading to prevent overheating and excessive glare, particularly during the summer. They:

- have good afternoon daylight
- can overheat in the late afternoon for much of the year
- may require vertical shading to prevent excessive overheating and glare in the afternoon
- Provide good direct solar gain for thermal mass heating of living spaces in the evening.

A west-facing orientation is suitable as a living area in households where occupants are away from home during the day-time but at home in the evenings. It is not generally suitable as a kitchen as the heat from dinner preparation coincides with low-angled afternoon and evening sun, potentially causing glare and overheating.



*Figure 4- 20 More glazing to the east and more thermal mass to the west can even out temperature swings from the sun's heat.*

### *SOUTH-FACING ROOMS*

South-facing rooms are not suitable for habitable spaces as they:

- have lower levels of daylight during parts of the year
- Have little or no heat gain.
- They are most suited for the location of the garage, laundry, bathroom, toilet, workroom and stairs, where people spend little time and/or use infrequently.

#### **4.2.1.4.2 ORIENTATION OF GREEN BUILDINGS**

Siting and structure design efficiency is the basic starting point of any successful design. The first step of a building orientation and siting can ultimately eradicate the following problems.

- Unwanted temperature rise in indoor environment
- Unwanted temperature fall in indoor environment
- Accumulation of condensed water molecules in small building pockets
- too much heat and light entering rooms
- No sun or heat all day.
- Energy consumption for heating or cooling of rooms

In order to be considered as Green Building a building must be oriented according to its function's needs.

#### **4.2.1.4.3 ORIENTATION OF SURVEYED BUILDINGS**

It should be noted that those building that face the uncomfortable direction of south west are not oriented in wrong direction. They are wrong format of designing if and only if nothing has been done to shade that side or if the building materials is not a thermal mass (thermal resistant) or in our case if it is built with curtain wall or large windows.

#### **4.2.1.4.5 GAPS BETWEEN GREEN BUILDINGS AND SURVEYED BUILDINGS IN TERMS OF ORIENTATION**

##### **GREEN BUILDINGS**

- Mostly north facing rooms are living, family and dining rooms.
- East facing rooms are mostly kitchen and breakfast area.
- West (south west) facing are get low – angle late afternoon sun storage or toilets are suitable because the heat hinders bacterial growth that could occur in the toilets.

##### **SURVEYED BUILDINGS**

- Seems like the orientation of buildings are thoughtless and random. (Source: sample building survey)
- Those that need shading from late afternoon sun are not properly shaded. (Source: sample building survey)

- Room lay outs are in such a way that do not limit excessive usage of energy to cool the indoor temperature rise. (Source: sample building survey)

#### **4.2.1.5 EFFICIENCY OF EMPLOYEES**

The summarized effects of clean and suitable indoor and outdoor environment along the proper orientation will have a positive effect on the efficiency of the users of the building.

##### **4.2.1.5.1 EFFICIENCY OF EMPLOYEES IN GREEN BUILDINGS**

If a building is designed well and considering all the angles of sustainability aspect it is bound to bring the occupants efficiency increase and comfort boost. The concept of all Green Buildings is to bring about a positive change in the indoor air quality so as to increase the efficiency and energy of occupiers. The theory is as simple as this; if a person is comfortable in a certain space he/she will have the energy that is need to work in an increased level of emotional and physical ability to complete a certain task. This means that with the collective effect of proper cross ventilation, temperature stability and non dampness causing microbial growth a person will experience increased level of ability.

##### **4.2.1.5.2 EFFICIENCY EMPLOEES OF SURVEYED BUILDINGS**

It is found from the survey conducted that performance of most employees and users of a building decreases during the afternoon time. This is due to the increase in temperature of the environment and there is nothing the buildings the employees are in can do o stabilize the increase. Since most buildings surveyed are facing southwest and built with non thermal mass they intend to heat up with the temperature boost. The metabolism of humans tends to decrease with increase or decrease temperature. This character is common in animals too and the process is called hibernation at its extreme level.

In interviews conducted respondents admitted they needed a form of stimulants that can revive the slowing metabolisms. That is caffeine. If we take 10 to be the level of efficiency and energy users of a building or employees have in early morning they were asked to label their level of efficiency in the late afternoon 0 being having no motivation or energy. And the graph below shows the average answer the respondents gave during this informal interview.

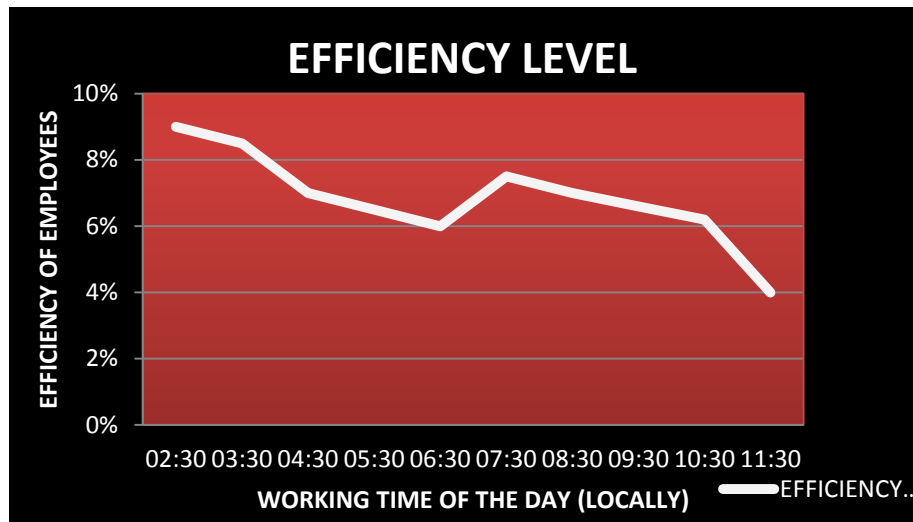


Figure 4- 21 Efficiency level

Source: sample surveyed data

#### 4.2.1.5.3 GAPS BETWEEN GREEN BUILDINGS AND SURVEYED BUILDINGS IN TERMS OF EFFICIENCY

##### GREEN BUILDINGS

- Efficiency of employees is at its highest mostly

##### SURVEYED BUILDINGS

- Since most of the buildings are not well sited and oriented they tend to have temperature variation leading to emotion swings of employees. (source: surveyed building sample)
- Most employees of surveyed buildings need some sort of aid in boosting their efficiency during the afternoon.
- Since there are no regulatory laws that tend to indoor air quality or efficiency of employees in accordance to the indoor air quality like Green Buildings, improving the condition is proving to be difficult.

#### 4.2.2 ENERGY CONSUMPTION

The energy consumption of green buildings and surveyed buildings will be discussed below. and also the gap will be addressed so as to clarify the comparison.

##### 4.2.2.1 ENERGY EFFICIENCY OF GREEN BUILDINGS

Essentially, economic consideration led architects and building developers to seek alternatives to the conventional fossil fuel sources of energy. Today, equal emphasis is given for the ecological necessity is for a change. By means of energy conscious construction, the energy requirements of living accommodation can be reduced by around 50% in comparison to older buildings.

The greatest energy losses from buildings arise from conduction of heat through windows, walls ceiling and roofs. There are three possible points that are taken into account when aiming to design an energy conscious building. (Neufert, 1999)

- (1) Reduction of heat loss
- (2) Increase in energy saving through the use of solar radiation
- (3) Conscious efforts by users to improve energy balance

In green buildings, the choice of the location of the building itself helps in way to reduce energy loss.

A 2003 analysis of the savings from green building found from a review of 60 LEED buildings that the buildings were, on average, 25-30% more energy efficient. However, it also attributed substantial benefits to the increased productivity from the better ventilation, temperature control, lighting control and reduced indoor air pollution.

Turner and Frankel in 2008 compared predicted to actual energy consumption in LEED buildings by using a dataset of 121 LEED-certified buildings provided by the New Buildings Institute. The buildings in this study voluntarily provided measured and predicted energy data, and is not a random sample of LEED-certified buildings. Within this set of buildings, the authors found that, on average, predicted energy savings were 25% below the baseline, while actual measured energy savings were 28% below the baseline. However, there was a large amount of scatter in the data; more than half of the projects' measured energy use intensity, or EUI (energy per unit area per year) deviated by more than 25% of the predicted value (30% of buildings used less energy and 25% used more than predicted). The authors noted that the study was limited by data availability, the collapsing of Platinum and Gold certified buildings into one category, and the over-representation of certain climate zones.

In 2009 and 2012 Newsham et al. reviewed the same data set analyzed by Turner and Frankel. In these studies, each building was paired with a conventional "twin" building within the Commercial Building Energy Consumption Survey (CBECS) database according to building type and occupancy. On average, LEED buildings consumed 18 to 39% less energy than their conventional "twin" building, although 28 to 35% of LEED-certified buildings used more energy than their "twin." The papers also found no correlation between the number of energy points achieved and actual building performance. The authors noted that the studies were limited by the fact that most LEED buildings are newly constructed and may still be experiencing unexpected problems with systems operations, as well as other characteristics which commonly vary across individual buildings of the same type (plug loads, occupancy hours, construction differences, etc.).

