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Msc 3 / 4 Graduation Studio Addis Ababa
Living Lab: New Standard for Contemporary
Ideals AR3AD105 |
Academic Year 2020 / 21

TU Delft
Faculty of Architecture and the Built Environment
Department of Architecture
Chair of Architecture & Dwelling

Revitalizing Riverbank Informal Settlements

TU Delft BK Bouwkunde Department of Architecture

Revitalizing Riverbank Informal Settlements

Urban Integration & Revitalization of the Bulbula River

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Graduation Report

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TU Delft
Faculty of Architecture and the Built Environment Department of Architecture Chair of Architecture & Dwelling

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Delft, 7 July 2021

This graduation booklet shows the work that is done during the ‘Global Housing Graduation Studio: Addis Ababa Living Lab’. The goal of this project was to research and design housing solutions to improve the livelihood of Addis Ababa’s urban dwellers.

Currently, Addis Ababa is facing the problems which are caused by the ongoing rapid urbanization. One of these problems, and the focus of my graduation project, is the degradation of the rivers and riverbanks. This project proposes a rehabilitation of the riverbank informal settlements of Addis Ababa, as well as implements a strategy to increase the density of the city which also takes into account the existing inhabitants of these riverbanks and offers them a dwelling type that fits their traditional way of life.

Motivation

Despite the difficult conditions due to global pandemic this year, the intensive tutor sessions helped me to broaden my knowledge about global housing. I have learned a lot from my tutors and their feedback helped me to bring my project to a more detailed and advanced level. I want to thank them for those informative sessions and how they helped me throughout the whole process.

Further, I would like to thank all the students of this graduation studio and how we helped each other by having discussions, always be able to ask questions and also provide a nice learning environment during the sessions we did have at university.

Lastly, I would like to thank my family and friends with whom I have talked, until boredom for them, a lot about my project and subjects on global housing and societal issues on the African continent.

The Students of the Graduation Studio Addis Ababa Living Lab 2020 / 21

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CHAPTER 1

Introduction

Motivation

The main motivation why I have followed the Graduation Course 'Global Housing; Addis Ababa Living Lab' had to do with my prior interests. Starting my master in 2019, I had just been on vacation to South Africa. There, for the first time on such a big scale, I saw the huge differences between lower-income populations and higher-income populations; the different ways people could live and the big contrasts of livelihood that happened even within one city. For me, this story of inequality was a gripping story.

The first year of my master I dedicated my history thesis to this story of inequality in South Africa, and how newly implemented housing developments in South Africa seemed to fail over and over again. The inhabitants wouldn't adapt to their newly gained houses and resorted one by one back to building their own informal houses.

The graduation studio 'Addis Ababa Living Lab' was for me an obvious choice to further explore this interest in global housing challenges, especially focussing again on the 'global South'. It was clear to me that the situation in Addis Ababa was not directly comparable to the housing challenge of South Africa. Nevertheless, the knowledge I gained from my history thesis could come in handy and already made me familiar with housing policies on the African continent.

Introduction

The goal of the 'Global Housing Graduation Studio: Addis Ababa Living Lab' as stated in the Course Guide 2020-2021 is *to research and design housing solution to improve the livelihood of Addis Ababa's urban dwellers.* [01]

The city of Addis Ababa is facing an enormous housing shortage due to the rapid urbanization. Previous urban development programmes since 2002 have focused on the wrong subjects, thus not forming a solution to the ongoing problem of adequate housing deficit. Those urban programmes have had drastic consequences on Addis Ababa's urban dwellers and on the liveability of the city. Existing social and economical structures have been disrupted and the needs and wishes of the urban poor have been neglected.

Further problems relating to the rapid urbanization is the degradation of the rivers and riverbanks. Mainly caused by the forming of badly build informal settlements along those riverbanks. Landslide and floods are becoming a bigger problem then ever before.

This project proposes a rehabilitation of the riverbank informal settlements of Addis Ababa, as well as implements a strategy to densify the city, that also takes into account the existing inhabitants of these riverbanks and offering them a dwelling location that fits their traditional way of life.

In order to come up with a substantiated design, the first part of this report will consist of the research and problem statement part of the project. I did research on the problems relating to the rapid urbanization, as well as did an ethnographic research on the living conditions at Addis Ababa's informal riverbank settlements.

In the second part, an urban vision will be developed and implemented. Here, each important aspect within the urban vision is highlighted and will be elaborated on per chapter. The design while be explained throughout all the architectural scales, from the urban scale to the 1:10 building-details.

Figure 1.1 The Current Urban Context of Addis Ababa

CHAPTER 2

Problem Statement & Research

A Context of Rapid Urbanization

Many developing countries over the world have to cope with the process of rapid urbanization nowadays. 'Pull-factors' such as education, culture or work result in a huge migration flow towards the growing cities. A telling fact; estimated is that by the year 2050, two-third of the world population will live in urban areas. [02] This urbanization-trend puts enormous pressure on these developing cities, its amenities, housing market and economy. Ethiopia is one such a developing country which has to cope with the process of rapid urbanization. Although, anno 2020, only 20 percent of the country's population lives in an urban environment, this percentage will grow rapidly. With an annual urban population growth rate of 4.78 percent Ethiopia is rapidly urbanizing. [03]

The country's capital city, Addis Ababa, is 'the' megapolis of the country and is challenged most by its growth. In a period of 20 years' time, the population has doubled. People from all over the country move to Addis Ababa to find the economic freedom they tend to achieve. The general problem is the fact that these internal migration flows are putting enormous pressure on the city of Addis Ababa; on the urban infrastructure, on the resources and on the housing market. [04]

Figure 2.1 Rural to Urban Migration Addis Ababa; Rapid Urbanization

The enormous rural-to-urban migration, and thus growth of the urban population of Addis Ababa, caused a huge housing shortage. The rapidly increased demand for shelter exceeded the supply of housing of the city. Various governmental policy plans tried to cope with this constantly growing need for housing, but in vain. As a result, the population who was in need for housing started to build their own shelters without building permits, so called informal squatter settlements. This type of city making was not regulated, nor authorized and can be identified as a spontaneous city development. [05]

Soon, the city was flooded with informal squatter settlements. To indicate, 70 to 80 percent of the population of Addis Ababa lives in these informal squatter settlements nowadays. [06] These neighbourhoods can be classified into four different 'informal squatter settlement'- typologies. The first typology is the inner-city informal settlement; these settlements are old non-planned inner-city settlements. The second typology is called the mixed formal-informal housing. These settlements are built without permission of the government, on legal property. The third type of informal squatter settlements are the extra-legal and non-planned peripheral informal settlements. These settlements are built at the periphery of the city. Without permission the squatters built their settlements on vacant land and contribute, by doing that, to the spontaneous urban sprawl of the city. The last type is the extra-legal and non-planned inner-city squatter settlement. These shelters are often made by the poorest of the poor and are small settlements built on street corners, in parks, or other vacant spots in the city. [07]

The government of Ethiopia have tried to cope with these problems caused by the process of rapid urbanization. Various mass housing schemes have been implemented as an attempt to cope with the enormous housing demand. The most prominent mass housing scheme, which is implemented in Addis Ababa, is the Integrated Housing and Development Programme (abbr. IHDP), implemented in 2005. The scheme is known as the 'Condominium Housing Project', relating

to the typical IHDP-building block; the condominium. Condominiums are building blocks that contain multiple apartments and communal spaces, inspired by modernist housing estates found, in particular, in east Germany. [08]

The goal of the IHDP was to upgrade the inner parts of the city by replacing informal squatter settlements with condominium buildings. The objective was to build 170.000 units in just five years. Fifteen years later, more then 175.000 housing units have been built, and still more than 125.000 are under construction. Where the initial goal of this mass housing scheme was to focus on upgrading the inner-city, almost half of the condominium-projects, more than fifty neighbourhoods, were located at the periphery of the city. These projects are so-called greenfield developments. Previously undeveloped pieces of land are used for condominium-development.