Scofield in 2013 analyzed two sets of data: 21 LEED-certified buildings in New York City and the same 121 LEED-certified buildings analyzed by Turner and Frankel, and Newsham et al. Unlike the other studies cited above here, Scofield looked at source, not site energy, which meant he accounted for the energy losses during transmission from each power source. Within the New York City database, Scofield found that buildings that had achieved LEED Gold used, on average, 20% less source energy than did conventional buildings. Buildings with LEED

Silver or LEED Certified ratings actually used 11 to 15% more energy, on average, than did their conventional counterparts. Within the New Buildings Institute data, Scofield identified three potential problems: 1) the conventional buildings used as the baseline were not suitably comparable, 2) the previous studies look at site energy, not source energy, and 3) the previous studies did not weight building size when comparing EUI data. Using a new analysis taking these conditions into account, Scofield found no significant difference in energy consumption non-LEED-certified buildings and LEED buildings found in this survey set. Replacing 20 million traditional bulbs with ENERGY STAR LED bulbs will save Americans more than \$118 million in energy costs and prevent greenhouse gas emissions equal to those from more than 150,000 vehicles, every year. (Energy star, 2012)

There are specific features of Green buildings that reduce energy consumption systematically. These features may cross boundaries with water consumption or green infrastructure. But in any case these interactions among water consumption and green infrastructure are what make the energy consumption rate reduce.

#### 4.2.2.2 FEATURES

Green building is not one aspect of building system it is a combination of many features and techniques. The building is said to be *Green* not only it comprises vegetation and looks pretty afar.



Figure 4- 22 Green building feature

#### 1. Design

In many cases the starting point for design is the floor plan. This process involves evaluating your lifestyle, planning for the future and being size appropriate. A bigger house requires more materials and products, it also requires more energy to build as well as to heat and cool. Considerations for the exterior style of the home should include proper roof orientation to enable photovoltaic and solar water heating systems to operate efficiently. Exterior doors need to be covered with a roof or awning to prevent water intrusion and roof overhangs sized

appropriately for the climate. Windows should be sized, located and shaded to help reduce heating and cooling loads.

Site or lot selection should include consideration of its location in relation to an existing floodplain, its location to existing infrastructure such as existing water and sewer service lines, and its location relative to basic community resources such as churches, schools, supermarket, a fire station, a park and public transportation.

Orientation of building according to sun rise and sun set and the seasons of year is also an important factor that separates a good design from bad. To further demonstrate this concept; Additional design considerations should include an approved energy analysis, a geothermal HVAC system, a fresh air circulation system, photovoltaic and solar water heating systems, enhanced basement waterproofing, advance framing and insulation techniques, tubular skylights in rooms without windows, a grey water reuse system, a rainwater harvesting system, landscaping and a high-efficiency irrigation system.

## **2. Appliances**

ENERGY STAR® is a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy. They have set strict energy efficiency guidelines and estimate that families can save about 1/3 in energy costs by purchasing appliances that have earned the ENERGY STAR.

Refrigerators built today have more insulation, better door seals, and better compressors resulting in energy efficiency that is triple the refrigerators built 30 years ago. When choosing clothes washing machines and dishwashers, choose models that are both energy and water efficient. New front-loading washers use about ½ as much water as top loading machines. An added benefit of using less water is that you will use less energy to heat the water.

## **3. Windows**

Windows play an important role in green building. They let in natural light, which reduces the need for energy-produced artificial light, and they provide views for more pleasant living environments. Windows can help control the temperature of a home by letting in warmth from the sun or by letting in a breeze on a cooler day. Size and orientation of windows are key to overall temperature control. Using double and triple-pane windows will increase the energy efficiency of as well as reduce the sound transmission through the window.

And finally, a window's installation is critical to it performs as well to the comfort of the homeowner. The exterior of all windows needs to be flashed properly to eliminate the possibility of water entering the wall cavity and the space between the window and the framing needs to be filled with foam insulation to eliminate air infiltration.

## **4. HVAC Equipment**

Selecting HVAC (Heating, Ventilating and Air Conditioning) equipment for a green home involves a great number of choices. Gas furnaces' have efficiency ratings from 80% to 95% and air conditioners have efficiency ratings of 13 SEER to 18 SEER depending on the brand. Heat pumps have efficiency ratings of 13 SEER to 18 SEER. Geothermal or "ground source" heat pump have efficiency ratings of 13 EER to 25 EER.

An approved energy analysis will allow you to make a logical decision about the operational cost of the equipment and the tradeoffs required to upgrade to higher efficiency systems. Most tradeoffs involve the initial cost of the equipment as compared to the operational cost over the life of the equipment. Once the initial cost is "paid back" by the operational savings, the owner then realizes the benefit in the terms of lower utility costs. The can also be tradeoffs with other features in the green home – see Insulation. High efficiency filters, programmable thermostats, humidifiers, and a fresh air circulation systems can be added that will further enhance the efficiency and comfort level of the home.

## **5. Light Fixtures and Ceiling Fans**

Like the other elements of a green home, a lighting plan needs to be logically designed, taking into consideration the other characteristics of the home. Using natural light (i.e.; windows) wherever possible will save energy. Adjusting the level of light by using dimmers will also save energy and make the room more inviting. There should be no incandescent lamps in a green home. CFL's (compact fluorescent lamps) last up to 10 times longer than incandescent lamps; they consuming about a third of the energy; and they give off less heat. LED lights have been around for a while in commercial construction, but are now being used in home lighting as well for recessed down lights, pendants, and wall sconces. LEDs are even more energy efficient than CFL's, but are more costly and not as widely available.

Ceiling fans are able to earn the ENERGY STAR label by incorporating an improved blade design and a more efficient motor. Ceiling fans should only be installed if they have earned this rating.

The duct system that delivers air to each room also returns it back to the equipment will be basically the same for whatever equipment is to be installed. The duct system needs to be designed with the shortest runs of duct possible and is required to be sealed to reduce air leakage. All ducts should be in "conditioned" space not in the attic. No ducts should be installed in exterior walls.

## **6. Faucets, Toilets and Shower Heads**

High efficiency toilets have redesigned bowls and tanks that use 1.28 gallons per flush as compared to 1.6 gallons for the previous generation of efficient toilets. A dual-flush toilet differs from traditional siphon-flush toilets in that it relies on gravity to remove waste from the toilet. The name dual-flush comes from the fact that it has two buttons for releasing water. It outputs water in both 0.8-gallon and 1.6-gallon capacities. The smaller level is designed for liquid waste, and the larger is designed for solid waste. The dual-flush toilet can save up to 67% of water usage. Low-flow faucets and showerheads have a flow volume of less than 1.75 gallons

per minute. If high efficiency toilets, low flow faucets and showerheads are installed, a smaller water heater and smaller-diameter piping can be used.

## **7. Water Heater**

The process of heating water accounts for 15 – 20% of a household's energy use. A tank-type water heater is the most common; it is rated based on the Energy Factor (EF). The higher the number, the better the energy efficiency. A tankless or "on-demand" water heater only runs when there is a demand for hot water. As soon as water flow is detected, an element (electric or gas-fired) is activated and the water is heated as it travels through the unit. The energy savings are that only the amount of hot water needed is heated and there are no "standby" losses". (This is the amount of heat lost from the tank, as the hot water is 'standing by' not being used.)

An on-demand circulation system eliminates wasting water waiting for it to heat up, by piping hot water to the fixture just before it is needed. Other cost saving alternatives include solar powered and geo-thermal.

## **8. Insulation**

Insulation is one of the keys to reducing energy consumption in a green home. Insulation is also key to the comfort of a green home. The "building envelope" is considered to be the floors, walls and ceilings that surround the "conditioned" or heated and cooled living space inside the home. Insulation plays an important role in the building envelope by resisting the loss of heat from the inside to the outside or the entry of heat from the outside to the inside. With insulation in the exterior walls and attic, the home becomes more energy efficient. The thickness of the insulation is directly related it's effectiveness to resist the heat loss or heat gain and is rate with an R value. The larger the R value the thicker and more resistive the insulation is to the transfer of heat.

Insulation plays an important part in the approve energy analysis - see HVAC. Increasing the R value of the insulation in the building envelope can usually result in reducing the sizes of HVAC equipment required to heat and cool the home. The increase cost of the insulation is a trade off for the less costly smaller sized HVAC equipment and lower utility costs.

## **9. Radiant Floor Heating**

There are 2 types of radiant floor heating – electric and hydronic. An electric system is installed underneath the flooring. The hydronic system consists of pipes or tubing embedded into a concrete floor, a boiler and a pump so that hot water can circulate within the piping. With both systems, the heat from the floor rises, creating overall comfort. It is very efficient as it heats the typical comfort zone of the home occupants, about 6'6" to 7' up from the floor. Radiant heat is most commonly used with ceramic tile because the tile conducts heat well. However, it can also work with vinyl, carpet, or wood flooring products.

## **10. Flooring and Carpet**

**Carpet:** When carpet is used, natural fibers such as wool and cotton are preferred because of having low volatile organic compounds (VOC's). VOC's can cause negative health effects in some people including headaches, nausea and dizziness. The "new carpet" odor that you sometimes can smell comes from a VOC called 4-phenylcyclohexene (4-PCH). A carpet that has been approved by the Carpet and Rug Institute (CRI) has been tested for emissions and would be a good choice. Carpets using recycled materials are now being produced and would be another environmentally friendly choice.