Figure 2.2 Typical Condominium Building Blocks

Further, two more types of condominium-projects can be recognized. The first type is urban redevelopment; pieces of land which are filled with poorly built informal squatter settlements are allocated as redevelopment sites. All the informal squatter settlements located on these sites have to be cleared to make place for condominium-development. The second type of development is brownfield development. Unused, previously developed land is re-used to build the condominiums on. These last two types of condominium-development, urban- and brownfield development, can be identified as urban infill, while greenfield development contributes to the urban sprawl of a city.

Besides the fact that these mass housing schemes have still not been enough to fully cope with the problem of the housing shortage, the city of Addis Ababa has another challenge to face. The spontaneous city development, informal squatter settlements, as well as the planned and regulated city development, mass housing schemes, have contributed to the urban sprawl of the city. This horizontal expansion of Addis Ababa has caused some problems, since the land area of Addis Ababa is landlocked by the Oromia region. Even though all the land in Ethiopia is state owned, expanding into adjacent regions can cause problems. This has to do with underlying tensions between the different regions of Ethiopia. The Tigray region is stated as 'region 1' in the federal constitution, which means they have most of the power and wealth, and, as well, can decide over decision makings such as masterplans. The Oromo people, habitants of the Oromia region; the biggest region of Ethiopia, feel disadvantaged by this disproportionate distribution of power and wealth.

A long-standing grievance reached its limits when a masterplan of Addis Ababa assigned farmland belonging to Oromia as greenfield development. This caused some political tensions and even deadly violent protests, leading to the 'declaration of a nine-month state of emergency' and the masterplan was scraped. Nowadays, Addis Ababa is not allowed to expand into the Oromia region, and thus only has its own land in between the regional borders to develop on. This land is almost

fully built and, certainly, doesn't offer the space for expansion needed in the future. Gardner [09] published an article in the Guardian concerning this problem, and he stated:

"As more and more of Ethiopia's 100 million inhabitants - 80% of whom still live in the countryside - spill into Addis Ababa, strains on the city's land have intensified. The consequences may be explosive. "Addis Ababa has run out space.""

The specific problem is the cities landlocked situation in combination with the current trend of rapid urbanization, that causes the need for urban expansion, which forms a great contradiction. Addis Ababa needs to expand without space in which it can expand.

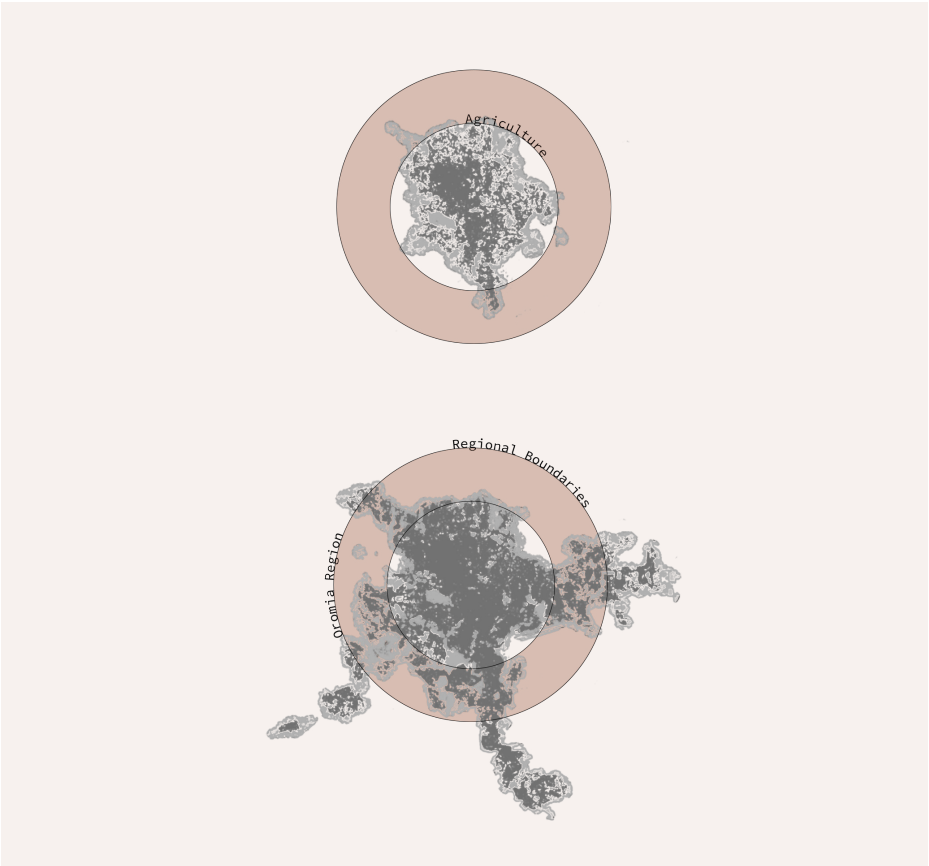


Figure 2.3 Urban Growth of Addis Ababa

Focus on Sustainable Urban Redevelopment

Due to the fact that Addis Ababa can't expand horizontally, the solution on the growing need for housing due to rapid urbanization needs to be found in between its own regional boundaries. Most of this land area is already in use, and therefore the focus needs to be on redeveloping the city itself and thus increasing the density of Addis Ababa. When redeveloping, the neighbourhoods with the worst quality will be redeveloped first. In the case of Addis Ababa, this will be the areas filled with informal squatter settlements. An investigation in sustainable urban redevelopment of such developing cities is the topic of many discussions in the previous decades. One controversial topic is the impact of 'urban densities and form' on the social sustainability and cityness of an urban site.

Before looking at this, it is important to clearly define the meaning of the terms 'urban densities and form'. Density can be defined as "the number of people or things in a place when compared with the size of the place". As stated by Harper [10], this basic description of density depicts density as 'cold' and a 'crude instrument of economic calculation'. But, broader implications of the term are neglected in this way. Harper describes densi-

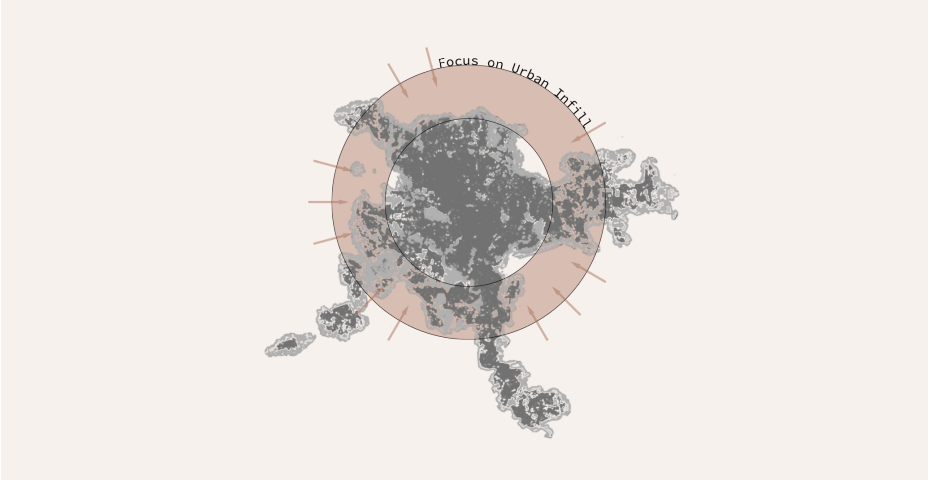


Figure 2.4 Focus on Sustainable Urban Redevelopment

ty also as an experience that is ‘sold’, an association with crowding and proximity. Just like Harper, researchers as Dave [11] and Halasz [12] make the same distinguishment. They divide density in two terms; the ‘physical density’, and the ‘perceived density’. The physical density, the crude instrument of economic calculation, are objective measures such as the ‘dwellings per hectare’ or the ‘people per hectare’. While the perceived density gives a clearer idea about the urban form or the social structures of a place, described as a more subjective density. The perceived density are measures such as the ‘crowding of buildings’ or the ‘crowding within dwelling’.