**Solid Surfaces:** Solid surface flooring such as hardwood, tiles, and polished concrete can provide better air quality than rooms with carpet. Solid surfaces do not contain VOC's and they do not tend to trap pollutants and allergens. Choices such as cork and bamboo have the added benefit of being "rapidly renewable". A resource is considered rapidly renewable if it regenerates within 10 years. Bamboo is the fastest growing woody plant, reaching full maturity in 5-6 years. Cork comes from the bark of the cork oak tree. It is harvested by hand without harming the tree. The bark will regenerate in 10 years, enabling the tree to be re-harvested.

## **11. Paint**

As paint dries, volatile chemicals evaporate into the air in a process called off-gassing. This process, which can pose a health risk, can go on for years after the paint has been applied. For this reason, the EPA requires that paint manufacturers list the amount of volatile organic compounds (VOC's) contained in the paint (or stain or varnish) on the label of the container. Paints with low or no VOC's are now available from most major paint manufacturers. They are the healthier alternative to conventional paints – both for interior and exterior applications.

## **12. Cabinets and Countertops**

Cabinet and countertop choices can affect air quality because of the finishes and glues used to make and install. They also affect material resources. There are numerous recycled materials for counter tops such as glass and concrete.

## **13. Exhaust Fan in Bathroom**

All bathrooms should have an exhaust fan to control moisture from showers and baths. The selection should be properly sized and ENERGY STAR rated. To ensure that the fan is fully utilized, automatic controls such as occupancy sensors or humidistat can be installed. Proper ventilation of the bathrooms, always to the outside, will help the overall indoor air quality of the home.

## **14. Central Vac**

According to the EPA, indoor air can be up to 5 times more polluted than outside air. A central vacuum system that is outside-vented or HEPA-filtered will improve overall air quality because it will clean without redistributing harmful dust and allergens often associated with traditional vacuum systems.

## **15. Roof**

The use of more durable roofing materials such as steel and fiber cement increases the durability and reduces the frequency of replacement. Light colors of roofing absorb less heat, which in turn reduces the cost of cooling during summer. Gutters and downspouts are used to move the rainwater away from the house to help avoid water intrusion. If a rainwater harvesting system is used, the gutter and downspouts, in conjunction with the roof, become part of the collection system. Various manufacturers now include recycled materials in their roofing products and metal roofing can be recycled. New photovoltaic products are available that integrate into asphalt shingles, standing seam metal roof panels, slate and fiber cement tiles.

## **16. Solar Panels**

Solar panels in various forms have been around for decades, but have often been considered too big, too ugly and too expensive. But as with any technology, they have evolved over time. Higher energy costs make the pay back much less than it was a decade ago and as tax incentives began being offered, more manufacturers began producing them, thus driving the costs down.

Solar panels basically come in two different types. The first is a product that is used to heat water. These panels are distinctly different than those that produce electricity. A typical residential solar water-heating system reduces the need for conventional water heating by about two-thirds. Most solar water-heating systems for homes have two main parts: a solar collector and a storage tank. The most common collector is the flat-plate collector. The sun heats either water or a heat-transfer fluid in the collector. Heated water is then held in the storage tank ready for use. The tank can be a modified standard water heater but it is usually larger and very well insulated. Solar water heating systems can be either active or passive, but the most common are active systems. Active solar water heaters rely on electric pumps, and controllers to circulate water, or other heat-transfer fluids through the collectors. Passive solar water heaters rely on gravity and the tendency for water to naturally circulate as it is heated. Because they contain no electrical components, passive systems are generally more reliable, easier to maintain, and possibly have a longer work life than active systems.

The second type of solar panels is Photovoltaic, and is used to convert solar energy into electricity. Photovoltaic production has been doubling every 2 years, increasing by an average of 48 percent each year since 2002.

Since both of these technologies utilize the sun's energy and since the sun is an intermittent source since it is sometimes covered by clouds and does not shine at night, these systems need to be part of an integrated system that acts as a back up when the solar equipment is not able to function. Both of these systems require tradeoffs involving the initial cost of the equipment vs. lower utility costs.

## **17. Concrete with Fly ash**

Fly ash is a by-product of coal-fired energy production. Millions of tons are produced every year. It can be added to concrete mixtures as a substitute for some of the cement. When added, it bonds chemically with the cement, making the concrete stronger, more water resistant, and more durable. So using fly ash has a double benefit: it provides a way to recycle this waste product and it provides a superior concrete product.

### **18. Vapor Barrier**

A vapor barrier or weather barrier refers to any material, typically a plastic or foil sheet, that slows the rate of moisture penetrating through a wall, ceiling or floor of a house. Obviously moisture occurs outside in the form of precipitation, but moisture also occurs naturally inside all homes in the form of vapor: occupants expel moisture when breathing and perspiring. Bathing and cooking also produce water vapor. Its important to keep water from the outside from getting inside but it is also important for water vapor inside to get outside. A good vapor barrier installation allows for both to happen. Most weather barrier products today come in long continuous rolls so the entire house can, depending on the size, be wrapped in one application. Careful attention to all openings such as doors, windows, pipes and ducts is required.

### **19. Roof Overhangs**

Roof overhangs are a design feature of a green home that serves to control both sunlight and water intrusion. Roof overhangs should be sized appropriately for the climate to shade windows from harmful infrared and ultraviolet radiation and prevent water intrusion. Exterior doors need to be covered with roofs or awnings as well to prevent water penetration.

### **20. Landscaping**

Landscaping can add beauty and value to your home. It also helps control rainwater, water usage and energy costs as well as acting as a habitat for birds and wildlife. Preserving any existing trees and plants that exist on the site reduces new landscaping requirements, thus saving energy and air pollution. One tree can filter 60 pounds of pollutants from the air each year. A green landscape includes use of native and drought resistant plants to reduce water needs and usage. Native plants often need less fertilizer and pesticides, which mean less pollution of ground water. Slow growing grasses need to be mowed less frequently which results in less noise and air pollution.

### **21. Irrigation**

A water-efficient irrigation system includes timers, soil-moisture meters, high efficiency heads, and drip irrigation equipment. Irrigation systems are designed to help you control the amount of water you are supplying to your lawn, trees, and plants.

### **22. Rainwater Harvesting System**

A rainwater harvesting system collects rainwater from the roof of a home and stores it in large aboveground or underground containers. The water is then re-used for either irrigation or an

indoor non-potable use of water such as flushing toilets. In addition to the obvious savings on the water bill, rainwater is good for irrigation because it has higher nitrogen and a lower salt content than water that is municipally supplied.

#### **4.2.2.3 ENERGY CONSUMPTION OF SURVEYED BUILDINGS**

The unhealthy way of manipulating energy in our country may not be considered on risky stage when compared to the world. But the path of our consumption following is a sure means to an end to the hazardous stage the world is now at.

#### **4.2.2.4 GAPS BETWEEN GREEN BUILDINGS AND SURVEYED BUILDINGS IN TERMS OF ENERGY EFFICIENCY**

##### **GREEN BUILDINGS**

- Uses proper orientation for ventilation and temperature stabilization to reduce extra energy used for cooling and heating of rooms,
- Appliances used for Green Buildings are certified for using up energy efficiently,
- Uses bio gas to facilitate activities that need energy
- Mainly use solar panels for heating water and electricity.

##### **SURVEYED BUILDING**

- As discussed in the above sections, use of renewable energy is uncustomary and unlikely in the surveyed buildings.
- Consumption of energy due to faulty design of building and also unwise usage of equipments is high

#### **4.2.3 WATER RESOURCE**

We use water in our day to day activities. It is known that more than 70% of earth's surface is covered with water. But most of this water which covers 70% of the earth surface is salt water. And this leaves us with only 1% of unsalted water. We have to make means with this little amount.

##### **4.2.3.1 WATER RESOURCE OF GREEN BUILDINGS**

Reducing water consumption and protecting water quality are key objectives in sustainable building. One critical issue of water consumption is that in many areas, the demands on the supplying aquifer exceed its ability to replenish itself. To the maximum extent feasible, facilities should increase their dependence on water that is collected, used, purified, and reused on-site. The protection and conservation of water throughout the life of a building may be accomplished by designing for dual plumbing that recycles water in toilet flushing or by using water for washing of the cars. Waste-water may be minimized by utilizing water conserving fixtures such as ultra-low flush toilets and low-flow shower heads. Bidets help eliminate the use of toilet paper, reducing sewer traffic and increasing possibilities of re-using water on-site. Point of use water treatment and heating improves both water quality and energy efficiency while reducing

the amount of water in circulation. The use of non-sewage and greywater for on-site use such as site-irrigation will minimize demands on the local aquifer.

- Section 01 81 13 includes some guidance regarding plumbing, mechanical and electrical components such as wiring, piping, and ductwork.

#### **4.2.3.2 AMOUNT OF WATER USED PERDAY IN SURVYED BUILDINGS**

Fig shows percentage of total consumed in surveyed offices and shops shows the amount of water consumed in offices and shops. As it is seen, toilets take the biggest portion of water usage. And all offices and shops use clean water for the toilet. (Statement concluded from field survey observation.) When asked if they recycle water, respondents in office and shop buildings responded by saying no. this means water used for toilets could be used for more important things in office and shops activities. 44% of the water consumed is spent on toilet flush.