The difference between these two types of density and its impact on the social sustainability or urban form can best be explained using ‘Figure 2.5’ (see next page). On this illustration, the physical density of each urban situation is all the same. The perceived density, on the other hand, varies by urban form. At the top of the illustration, we can identify the ‘tower in the park’-principle. This principle, introduced by Le Corbusier in the middle decades of the 20th century, can be seen as a high-rise urban typology. This typology offers an efficient and healthy city with lots of green open spaces and good transportation. [13] At the bottom of the illustration we can identify a low-rise urban typology. This typology is known for its narrow streets and often small houses, close on each other. Here, the perceived density is much higher. Dave concluded in his paper that this higher perceived density often resulted in more negative perceived associations of density and thus more negative social sustainability. This has to do with the feeling of safety, the provision of greenery and the feeling of openness. This conclusion supports this western idea of the ‘Tower in the Park’ as an ideal approach for densificating a city while keeping a high social sustainability. Thus, as an ideal approach for coping with rapid urbanization and urban redevelopment.

The ‘Condominium Housing Project’ can be seen as an approach as such. As said before, the condominium blocks followed post-war west modernist housing estates example and created neighbourhoods with a higher physical density while the perceived density was much lower than the existing informal squatter settlements. Following the reasoning of Dave, these new neighbourhoods should be way more social sustainable and thus improve the livelihood of the people who live there. Nevertheless, in many cases the contrary seemed to be true. This all had to do with the complexity of the cityness of Addis Ababa. Cityness can be defined as “how urban citizens give meaning to the city they live in and how this creation of meaning alters the way the city is represented” [14]

In Addis Ababa it is hard to ascribe one cityness to the whole city. As Yitbarek [15] refers to Addis Ababa as a “collage of cities”, explains the complex situation of the city. As a result of both the spontaneous- as planned and regulated city development, the

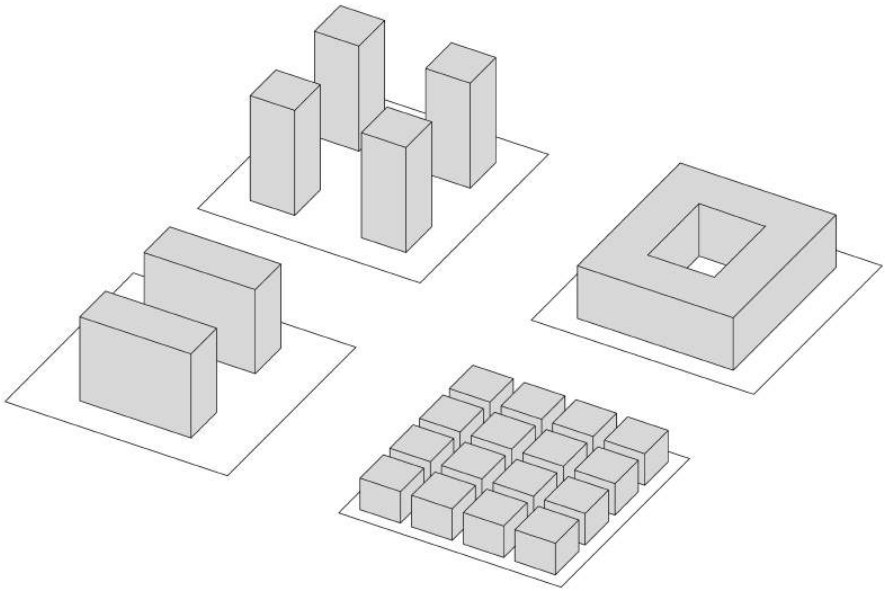


Figure 2.5 Density, Spatial Patterns & Perception

urban fabric can be divided into different types of cityness; the old city, the industrial city, the informal city, the market city, the condominium city, and so forth. Even within these types of cityness, huge differences can be found. Take for instance the informal city. Like described before, informal squatter settlements in Addis Ababa can be subdivided into four different types. This enormous differentiation of the urban fabric makes it hard to describe the cityness of Addis Ababa as a whole. In this paper the focus will be on the informal city, where in the design task special emphasis will be on riverbank informal settlements, a form of 'extra-legal and non-planned inner-city squatter settlements.

The cityness of the informal city can be described as a simultaneity of congruities. The spontaneous way these neighbourhoods emerged and gave place to the rural-to-urban migrants, resulted in neighbourhoods with irregular shapes, bad infrastructure and bad sanitary conditions. On the other hand, this spontaneous development created communities with people of different income groups and ethnic and religious backgrounds. Tesfaye & Teklehaimanot [16] describe this process and its influence on the cityness of Addis Ababa as follows:

"spontaneous growth and rapid urbanization of the city has resulted in a "bizarre juxtaposition of luxury and squalor". Such a condition has allowed for various forms of exchange to happen in the day-to-day life. Community dwellers depend on livelihoods based on small-scale domestic production and exchange. The mixed presence of commercial and residential areas, high and low-income groups, different financing systems, and variety of spaces within a district in the city are virtues of the sefer." (P. 64)

The feeling of community responsibility, the existing cohesion between the different groups and the important socioeconomic climate of the informal squatter settlements is rooted in the cityness of Addis Ababa. This can also be seen in the documentaries of Heisel and Kifle. [17] These documentaries show how people have built and adapted these informal squatter settlements to their needs and tradi-

tional life patterns. Specific spatial characteristics of these settlements play a major role in the socioeconomic climate of these neighbourhoods and became, thereby, embedded into the cityness of Addis Ababa. One of these characteristics is the ever-existing connection to the ground floor. The socioeconomic climate of these informal settlements is based on small-scale companies run in the courtyards, small streets and houses. The connection with the ground floor is of great essence for these companies. As concluded by Hebel and Heisel [18] approximately 40 percent of Addis Ababa's businesses won't even operate on a high floor level. Another characteristic is the simultaneity of congruities on these ground floor spaces. In the documentaries of Heisel and Kifle, for instance, the importance of the courtyard in the informal squatter settlements is highlighted. The documentaries show how the courtyard doesn't solely function as a courtyard, but as a constantly changing active and dynamic space. This way of using space refers to the rural roots of the habitants. In rural areas, housing can be seen as nothing more then a shelter. This shelter is multi-purpose and thus has no differentiation of functions. Every daily activity can happen in the same space due to the high adaptability of this space. This "shelter-typology" is brought into the urban context and formed the base for these informal squatter settlements. A research by Heisel [19] concluded that 77% of all informal squatter settlement houses serve different functions which change between day and night. 33% of the dwellers even turn their houses into public functions, such as shops or restaurants. Temporary separations, such as curtains, create the flexibility for these ever changing activities in these houses. Nowadays, these characteristics of these informal squatter settlements, are embedded in the cityness of Addis Ababa.

The IHDP-development neglected thiscityness of the informal squatter settlements of Addis Ababa and developed multiple condominium-schemes, a more "western" urban scheme. Hassen and Soressa [20] explored the 'experiences of the poor in the contemporary urban resettlement of Addis Ababa' and discussed two major issues. The first major is-

sue of the IHDP was the urban resettlement process. Illegitimate appropriation of the, by the state owned, land made it possible for the government to claim informal squatter settlement areas for redevelopment. Dwellers on these pieces of land had to relocate, often to locations at the periphery of the city. This major displacement of the dwellers resulted in disruption of social and economic networks. The second issue of the IHDP was the experience of those people who lived inside a condominium. The living conditions of many improved when compared to their previous informal settlement. Nevertheless, the residents are not able to adapt and fit their traditional way of life into these new condominiums; the spaces are standardized, there are restrictive rules and so forth. Soressa and Hassen conclude that the livelihood of the resettled have been negatively affected by the program. The program tried to densificate and redevelop the city, but this change of the urban fabric conflicted with the cityness of the informal city.

This effect of the IHDP on the cityness of the habitants can be explained, according to the research of Ruszczyk [21]. As Ruszczyk states: “I reflect on density through ruralisation where people carry their past into their present habitus. People use their history and their knowledge to make sense of their newfound engagement and residency in cities.”. The IHDP implemented a new urban density and form. Where the low-rise urban form of the informal squatter settlements gave space for rural habits, did the medium- to high-rise condominium building not provide this space. Rural habits couldn’t be lived and people felt distanced from their roots. The specific spatial characteristics of the informal squatter settlements, which were important for- and embedded in the cityness of Addis Ababa, were not addressed in the design of the condominium. Soressa and Hassen as well as Keller and Mukudi-Omwami [22] concluded that this development, of a medium- to high-rise high-density urban typology, despite the success in expanding the availability of quantity and quality low-income housing, has failed to address the needs of the poor and disrupted their cityness on which their livelihood was depended.

The IHDP have proven that ‘urban densities and form’ can have a major impact on the cityness of an urban site. As the example of Addis Ababa shows, a change in ‘urban densities and form’ can be fatal to the traditional life of the habitants. Daily activities can no longer be carried out and the livelihood of these habitants is limited by the new urban context. Therefore, density shouldn’t only be seen as an interesting number, but also as a tool that can clearly influence cityness. Thinking about density as a general condition and linking it to an ideal solution for urban redevelopment, like Dave did with the ‘tower in the park’-principle, is therefore too short-sighted. As can be seen from the example of the IHDP, it is necessary to consider the cityness of a location simultaneously with the urban density and form. There is the need to reconceptualize thinking about urban densities and form in relation to cityness, and come up with new proposals for sustainable urban redevelopment and densification which won’t disturb the existing cityness of Addis Ababa.

Reconceptualize Thinking about Sustainable Urban Development

What went wrong with the ‘Integrated Housing and Development Project’ is a well-known mistake. The IHDP can be seen as a top-down approach and is a great example of an urban development which ruptures the existing urban fabric. The context is erased and the plan is to move forward by big, bold declarations. [23] A comparison can be made with projects like the ‘Plan Voisin’ of Le Corbusier or the ‘Pruitt-Igoe’ in St. Louise and the condominium housing project. A new urban density and form is introduced, breaking from the traditional urban fabric. The architecture neglects the contemporary cité and creates a new urban realm. The condominium was introduced in Addis Ababa as a new urban reality and its relation to the city and its people, the cityness, was “nowhere” to be found. It can be seen as the big, bold statement; a placeless type of architecture, not embedded in its surroundings, not adapted to the cityness of Addis Ababa. A stamp which can be spread around the city

or even around the world. Rather this lack of regionalism has been the downfall of the condominium project.

Lack of regionalism, or placeless architecture, is a well-known critique on post-war and postmodern architecture of the latest centuries. As Pieterse [24] mentioned in his paper, it is important to explore African cityness when designing sustainable urban development. The need to research ethnographic textures, sociological patterns and topographies and spatial practices is important to understand how people will adapt architecture to their needs and traditional ways of life. It is important to reconceptualize thinking about urbanization and densification in the context of the projects location, in this case Addis Ababa.

As it seems, the urban low-rise form of the informal squatter settlements doesn't match current day problems of rapid urbanization and livelihood quality, while the urban high-rise form of the condominium doesn't fit the traditional cityness of Addis Ababa. Other or newly developed urban forms have to be taken into account. These forms have to be adapted to the needs of the people and the cityness of Addis Ababa. At the same time, they also have to cope with the problem of densifying the city. Hebel and Heisel (2014) did a small-scale research on the cityness of Addis Ababa and they accentuated the necessity of the ground floor networks in the city of Addis Ababa and related this characteristic of the cityness of Addis Ababa with the need for low-rise development. They emphasized, and in that sense seemed to agree with Pieters, on the importance of the African Urban Knowledge. In their paper they say the following:

"However, should this vision be based on cities like Dubai, Shanghai or Singapore where most public space only exists in shopping malls? When we ask "How high should we built this city?", it is important to remember that this is more a question of lifestyle, than a question of necessity." (p. 19)

In this sentence they re conceptualized thinking about urbanization, as Pieterse stated, by not just looking at successful attempts of urbanization in the Western society, but also

by focusing on the cityness of Addis Ababa. Important spatial characteristics and lifestyle habits form a better reference than projects done in other cities. Each place in the world has its own cityness, and these different types of cityness all create a different need for urban densities and form. There is the need to re conceptualize thinking about urbanization and densification in a more contextual approach and come up with new proposals for urban redevelopment and densification which won't disturb the existing cityness of a place. Therefore, further research projects must explore a way there can be dealt with densifying cities while maintaining, or even strengthening, the traditional cityness.

Research Questions

Main Question:
How can Addis Ababa implement a low-rise high-density urban scheme that contributes to densifying the city and at the same time creates social sustainability and fits the cityness of the informal city of Addis Ababa?

Sub questions:
• How can urban redevelopment be designed to create social sustainability?
• How can urban redevelopment be designed to fit the cityness of the informal city of Addis Ababa?
• How can a low-rise high-density urban design reflect the cityness of the informal city?

CHAPTER 3

Site Introduction

Addis Ababa

Two major rivers flow through the city of Addis Ababa. The Tinishu Akaki (Little Akaki) and the Tiliku Akaki (Great Akaki) Rivers. These two rivers are tributaries of the Awash River which is a 1.200 kilometres long Ethiopian river which originates in the Ethiopian Highlands, located north to Addis Ababa. These two rivers have on it's own also many tributaries, of which one of them is the Bulbula river. [25] The chosen site is located along the Bulbula river and is indicated on the location map with a small brown dot.

Figure 3.1 Chosen Site on City-Scale

District Bole / Kirkos

The chosen site is located on the edge of district Bole and adjacent to district Kirkos. Bole is one of the most busy and prosperous districts of Addis Ababa. The 'Addis Ababa Bole International Airport' is located approximately 2 kilometres away from the chosen site.

Other well-known places in Addis Ababa such as the Gotera Square or the Meskel Square are all located within a radius of 3 kilometres wide. Thus, is the chosen site located on one of the places with very high potential within the city of Addis Ababa.

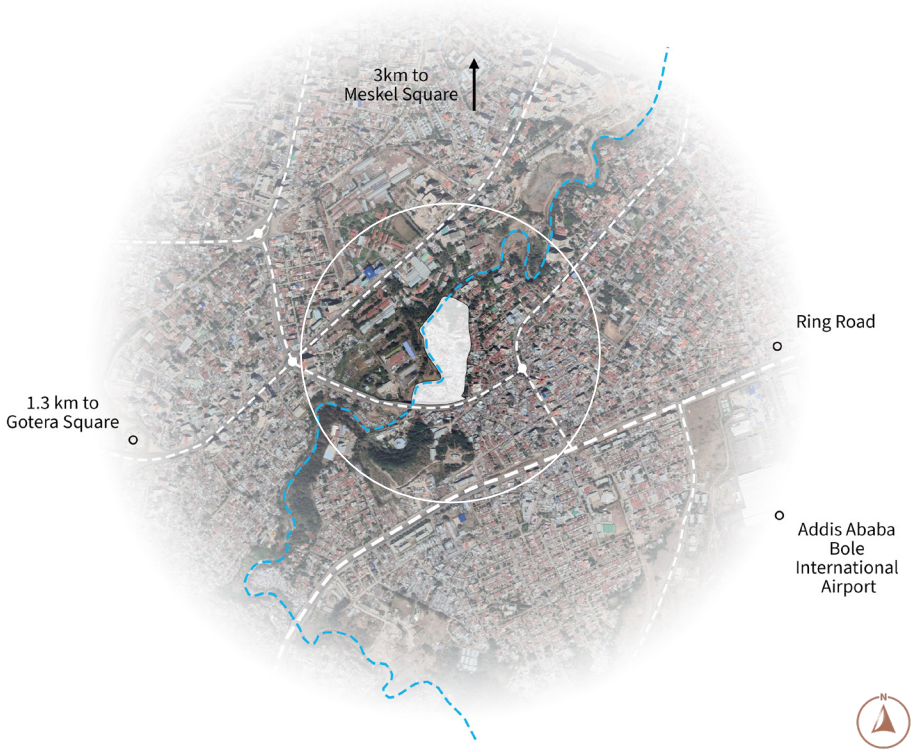


Figure 3.2 Chosen Site on District-Scale _ pt. 1

Figure 3.3 Chosen Site on District-Scale _ pt. 2

Neighbourhood

As previously discussed in the chapter 'Research', the Neighbourhood is a 'Riverbank Informal Settlement' which has been set up along the bank of the Bulbula river. This left-over space is located within the vibrant district Bole and thus, many facilities and amenities are located nearby. For instance a local hospital, many shops and restaurant, the Wegagen Bank Bole Micheal Area, and many other facilities are mostly located along the Rwanda street which connects to the site.