Offices and shops that have cars use clean water to wash those cars twice per day in average. This makes up 19% of the total water consumption. Offices and shops use 26% of water consumed for item washing, 4% for drinking and only 2% for food.

#### **4.2.3.3 GAPS BETWEEN GREEN BUILDINGS AND SURVEYED BUILDINGS IN TERMS OF WATER EFFICIENCY**

The major gap between Green buildings and surveyed buildings is *recycling*. The Green building that is considered successful recycles used water and apply it in different activities that need lesser clean water whereas surveyed buildings do not follow such trend mostly. This causes for the bills of water to increase. Though most buildings in AA in general have reservoirs of water this water is used up unwisely and finished quickly. And in the absence of water supply (which occurs frequently and for a length of time in our city especially in studied area in the area having reservoir has proven to be useless. This is due to careless usage of reservoir water. The consumption rate uses up the available water.

#### **4.2.4 WASTE MANAGEMENT**

Access to adequate sanitation reduces local environmental degradation, improving ecosystem services as well as human health and well-being. Alternatively, human and animal wastes can be used to produce bio fuel, an accessible, reliable, clean and renewable fuel option (UNU-INWEH, 2010, pp. 12-13).

Biologically safe and hygienic disposal of human waste is important in maintaining a healthy environment. Sanitation and sewage treatment should be seen as preventive barriers in local source water protection, especially for surface waters and shallow groundwater resources.

##### **4.2.4.1 WASTE MANAGEMENT OF GREEN BUILDINGS**

Integrated Solid Waste Management is what makes Green Buildings stand out. Integrated Solid Waste Management is comprised of the following:

## Avoid or Reduce use

- Reduce – packaging, creation of waste, especially non-biodegradable
- Waste minimization: development of locally appropriate means of reducing the total amount of household waste – home composting of the bio-degradable component of house hold waste;
- Providing incentive for waste minimization or recycling

## Re-use

- Reuse – glass bottles, jars, boxes, paper, containers, plastic and paper bags, newsprint, wrapping paper, etc.

Re-cycle - refers to using material to make a new product (also de-manufacturing)

- Japan recycles 60% of its waste; Seattle recycles about 50% of domestic waste
  - Often involves sorting at hh or business level
  - Economics of recycling is a challenge
  - Composting – collecting agricultural or yard waste and/or organic household waste and letting it biodegrade with aeration – using it as fertilizer
  - Recycling must take priority over disposal e.g. recycling biodegradable waste in local parks and making profit in waste through composting and selling.
    - Encourage and support informal waste collection
  - Encourage new partnership and the private sector
- Incinerate-waste -to - energy
  - Dispose in sanitary landfills
- Non-recyclable waste must as far as possible be sent to disposal of any kind that insures it will not give rise to any adverse environmental impacts either now or in the future.

All in all, the integrated waste design is based on

1. Reduction of packaging and production of environmental unfriendly items.
2. Reusing of waste materials
3. Recycling: capture resources from garbage

Integrated waste management is the first step of administrating waste in Green Buildings. The second step is *composting*.

Biological degradation and transformation process for organic substances under aerobic conditions by a variety of microbes and may be other small organisms. It leads to the evolution of heat, the formation of carbon dioxide and water. Humus rich compost is generated as a product.



Figure 4- 23 Compost

Depending on scale of operations: Quantities of organic waste and bulk material have to be secured.

- Seasonal variations: this may have effects on quantities or composition.
- Origin: (mixed) household waste, market waste, hotels...
- Contaminants – Purity of input material => sorting process is necessary.
- Collection of input material



Figure 4- 24 Inputs for compost

Green Buildings do generate income in addition to being environmentally friendly structures. This is where the third step takes part marketing strategy. This simply means from the composted material occupants of Green Buildings provide, if there are any that can be sold this helps support the economy of the population involved. This engages the following steps:

- Market analysis: Assessment of existing and potential markets for compost. Who are potential end-users of compost? City farmers (urban agriculture), Parks, horticulture,
- Estimation of the value of the product to the user (Willingness to Pay, Price of competing products)
- Marketing strategy: Adapted to local requirements: soil characteristics, agricultural practices, social customs, transportation costs, seasonal variations etc.

And from those that can be sold some can be used to add to the Green Building concept literacy. For instance, plastic bottles are used as planting device.

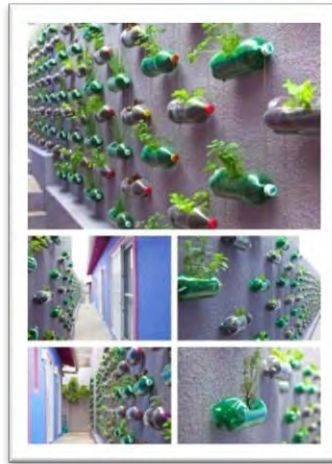


Figure 4- 25 Plastic bottles used for vertical gardening

#### 4.2.4.2 WASTE MANAGEMENT IN SURVEYED BUILDINGS

In physical social and economical findings it was stated that surveyed buildings do not generate income, do not promote socialization and also their interaction of the environment is very weak. One way a building interacts with its environment is through the amount of waste it produces. The Giant land fill site that lies around Ayer Tena is the judge of how much waste is produced in the study area. The area's frontal length stretches about a kilo meter long and the width about 300 meters. And the area is filled with mounds of waste composed of different substances. Plastic, paper, metal, glass, clothes, ashes, and so on.

This tells us that a lot of waste is produced in buildings and households. Though the very concept of sustainable design is to reduce waste that go to land fill, first building occupants must sort their garbage to take that step. But section 4.5.3 clearly states that most of respondents do not sort garbage. The section above states that the first step to becoming *Green* is to sort the garbage. Since the surveyed buildings do not sort he garbage they can't reach the next steps to becoming sustainable buildings. This means more garbage goes back to land fill sites creating foul smell disturbing the neighborhood.



Figure 4- 26 Landfill around Ayer Tena

#### 4.2.4.3 GAPS BETWEEN GREEN BUILDINGS AND SURVEYED BUILDINGS IN TERMS OF SOLID WASTE MANAGEMENT

##### GREEN BUILDINGS

- Reduce : the use of indecomposable materials
- Recycle : to produce new material
- Remanufacture : those that can be altered and function almost as the new ones
- Reuse : the waste material
- Compost : the rest of the materials
- Market strategies: prepare them for market after studying what the material demands
- Vertical Gardening: uses those that can enhance the greenery aspect of the Green Building.

##### SURVEYED BUILDINGS

- Only 99.4% sort their garbage. (This figure is a rounding number and those considered to sort do not exactly sort in terms of international standards.)
- None of respondents sell waste materials that can be reused if sold to industries or individuals.
- No material is recycled so as to enhance any aspect of buildings condition.

#### 4.2.4.4 LIQUID WASTE MANAGEMENT OF GREEN BUILDINGS

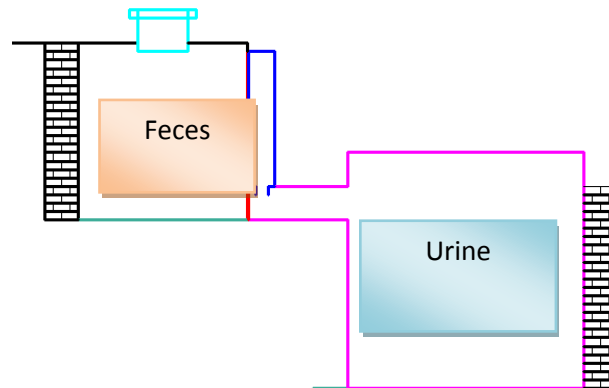


Figure 4- 27 Two chambers of the proposed portable Eco toilet (Author's design, 2013)

Though the world has reached several technologies that deal with toilet waste, the chambered Eco-toilet is the recent and clearer version of technologies that could be understood by any person looking at the illustration.

Some Green Buildings' integrate their sanitary design with such system of separating urine and feces making it very easy to convert the toilet waste into bio gas. It was also easy to provide such mesh and separating funnels to septic tanks so the slug could settle on the base and the urine liquid waste) could be suspended and pass through a funnel to its own collecting pit.

The portable eco-Toilet considers the following criteria:

- The mesh, which is planned to allow only the liquid waste, is proposed on the side of the portable toilet planned to hold feces to reduce closet of the opening of the mesh which may result from the settling of the feces that in turn hinders the passage of urine through the mesh.
- Although the proposed mesh extends on the side, a little bit making lower from the upper part of the toilet to protect the over flow of feces that may happen during the toilet fills.
- The portable Urine holding toilet is designed at the lower portion of the toilet planed to accumulate the feces. This helps for easily draining the urine into this chamber of the proposed portable eco toilet.

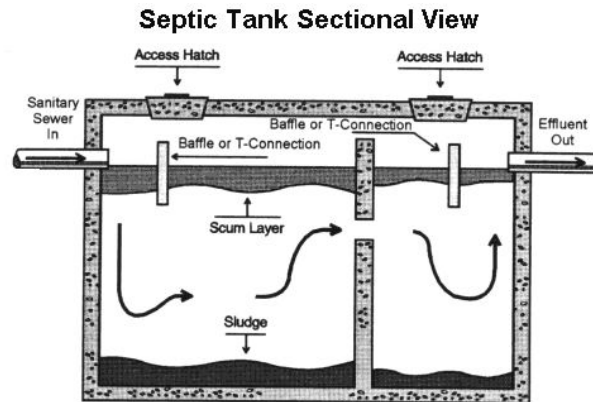


Figure 4- 28 Advanced septic tank

Source: retrieved May, 2014 from <http://www.adamsbros.ca/Howsepticssystemworks.php>

Septic tanks are on-site waste water treatment units which allow waste water to run through a leaching field and for the bacterial breakdown of some of its solid contents. Essentially they replace the need for municipal sewers to your property.

#### 4.2.4.5 TOILET WASTE MANAGEMENT OF SURVEYED BUILDINGS

80% of the buildings use the system of closed septic tank making it easy for the stored waste is converted into bio gas. Though there was no effort done to convert the waste into bio gas his still provides a great potential for replacement of non renewable energy with a renewable and sustainable one.

#### 4.2.4.6 GAPS BETWEEN GREEN BUILDINGS AND SURVEYED BUILDINGS IN TERMS OF TOILET WASTES.

##### GREEN BUILDINGS

- Use eco toilets that separate urine and feces making it easier for conversion to bio gas
- Uses the left over substances for fertilizer of the green elements on the buildings

##### SURVEYED BUILDINGS

- Though almost all of the buildings use the closed system of sewerage collection, there has not been a step taken to utilize the untapped energy that lays underneath those pits.

## **CHAPTER V : POSSIBLE REMEDIAL SOLUTIONS BASED ON ENVIRONMENTAL PLANNING AND LANDSCAPE DESIGN SOLUTIONS:**

This chapter discusses the obtained results in detail by comparing with the existing facts and puts possible onsite sanitation options for each problem so far discussed.

### **5.1 POSSIBLE REMEDIAL SOLUTION for INDOOR ENVIRONMENT QUALITY**

Though it is a bit difficult to regulate temperature of existing building it has not proven to be impossible. There are two ways of looking at the existing situations with their solutions.

#### **5.1.1 POSSIBLE REMEDIAL SOLUTION FOR TEMPERATURE**

The surveyed buildings have different temperature character when it comes to indoor environment quality. Some have high indoor temperature and some have lower indoor temperature. For each certain solutions are given below.

##### **5.1.1.1 POSSIBLE SOLUTIONS FOR RELATIVELY HOT ROOMS**

The special character of plants that is very important for this section is vapor transpiration. This basically means plants breathe through their leaves making the atmosphere surrounding them very cool.

Buildings those are located on the harsh sun direction need shading device from the heat and glare. There are many devices that can shade buildings like louvers, over hangs, awnings and so on. But the particular shadier that Green Building is interested in is Trees! Trees can shade buildings from sun's heat and from glazing's glare. Buildings that have balconies can be provided with greeneries that can help in providing total shade from the sun and simultaneously having a cooler atmosphere. And buildings that do not have balconies can use their walls for gardening as shown in fig 5-1 in vertical gardening. A vertical garden as a sky landscape is able to improve the greatness of concrete architecture. Besides the aesthetic it transforms the carbon dioxide produced by traffic and heating in to carbon hydrates and oxygen also retain cold breeze.

Things to consider while applying such system are:

- Plants that is evergreen because if we use seasonal climbers, when they shade their leaves the resulting dirt will be hard to manage.

- While applying such techniques we should be considerate of the building's openings



Figure 5- 1 Consideration while applying vertical gardening

- In order to protect the buildings' walls from deteriorating it is better to use climbers first planted in pots and that later on will free fall to the ground without touching the wall or to guide the climbers with ropes or wires.
- While applying greeneries on roofs or walls we need to consider *Zeroscaping* which is the term used for plants that use small amount of water also we need to study the types of plants that are to be considered.

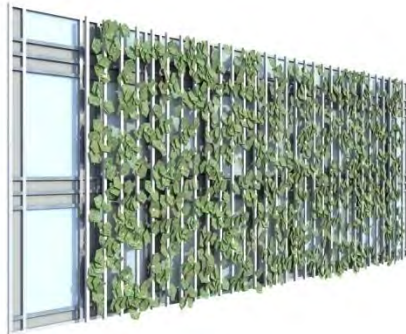


Figure 5- 2 Application of green on existing surveyed buildings for cooling purpose A simple additional frame that supports climbers in front of curtain wall façade that could shade the indoor space from the harsh sun

- The best examples from the surveyed data where this technique could be applied are *Adam's Pavilion and Dembel city center*.

### 5.1.1.2 POSSIBLE SOLUTIONS FOR RELATIVELY COOL ROOMS

A modern adaptation of this principle is a glass-walled sunspace, or greenhouse, on the south side of a building. Massive energy - storing materials, such as brick walls, stone floors, or barrels of heat -absorbing water, incorporated into buildings collect heat that is released slowly at night. Where sunless days are rare and seasonal variations are small, a small, insulated water tank is a good solar energy storage system. In areas where clouds block the sun for days at a time or where energy must be stored for winter use, a large, insulated bin containing a heat - storing mass, such as stone, water, or clay, provides solar energy storage.

During the summer months, a fan blows the heated air from the collector into the storage medium. In the winter, a similar fan at the opposite end of the bin blows the warm air into the house. During the summer, the storage mass is cooler than the outside air, and it helps cool the house by absorbing heat. During the winter, it is warmer and acts as a heat source by

radiating stored heat. In many areas, six or seven months' worth of thermal energy can be stored in 10,000 gal of water or 40 tons of gravel, about the amount of water in a small swimming pool or the gravel in two average-size dump trucks.

Also another possible onsite solution in such cases is reducing the sizes of openings. This allows the pockets and vents that heat escapes through to be limited so that heat could be trapped for longer time.

- *Buildings that face such problems from the survey are Stairs, The Red Terror Martyrs Museum and DH Geda Tower.*

### 5.1.1.3 POSSIBLE REMEDIAL SOLUTION FOR MICROBIAL GROWTH AND DAMPNES



Figure 5- 3 Showing some of the problems in existing buildings caused by dampness and microbial growth

The first step in solving problem related to dampness and microbial growth is identifying the type of problem and investigating the stage of the problem. This will help us in identifying the type of remedial step we should take.

'Green structures can improve city air due to filtering out and absorption of dust and due to oxygen production.' (Ernest Neufert, 1999) The above statement helps us to understand the use of green infrastructure as a buffer between the road and the surveyed buildings. And also replacing the damaged portion with a sustainable and permanent material is the next step.

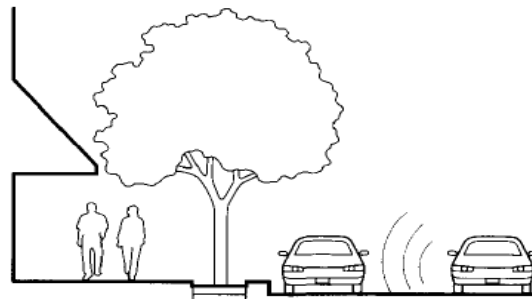


Figure 5- 4 Street plantation as buffers to protect from VOCs emitted from cars

Buildings that face the problem of microbial growth, dampness and lack of ventilation are 96% from the total.

#### 5.1.1.4 POSSIBLE SOLUTION FOR ORIENTATION FOR EXISTING BUILDINGS

The case of orientation is much related to both building material and indoor temperature of the rooms within the building itself. The effect of one is the cause of another. In this cyclic circumstance of cause and effect it should simultaneously be noted that solving one makes a stepping stone to solving the rest.

If buildings are shaded well from harsh sun they are most likely to have more or less cooler temperature within their enclosed rooms. If we have a relatively thermal resistant building material it is expected that we would have a relative room temperature that is optimum to do our task properly. Buildings with roof gardening system can generally enhance the system of absorbing excess solar energy and converting it to food energy. Both Vertical gardening and roof gardening can provide a solution in the following ways.

- Psycho-physiological value of cultivated area (the feeling of well being is positively influenced by the area of the greenery.) (Ernest Neufert, 1999)
- Adds to natural cycle of nutrients and resources of bio diversity that may have been hindered by urbanization.
- And most important to this section, cool and moister air due to high heat consuming plants. (Ernest Neufert, 1999)
  - ✓ Where a conventional flat roof temperature rises up to 80<sup>0</sup>
  - ✓ The green roofs falls to 35<sup>0</sup> due to transpiration of H<sub>2</sub>O



Figure 5- 5 Wall covered by Green Acts likes a shade and also helps reduce urban heat island effect

- *The best examples from the surveyed data where this technique could be applied are Adam's Pavilion and Dembel city center.*

## 5.2 ENERGY CONSUMPTION

Urbanization along with population growth, economic development and industrialization, is one of the principal forces driving the global increase in energy demand. In rural areas and small urban centers, biomass fuels provide most domestic energy supplies while today's urban societies are characterized by their reliance on fossil fuels and electricity. Most of the non

renewable energy we have cannot last as for long due to unsustainable use. Fossil fuels add GHGs to the atmosphere and the most useable art of their combination is lost in combustion.