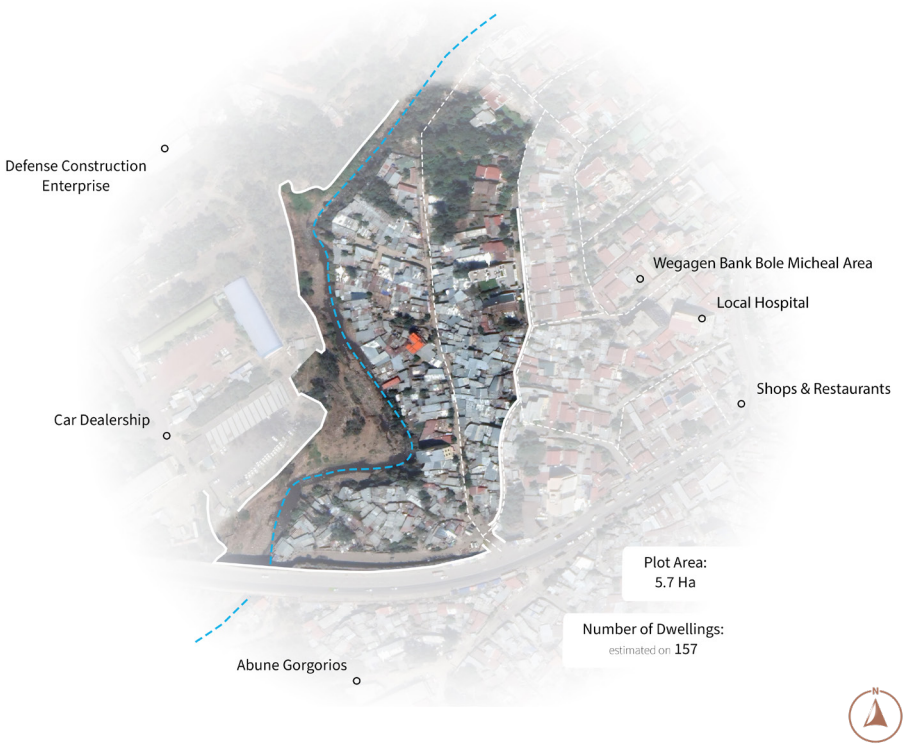


Figure 3.4 Chosen Site on Neighbourhood-Scale

Figure 3.5 View on the Bulbula River (further Upstream) [Source: Riverside Luxury Hotel Apartment Ethiopia]

Figure 3.6 View on the Rwanda Street at the site's entrance [Source: Google Earth]

Figure 3.7 Indicator for Location of Picture

Bulbula River

The Bulbula river flows past / through the chosen site. The stream is oriented north-south and thus, the water leaves the site at the “bottom”. As can be seen in the image below, the river is meandering its way through the site. As our group research on Addis Ababa as well as my own research has showed, Addis Ababa has to deal with floods that occur often during the rainy season (the Kremt). Therefore, the river takes a very important place in the design process with not only huge potentials, but also with various threats. More over in ‘Chapter 7 - Revitalized Riverbank’.

Figure 3.8 The Bulbula River

Topography

Ethiopia's topography is known as one of the most rugged in Africa. Even in the city-centre of Addis Ababa this irregular landscape has huge impact on the city, making it even impossible to build on various places.

After topographical analysis, I separated the topography of the chosen site into two zones; the 'lower plateau' and the 'ridge'.

The 'lower plateau' is the hatched area around the river. The 'lower plateau' is slightly elevating, but, on average, is located at a height of e.g. 2279m MSL. Here, the risk for floods is highest.

The 'ridge' is located at the sides of the lower plateau and rises steeply.

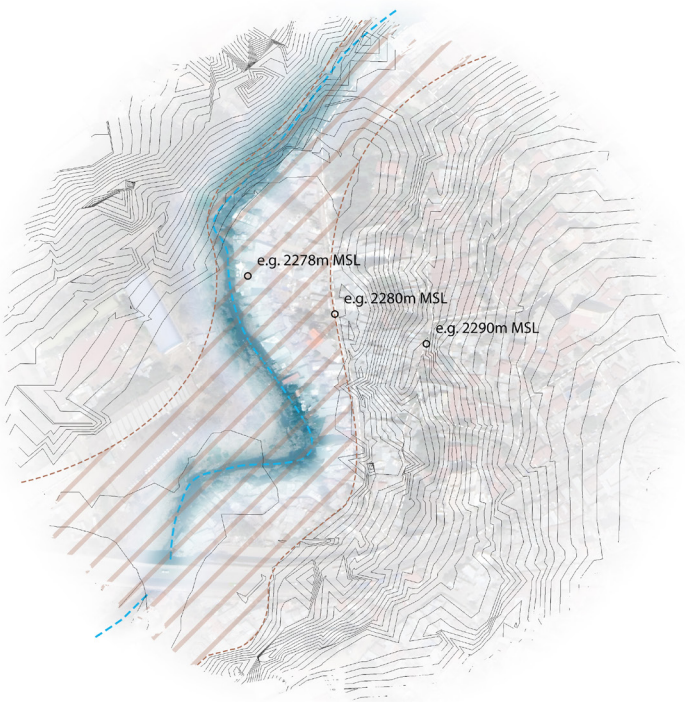


Figure 3.9 Indicator for Location of Picture

CHAPTER 4

What Once was a River Landscape

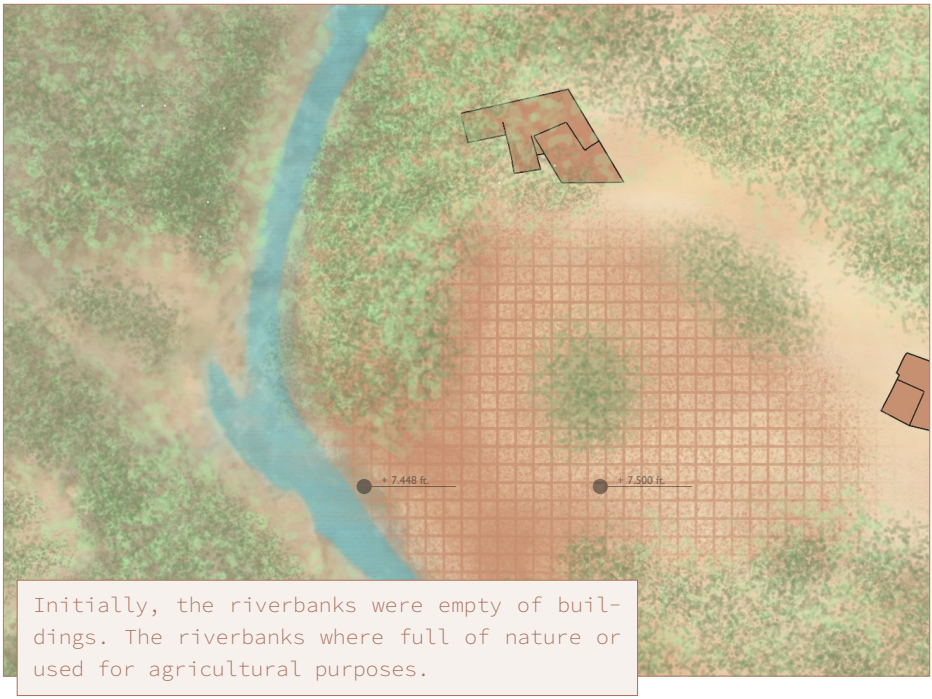
Introduction

As a way to represent my research on the exploration of cityness, I made a graphic anatomy during the P2. In this graphic anatomy I did a historical analysis of how the function of the riverbank has changed over time and how rapid urbanization caused these changes.