In the case of surveyed buildings, energy is consumed uncontrollably in daily basis. For instance, bulbs in most offices are turned on almost all day which accounts for the most of working hours. Refrigerator also is hooked up 24 hours. These may seem small considerations but if we take a closer look at the silver lining, the small facts are those that mount to the bigger picture. Though most of the surveyed buildings do have windows do not let in enough light had to use artificial lights. But it was in fact proven that daylight reduces energy costs \$0.15 per square foot annually. (Gregg D. Ander, 2012)

Knowledge about bio gas in study area is surprisingly vague and minimum considering all the media advertisement done on the renewable energies especially bio gas. From the respondents only 10% are considered having an adequate knowledge of bio gas. 38% seem to have enough (relatively medium) knowledge to discuss with others. 52% have poor knowledge about what renewable energy deals with. Also in informal interviews and discussions held during site visits and survey it was found that most of the respondents do not actually know that there are other items than bulbs that are considered energy efficient.

### 5.2.1 POSSIBLE REMEDIAL SOLUTION FOR ENERGY CONSUMPTION

The first step in bettering the existing condition of the study area is creating awareness of how bio gas is produced and how useful it is in maintaining a sustainable environment. This helps in branching the information web in such a way if one person is educated he/she will educate her/his family. Also creating awareness about other energy efficient objects can help in bringing about a huge change in energy utilization. Because some of the respondents do have the exposure to buy such elements hence, they could reduce their expense.

Second step is more or less related with waste management, i.e. separation of urine and feces by using the concept of Eco toilets in section 6, illustration 6.4.4. The Eco- toilets can easily be applied on the septic tanks of the buildings. The separately accumulated wastes can be used to produce bio gas which can supply energy for many households and buildings.

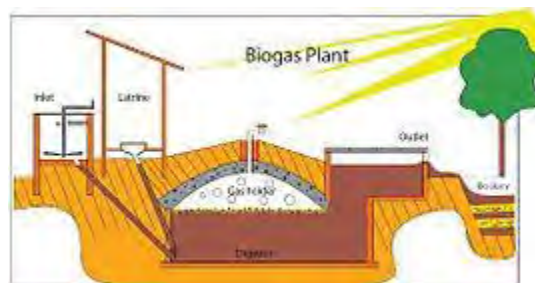


Figure 5- 6 Simple sketch showing house hold bio gas plant

### 5.3 WATER CONSUMPTION

The existing condition of water usage follows the trend of spending but not refilling or reusing. No trend of using rain water or using already used water for secondary activities. All in all, it can be said that most of the buildings do not use water economically.

#### 5.3.1 POSSIBLE REMEDIAL SOLUTION FOR WATER CONSUMPTION

People's knowledge about water resource and recycling of water is low. In fact, most people do not find that using rain water as a useful resource totally. On this note, the first step we must take toward the onsite solution of water consumption is creating awareness about the system of recycling and reusing water. Also educating people on double plumbing and sanitary fixtures that reduce excessive usage of water will enlighten people to know that there are other ways that could direct their point of view to sustainability. This will certainly change people's attitude and in turn their system of using water.

Second step that should be taken is actualization of those materials on the site needed. This means, using double plumbing that conveys water's direction say for instance from hand wash basin into toilet box, thus helping in reusing the water. Also, promoting the use of less water flushing WC instead of the regular WC will help improve the using water sustainably. Since it is known the regular water closet flushes 6 lit per flush for both solid and liquid waste. But the improved water closets have two buttons one for urine and the other for feces flushing and actually has a cylinder for containing the excessive water that is pressured into the water closet's box and reusing it for the next round.

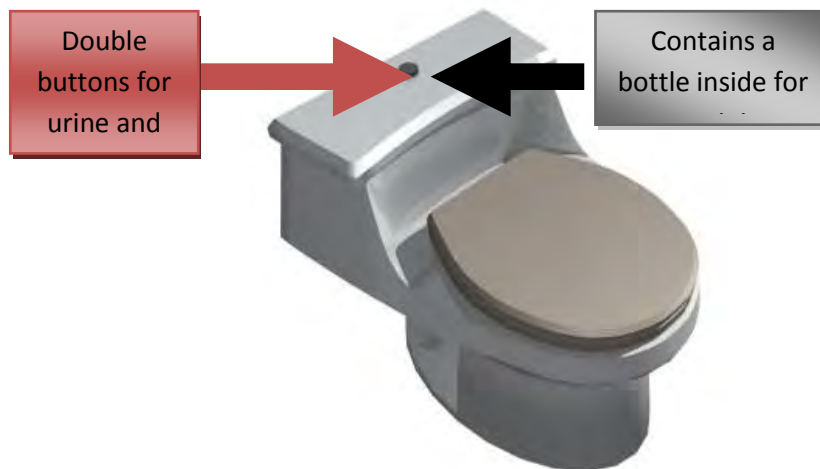


Figure 5- 7 Showing improved water closets

What's done is done. Now it is time to change. And change starts with awareness. Governmental bodies and professionals should create the media for teaching about recycling and reusing water. And also point out the risk of continuing with the current trend of water consumption. We may not be at risk right now. But for the next generation, it may prove to be difficult to supply water for every house hold if we continue using water as carelessly as we do now.

## 5.4 WASTE MANAGEMENT

It is mentioned in several chapters above, that people have almost no knowledge when it comes to the relationship between waste management and sustainable building and environment. Because of this reason 99.4% of respondents do not sort their garbage and what's even more unsettling is they do not see the problem in not doing so.

But this hazardous habit of careless compacting of waste should not be allowed to continue because as table 4.4.1 shows 36% of the total surveyed buildings' composition of waste is plastic. This element is known to be indecomposable material. And this portion would rather be utilized for some other purpose than going back to land fill site. It should also be noted as discussed in chapter three respondents did answer that they do not actually reuse, resell or remanufacture items from the waste composition (fig 3.21).

### 5.4.1 POSSIBLE REMEDIAL SOLUTION FOR WASTE MANAGEMENT

The first step in bettering the existing condition of the study area is creating awareness of how properly managing waste can add to the sustainability of the environment. This, again, helps in branching the information web in such a way if one person is educated the/she will educate her/his family. Also creating awareness about waste management according to the Green Building system will help the respondents to understand the interrelationship between sustainable energy, water resource management and waste matter management. And furthermore they will keep up with the world's knowledge on how Green building is the media balancing all the mentioned four subjects (water, waste, indoor air quality and energy management).

Second step is more or less related with waste management, i.e. sorting of garbage in such a way they are classified into plastic, paper and organic. Since a good building design and planning integrates the energy aspect as well as the plan and lay out a space should be provided for such activities. The separately accumulated wastes can be collected by waste collectors grouped as small and micro enterprises and the plastics and metals can also be sold for the 'Kurales'. Besides creating awareness for the residents, restricting by laws not to dump solid wastes into garbage in a careless manner is the further step that needs to be taken.



Figure 5- 8 Sorting of garbage

The third step after creating awareness and sorting garbage is composting. This will help in decomposing organic materials hence reducing the portion of organic materials from going to the mounds of land fill sites.

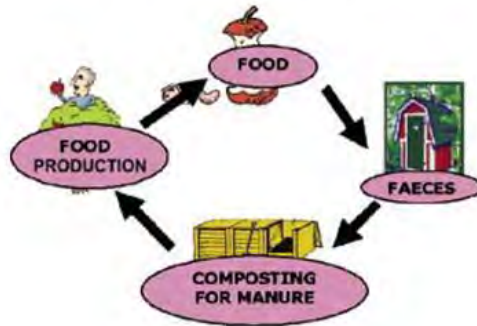


Figure 5- 9 The Principles of nutrient cycle (Sari h., 2006)

The fourth step is differentiating which materials to recycle and which to give to remanufacturers and also which materials to sell adding to the economic aspect of the building. And at last, taking the time to teach people how to use those materials that do not get decomposed easily in the integration of vertical gardening is a necessary step.

Another remedial solution related to the management of waste is the use of waste loving plants to absorb the nutrients from the waste and thus facilitating the decomposition rate by significant rate (Karvonen, 2000). Pretreatment removes materials that can be easily collected from the raw sewage before they damage or clog the pumps and sewage lines of primary treatment clarifiers (trash, tree limbs, leaves, branches etc).

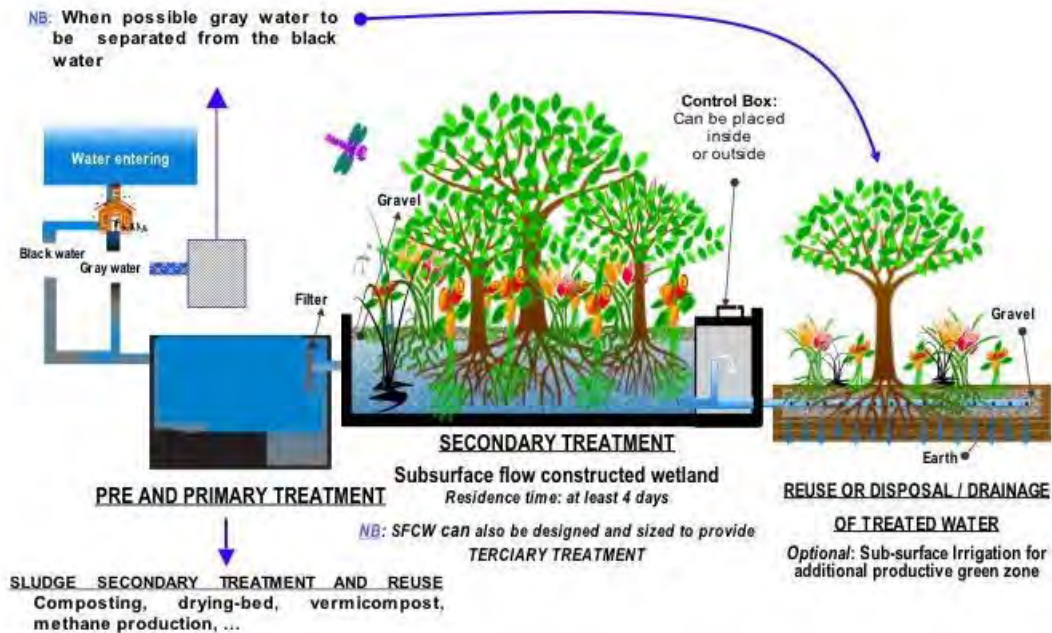


Figure 5- 10 Treatment plant for dirty water or waste

## **CHAPTER VI: CONCLUSION and RECOMMENDATION**

### **6.1 CONCLUSION**

Sustainability is not a complicated ideology that reviles itself only to educated individuals. But, it is what we can come across in our way of living activities when we respect our surrounding.

The results in section four show that most of the assessed buildings were built not only ignoring the environment but also the society they are built for. The functional layouts of the building are the evidences for such faulty characteristics of Addis Ababa buildings that are built without considering basic needs of our society.

Indoor air quality is faced with the inevitable degradation from outdoor pollution. This in turn affects the temperature of indoor environment, formation of microbial growth and the decrease in efficiency of users.

Energy is misused due to defective building enclosures. Over using incandescent bulbs during day time and lack of knowledge on how to use renewable energy shows unhealthy consumption of energy on the assessed buildings.

In the assessed buildings water resource is over used and taken for granted. Due to this, water shortage strikes users of the buildings. This shows that the value of saving the water resource for the future which is the core notion of sustainability issue is unattained.

Solid wastes are not properly sorted out, collected and damped. The buildings that have communal waste collection containers do not use their container appropriately because they don't like to walk to dispose their wastes especially the users of upper floors. Solid wastes that can easily decomposable are disposed to land fill site rather than of using as a resource through compost making.

Even though toilet wastes of the assessed buildings are collected mostly in septic tanks, these septic tanks are mere containers and liquid wastes are usually sucked out rather than of using the wastes for biogas.

The basic necessity of this research is to answer whether these buildings can be healed or not. Having said this, these buildings can be healed if the pointed recommendation based on environmental planning and landscape in chapter 5 are applied well. The solution given by this paper could help in filling the gap and add a step closer to attain sustainable building and living environment.

Of course the remedial cost for the assessed buildings will expensive, but if these buildings are not repaired soon the cost that will be spent for the damage they will cause in the future will be twice as expensive. cost issues may not be the only problem we may come across while trying to heal these buildings, creating awareness may also pose a significant setback. if the society is not well informed they may not be willing to cooperate with professionals.

since the research paper has narrowed down the area of problems we should consider when healing a building, it should be easier to collaborate with different professionals, government officials and small/ big enterprises accordingly.

The healing process of these buildings are feasible and easily maintainable. if we use local materials along with local plants (used for shading and vertical gardening) we can easily manage the healing process.

## **6.2 RECOMMENDATION**

The remedial solutions described in chapter 5 illustrate how these buildings can be healed and can be made to function more sustainably. but below listed are some of the observations and suggestions architectural professionals have added to the recommendations in how to heal the buildings from their own.

### **6.2.1 RECOMMENDATIONS FROM SPECIALIZED PROFESSIONALS**

#### **6.2.1.1 BUILDING FUNCTION AND OVERALL DESCRIPTION**

A person using the toilet should wash his/her hands immediately because it is reasonable for hygiene and self assurance. So those functions (toilet and hand wash) must be continuous. Unlike most reasonable designs we come across *Ras Leyu ketfo* building has placed the toilet and the hand wash not only separately but also on different levels.

Secondly, anyone who is eating at a restaurant do not want the trash to be taken through the front door. If the assessed building is a restaurant it should have a back door that serves as a passage to take out the waste and unwanted items. This is very important

1. To avoid bad smell that results from the mixing of waste.
2. To avoid the disgusting sight of the unattractive trash collection
3. To protect customers from sickness and irritations that could arise from micro bacteria that live on the trash.

The public must be accessible to all both in location and in its architectural lay out. Accessible means to disables and healthy people equally without discrimination. To provide such fair service, a building must have a ramp.

In the case of “Red Terror” Martyrs Memorial Museum the building has no ramps that could provide a passage for disabled people to go to leveled surfaces. Disable people must go all the way to the back to access the cinema.

Inner stairs should be well guarded, though they may be cracked due to the age of the building or lack of concern. Either way children that live on that building may not be safe.

It has been observed that in some buildings toilet shuffles (changes location) when we go from floor to floor. This makes the building susceptible dampness and leakage. In buildings such shuffle of functions happens, care must be taken and maintenance is mandatory.

Entrances should be emphasized so as to give a clear implication how to enter the buildings. Bank O De Roma's entrance of the building is not emphasized well enough for people to walk in without asking which ones are dead ends and which ones are in fact entrances. Though level differences by themselves suggest ramps there are none seen when moving from one level of the verandah to another.

### **6.2.1.2 INDOOR ENVIRONMENT QUALITY**

#### **TEMPERATURE**

In order for people to function properly concepts like building material, orientation and many other scopes must come together to give a sensible indoor environment where comfort is first priority. From the many concepts described above, temperature is one of the most critical terminologies we come across whenever we try to better indoor air quality.

Coupled with orientation and building material, temperature could be altered and changed. A building facing the south west direction with a building material of curtain wall will certainly have a different indoor temperature than one with the same building material facing the northern direction.

Those that occupy the space that faces the south west direction experience a raised level of temperature. It was observed that those floors that do not have any natural shading device that would cool the space. Shading devices like plastic shutters do shade from the sun but they do not automatically cool the inside space but green structures do cool the area they are planted around by transpiration.

When a room height is shortened it can trap more heat. For instance, in the case of STAIRS, though the rooms have lower ceiling levels due to the openings in the ceilings (which is a system used in hot areas to cool the indoor space), they are not as warm as short ceilinged rooms should be. This is unwise use of open downs that are usually not applied in such cool rooms. May be the architect has a reason for putting such element in the design; nonetheless it has resulted in cool air temperature.

#### **WINDOWS AND LIGHT**

As there is a specific optimum value of temperature that should be maintained in a room, the amount of light and number of windows should also be controlled. This particular character of maintaining and controlling light and windows is what makes Green Buildings efficient.

Some of the buildings' toilet do not have windows that allow proper light to enter. This is improper when it comes to the accomplishment of tasks within the space. Replacing the doors of these toilets with half frosted glass doors might reduce the use of artificial light.

some buildings that do not open their windows due to glare can be shaded by both natural (vertical landscaping) and artificial (shutter) means (Chapter 5). For instance, in buildings like Adam's Pavilion, the frontal spaces that are *Kaldi's* coffee & smaller shops & bank (commercial bank of Ethiopia) and others suffer from too much afternoon light. These spaces occupy the faced that face the south west direction get low sun rays that are hard to block. These spaces

side is built from curtain wall & this lets in full sun light with its glare. Most of these shops & café pass through these hot times by lowering their metal shutters. This in turn forces these places to put on their light because lowering their shutters creates dark interiors.

The presence of sky light in addition to regular windows adds up to the light amount entering an enclosure. A well functioning window lets in enough light so that any task can be done without the need to turn on artificial light. This is a very important point that needs to be noted.

### **MICROBIAL GROWTH, VENTILATION AND DAMPNES**

When the materials in a building become sufficiently damp to cause material damage or visible mold growth we often say that the building has a dampness problem or we characterize the building as a damp building.

If a room doesn't get enough ventilation there is the inevitable outcome of foul smell. Due to old age and construction fault microbial growth may occur from dampness and leakage of structures. This is very dangerous as it may cause mild to serious case of Asthmatic attacks and also common flu to those who use it frequently. One of the crucial points of a Green Building is addressing the case of dampness, microbial growth and using of toxic finishing materials. In the case of this building's toilet, the issues of leakage, dampness and ventilation needs to be addressed immediately.

### **6.2.1.3 ENERGY, WATER and WASTE MANAGEMENT**

The regular turning off of light seems to occur all over the city. But the use of another alternative energy is foreign and strange to the respondents that work in the building. This has a great effect in the building's system because since they do not have a Generator when light goes off, the only option is for them to depend upon the fluctuating light system that seems to go on all over the city. Using of alternative energy is the one of the character of a Green building functioning. Decomposing the waste material in order to have cheaper and more reliable source of energy is what differentiate a common building such as this one from a Green Building. buildings that have flat roofs can support Green Roofs that can easily cool the environment around it (Neufert, 1999). This in turn help in reducing the amount of energy used to cool the environment.