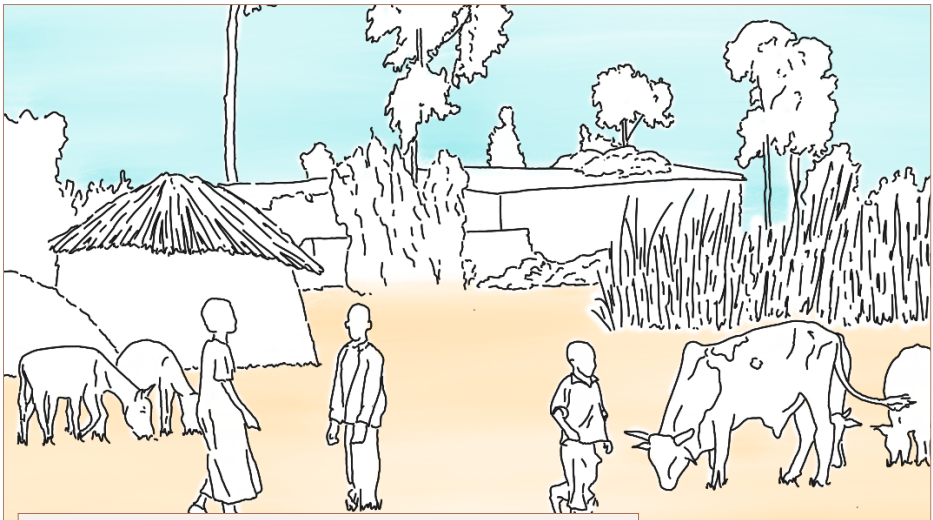
Since not much information about the specific site was available, I made several assumptions based on different sources about Addis Ababa's riverbank. The key weaknesses and strengths of the informal riverbank settlements should come forward in the graphic anatomy.

In a later stage of the whole project I also made a graphic novel; 'The Story of Kofi Tadesse', see "APPENDIX B" on page 227. In this story, several key aspects of those riverbank informal settlements also come forward in this graphic novel.

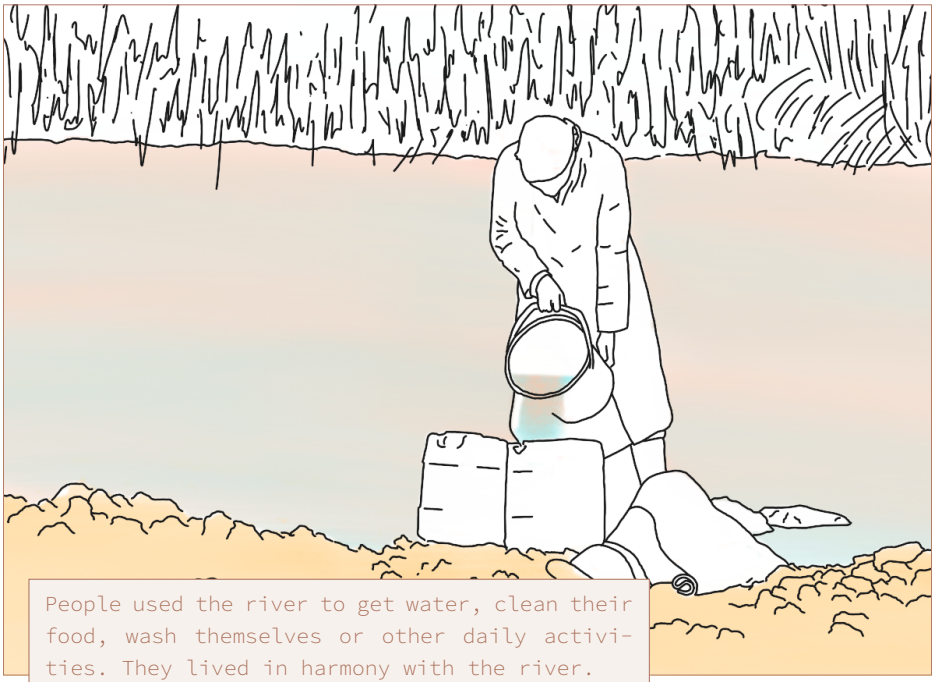
This chapter is concluded with a SWOT-analysis in which all the strengths, weaknesses, opportunities and threats of such informal riverbank settlements are summarized.



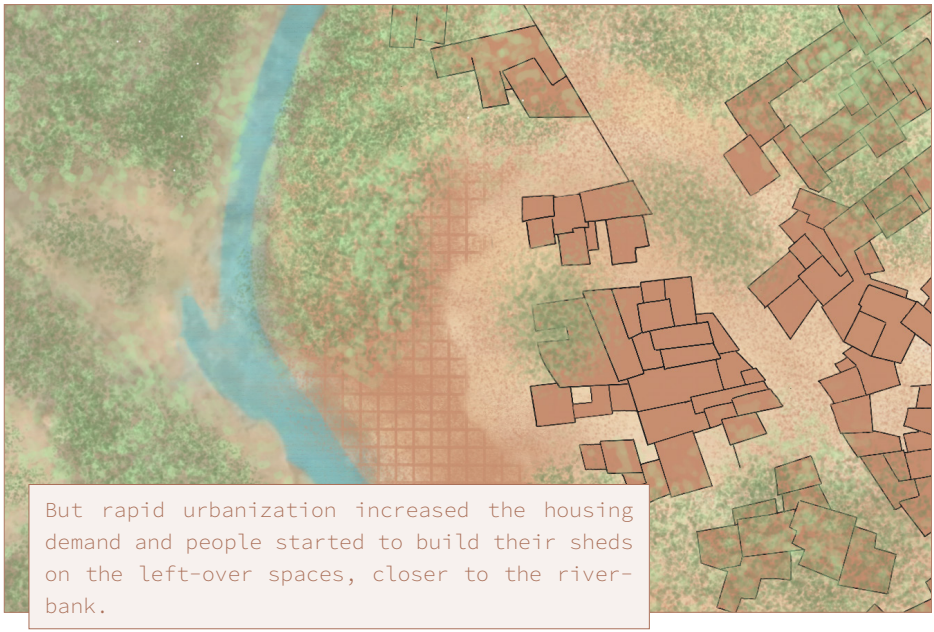
Initially, the riverbanks were empty of buildings. The riverbanks where full of nature or used for agricultural purposes.



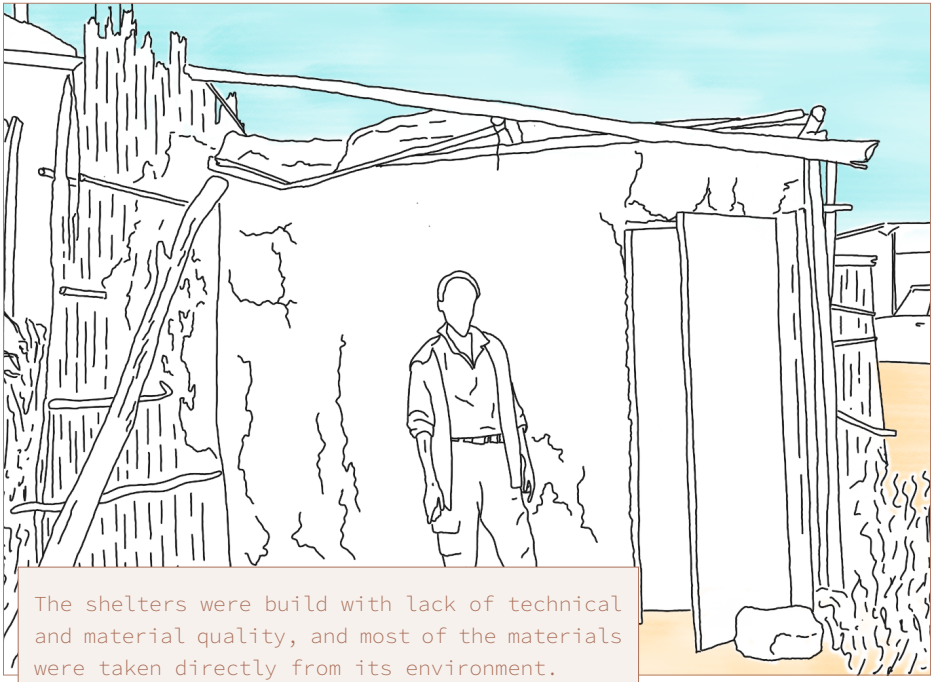
Thus, only a few small sheds were to be found along the riverbanks. Mostly placed far from the river.