The water resource just like the light energy comes and goes irregularly and throughout the city. The use of used water on toilets and saving the clean water for more important function is a well practiced culture in Green Building System which is made possible by the use of simple tool like double plumbing. It is a modern and wise system of saving, storing and reusing water in developed cities that design their commercial buildings according to Green Building's check points.

Water is consumed in buildings for food, drinking, washing items, toilet and hand washing; the water used for all these activities in assessed buildings is mostly clean water (fig 4-10). There is no double plumbing system in the pipes witnessed during assessment. They neither recycle nor reuse water.

The most efficient building system is one that does not harm the environment with its products and if not add to the health of the surrounding by the system of composting and adding that compost to the green area. A cyclic economical process that seems to benefits almost everyone involved (Architect Mesfin Mulugeta). If the buildings used the disposed waste to create a renewable energy it would have come closer to being more Green Building than many of the buildings in Ethiopia. Though the energy consumption is not much, it would have saved even more by using the more rechargeable and renewable energies.

### **6.2.2 COLLABORATION WITH OWNERS OF BUILDINGS, DESIGNERS, THE BUILDING CODE & GOVERNMENT**

The owners of the building are the ultimate stakeholder in implementing the proposed remedial solutions. But, if the owners are not aware of the consequences of such unhealthy buildings, they may not be willing to cooperate. In addition to the owners of the buildings, the building code of Addis Ababa can enforce laws and regulations in promoting sustainability issues that could improve the situations in the studied areas.

Designers (Landscape Architects, Architects and Urban planners) and environmental planners should design sustainable building and should create eco-friendly environment. In addition, they should aware their clients about the benefits of such buildings. The government should encourage those clients and designers to apply the principles of sustainability by giving them awards and promoting their works. The government can also support importers, small and micro enterprises in importing or producing energy and cost efficient items for buildings' facilities.

## REFERENCES

- A, S. (2008). *Towards a more sustainable solution* .
- Baker, W. T. (1994). *New Classicists* .
- Brandi, U. (2000). *Lighting and health*.
- CERFE. (2005). Environmental Sanitation in Addis Ababa, Kenya .
- Christopher, D. (2002). *Spirit and Place*. Oxford: MPG Books.
- council, L. (n.d.). Sustainable Design Requirments. *Section 01 81 13* .
- Council's, T. U. (2002 ). US Guidelines to Green Building evaluation . USA.
- Development, P. C. (1998).
- Dreiseitl, H. (2005). *New Waterscapes Planning , Designing and Building with water* .
- Eccleston, C. H. (2008). *NEPA and Environmental planning, Tools , Techniques and aproaches for practitioners* .
- F.Pile, J. *Interior Deesign, Introduction to Architectural Interiors* .
- Frankel, T. a. (2008). *LEED*.
- Hopkins, R. (2002). *A natural way of Building*.
- James, L. (2008). *Site Analysis Aconceptual approach to sustainable land planning and site design*. California.
- Karvonen, L. (2000). *Guidelines for Landscape Ecological Planning*. Forestry Publication of Metshallius.
- laboratory, L. B. (2009).
- Neufert, E. &. (1999). *Architects' Data*.
- Plainiotis, Y. J. (2006). *Design for Sustainability*. Beijing: Chaina Architecture & building Press.
- S, M. (2005). PhD thesis: Investigation of input and distribution of polluting elements in Tinishu Akaki River, Ethiopia.
- Solomon, B. (2013). On Site sanitation Options to reduce the impacts of poor Sanitation condition og 'Kochi Sefer' slum neighborhood along Jemare river.

Street, E. W. (1960). *Water Supply and Sewage Texas Mc Graw*.

T, U. (2010). *Sanitation as a key to Global Health Canada* .

Triangle, T. U. (2002). *Green Infrastructures* .

UNUINWEH. (2010). *Waste, Environment and Health*.

UNU-INWEH. (2010). ). *Sanitation as a Key to Global Health. United Nations University Institute for Water, Environment and Health (UNU-INWEH), pp.12-13*.

*Wekpedia*. (2014, jul 20). Retrieved 7 14, 2014, from www: www.d

WHO. (2001). water supply and sanitation assessment africa region: part 2, pp28.

*Wikipedia* . (2011, -----). Retrieved March 14, 2014, from www.wikipedia.com:  
[http://en\\_wikipedia.org/wiki/the\\_Green\\_building](http://en_wikipedia.org/wiki/the_Green_building)

Wines, J. (2010). *Green Building*.

## ANNEXES 1

### Questionnaires for sample building

This questionnaire is prepared by Taeka Haileleul, Addis Ababa University the department of Environment Planning and Landscape Designing second year Masters Program student, who currently is working on the topic 'Green Building'. This questionnaire is prepared for information gathering purpose and any form of support is greatly appreciated.

Date / /

1. Number of people living in the house hold?
2. Number of rooms in the house hold including kitchens and toilet?
3. Family's monthly income?
4. Is the monthly income stable or flexible?
  - a) Fluctuates
  - b) Does not fluctuate

#### QUESTIONS ABOUT INDOOR ENVIRONMENT QUALITY:-

5. \_\_\_\_\_ out of \_\_\_\_\_ rooms have windows?
6. How many of the rooms get natural light?
7. What kind of system do you use to cool your house during hot seasons?
  - a) Mechanical or ventilator
  - b) Opening widows
  - c) Mixed system
  - d) None
8. Are you faced with microbial growth, dampness or ventilation problems?
9. Do you have garden or green structure in your house or around your house hold?
  - a) Yes, I have a green structure / garden
  - b) No, I don't.
10. If your answer is yes for question 9 then can you explain for what purpose do you use it?

#### QUESTIONS ABOUT ENERGY EFFICIENCY:-

11. Can you list the items that use electricity in your house hold?
12. Is there any other source of energy used in your house hold?
13. What is your knowledge about bio gas?
14. Do you use renewable energy?
15. How many lamps are used in your house hold?
16. Do you use energy efficient lamps?
17. If the answer for question 16 is yes then how many?
18. What do you use to heat water?
  - a) Sun energy
  - b) Electricity
  - c) Charcoal or kerosene gas
  - d) None s
19. From your monthly income how many percent is used for electric bill?
20. Are the bills you pay same from month to month or do they fluctuate?
  - a) Fluctuates
  - b) Does not fluctuate
  - c) Fluctuates but not that much
21. Can you list for how long you use the electrical items within 24 hours?

	Name of item	Hours

Item 1		
Item 2		
Item 3		
Item 4		
Item 5		
Item 6		
Item 7		

QUESTIONS ABOUT WATER RESOURCE:-

22.

	How many times per day	How many liters per usage	Total
• Food			
• Drink			
• Washing			
• Toilet			
• Car wash			
• Plants			
• Others			
<i>Summation</i>			

23. What percentage do you spend from your total income for water usage bills?

24. Do you collect and use rain water?

- a) Yes
- b) No

25. What kind of water do you use for toilet?

- a) Water you already used
- b) Clean water
- c) Mixed water
- d) Do not use water for toilet

26. What kind of water do you use for green garden?

- a) Water you already used
- b) Clean water
- c) Mixed water
- d) Do not have garden

27. What kind of water do you use for car wash?

- a) Water you already used
- b) Clean water
- c) Mixed water
- d) Do not have car

QUESTIONS ABOUT WASTE MANAGEMENT:-

28. What kind of waste material disposal do you have?

- a) Personal garbage
- b) Communal garbage

- c) Both
- d) None

29. Composition of waste material;

Types of waste material	Percentage from total
Plastic	
Paper	
Organic mater	
Cloth or textile products	

30. you use System of classifying garbage?
  - a) Yes
  - b) No
31. From the waste material you dispose, are there any that can be adjusted a little bit and be sold?
32. Do you have the culture of recycling waste material?
33. Do you have the culture of using recycled material?
34. What is the system you use when disposing solid / liquid waste material?
  - a) Garbage Can for the solid waste material and plumbs for liquid waste material
  - b) Use Garbage Can for both types of waste materials
  - c) Just dispose both waste outside house hold area
  - d) All
35. How is the disposal system of toilet waste?
  - a) Sewerage system
  - b) Drain to a river
  - c) Drain to an open space
  - d) Closed system
36. How does municipality collect the waste mater?
37. Do you convert the waste material into fertilizer for your green area?
38. Amount of garbage disposed in terms of Kurtu?

QUESTIONS ABOUT BUILDING MATERIAL:-

39. What is the building material used to build your house?
  - a) HCB + plastering + painting
  - b) Stone
  - c) Wood
  - d) Mud
  - e) Other
40. What are the disadvantages of the material used?
41. What are the advantages of the materials used?
42. If there is any other special material used describe the benefits and disadvantages?
43. What is the finishing material used for the interior walls of your house?
  - a) Paint
  - b) Mud
  - c) Asbestos
  - d) Wood
  - e) Gypsum
  - f) Mixture of ..... & .....
44. What are the disadvantages of the materials used?
45. What are the advantages of the materials used?
46. If there is any other special material used describe the advantages and disadvantages?
47. What are the finishing materials used for the interior floor of your house?

- a) Ceramics
- b) Cement screed
- c) Wood
- d) Mud
- e) Carpet
- f) Plastic tiles
- g) Mixture of ..... & .....

48. What are the disadvantages of the material used?

49. What are the advantages of the material used?

50. If there is any other special material used describe the advantage and disadvantages?