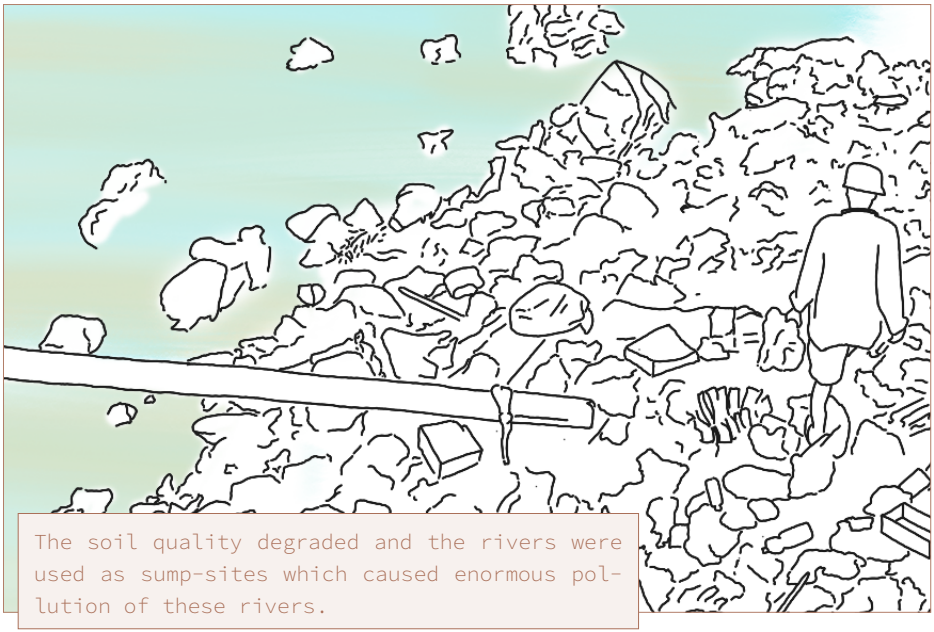
People used the river to get water, clean their food, wash themselves or other daily activities. They lived in harmony with the river.



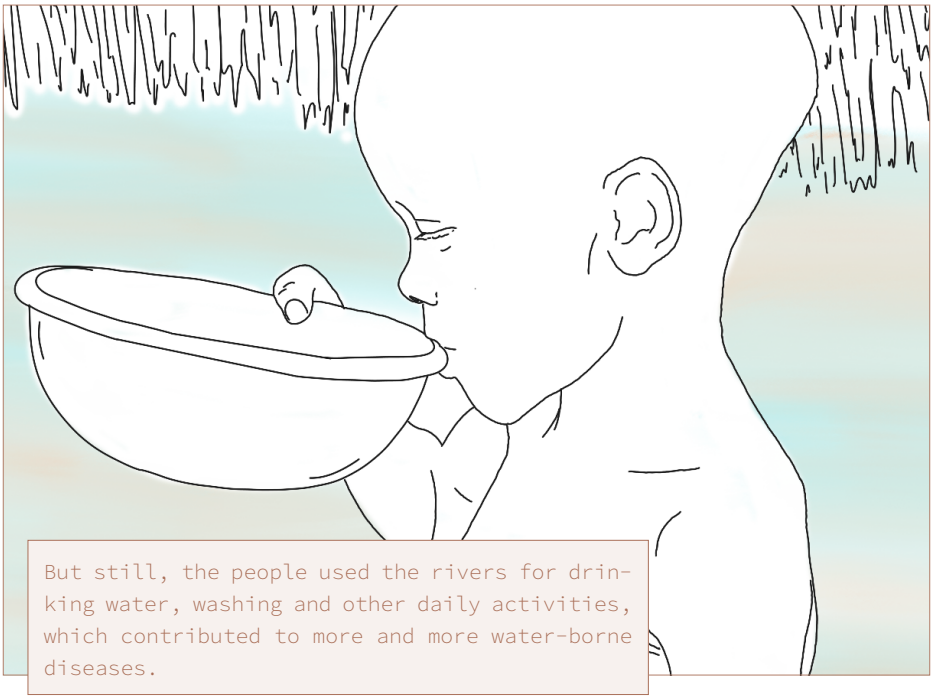
But rapid urbanization increased the housing demand and people started to build their sheds on the left-over spaces, closer to the riverbank.

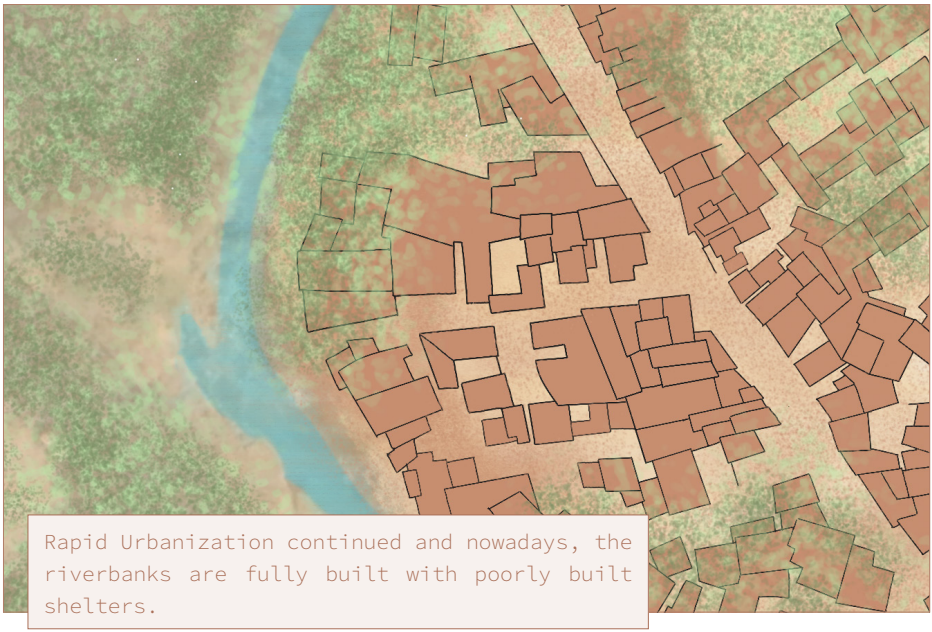


The shelters were build with lack of technical and material quality, and most of the materials were taken directly from its environment.

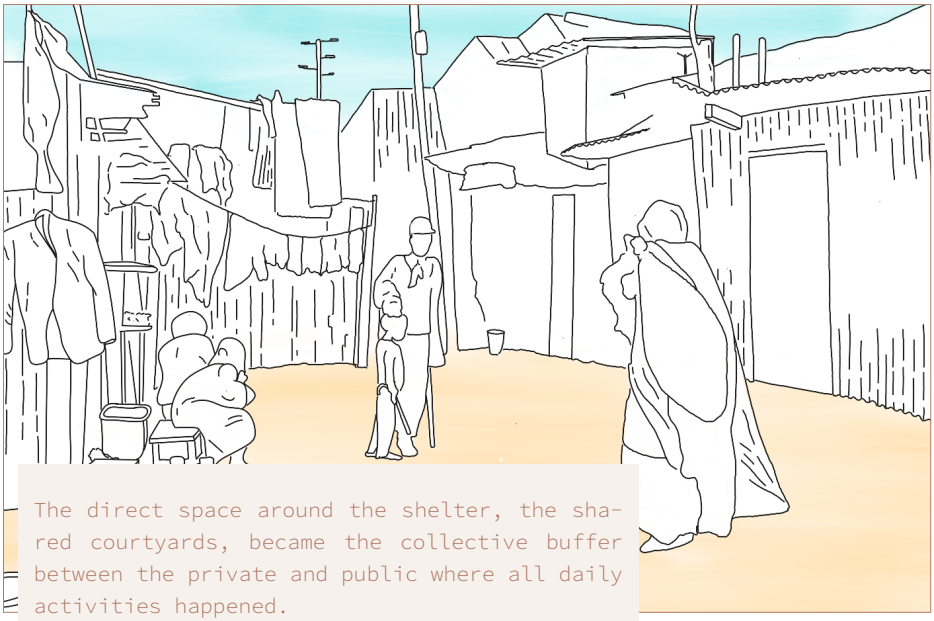


The soil quality degraded and the rivers were used as sump-sites which caused enormous pollution of these rivers.


But still, the people used the rivers for drinking water, washing and other daily activities, which contributed to more and more water-borne diseases.

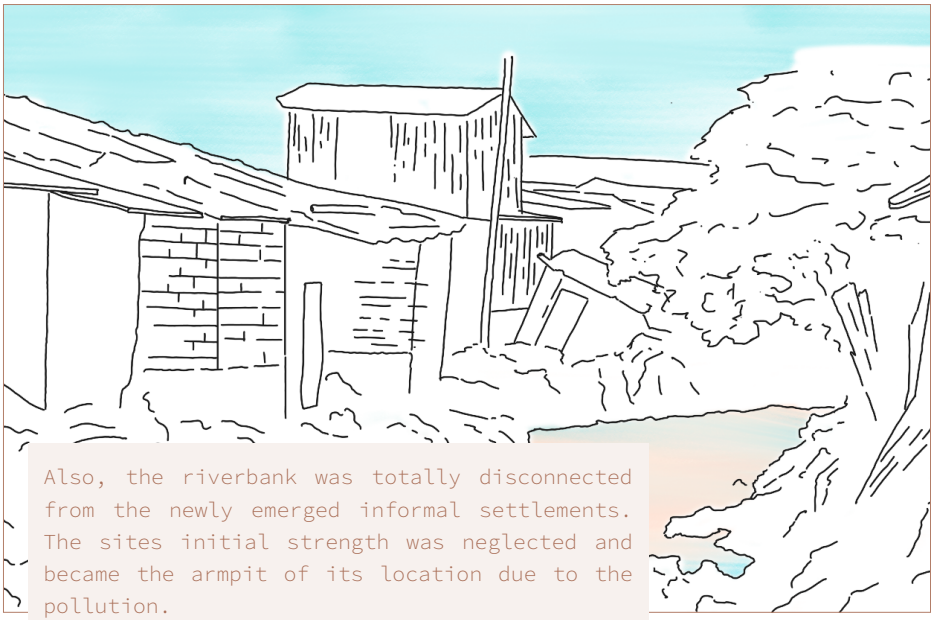

Rapid Urbanization continued and nowadays, the riverbanks are fully built with poorly built shelters.

The public spaces that emerged where of high value for the whole community, functioning as a public realm for informal retail, social connections, and so on.



The direct space around the shelter, the shared courtyards, became the collective buffer between the private and public where all daily activities happened.

But due to the high density, the inter-connecting spaces became a spiderweb street grid that caused a feeling of unsafety and unpleasentness.



Also, the riverbank was totally disconnected from the newly emerged informal settlements. The sites initial strength was neglected and became the armpit of its location due to the pollution.

SWOT-Analysis

The graphic anatomy represented various key weaknesses and strengths of the informal riverbank settlements. The same weaknesses and strengths of those riverbank informal settlements also come forwards in ‘The Story of Kofi Tadesse’.

Those characteristics of the informal riverbank settlements have been summarized in a SWOT-analysis, showing the strengths, weaknesses, opportunities and threats of these specific type of informal settlements.

Figure 4.1 SWOT-Analysis Riverbank Informal Settlement

“The location’s greatest potential, became its biggest threat.”

CHAPTER 5

Design Hypothesis

Urban Integration of the Bulbula River

As the previous chapter showed, the rivers and riverbanks of Addis Ababa face several problems. These vital ecosystems become more and more the armpit of the city, rather than of its strengths. The rivers and riverbanks go hidden behind the informal riverbank settlements and, thus, the rivers and riverbanks are disconnected from the existing urban fabric. Every relation to the river is blocked by the developments caused by the rapid urbanization.

Since these rivers and riverbanks are totally neglected, the quality of it is totally deteriorated and and need revitalization to become important again within the cityscape. Therefore, **the proposal needs to create urban integration and revitalization of the Bulbula river.**

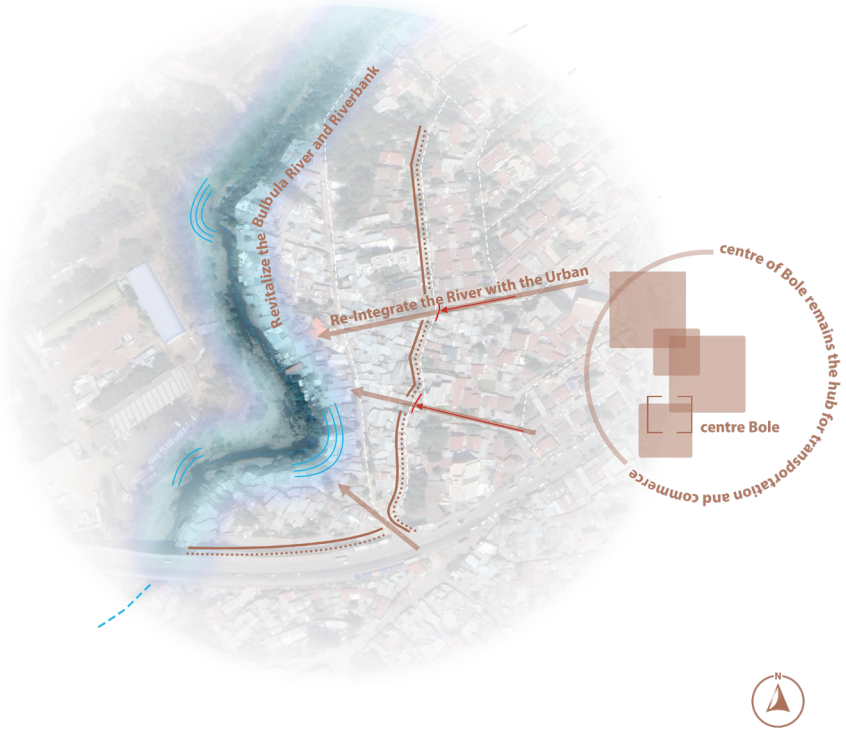


Figure 5.1 Design Hypothesis of Chosen Site

Going Along with the Cities Ambitions

The revitalization and urban integration of the rivers of Addis Ababa is already an on-going project of the Ethiopian government; known as the "Sheger Beautifying Project". This project aims to clean the rivers of Addis Ababa and create public spaces along these rivers. Initiated and funded by the Ethiopian government and Chinese counterpart, millions will be invested in this project. The images on the right page show renderings of the proposed plan. In these renderings the proposed goals of the project are visible; to create a nice public environment, to increase the amount of greenery in the city, and so on. The project also aims at sustainability, not only by creating green spaces, but also by using high quality materials that relate to current problems of Addis Ababa. [26]

Apart from the positive effects the "Sheger Beautifying Project" will have on the city of Addis Ababa, the project also has a few downsides. The news article shown in 'Figure 5.3' shows one of the downsides of the riverside project. It states that the project gives priority to development over residents (informal riverbank residents). Shelters along the riverbank are demolished 'without warning' and the people living in those shelters need to find new accommodation, their livelihood is taken from them.

My design needs to propose a solution that takes into account both the rehabilitation of the riverbanks, as well as takes into account the existing inhabitants of these riverbanks and offering them a safe opportunity for life. Rather than only focussing on the riverbank landscape, a synthesis between the riverbank landscape and a dwelling landscape needs to be found. [27]

Therefore, the main question that needs to be answered with the design is;

'How can Addis Ababa implement a strategy to densify the city, that caters for the rehabilitation of the riverbanks as well as creates a dwelling landscape that takes into account the cityness of the informal city of Addis Ababa?'

Figure 5.2 Renders and pictures of the : Sheger Beautifying Project”

Addis Ababa riverside project gives priority to development over residents

Published on 12/03/2020, 6:00am

Ethiopia wants $900 million riverside project to be a model of green development – yet one resident says shelters were demolished ‘without warning’

Figure 5.3 Newsarticle that states one of the downsides of the project

CHAPTER 6

Urban Strategy

Introduction

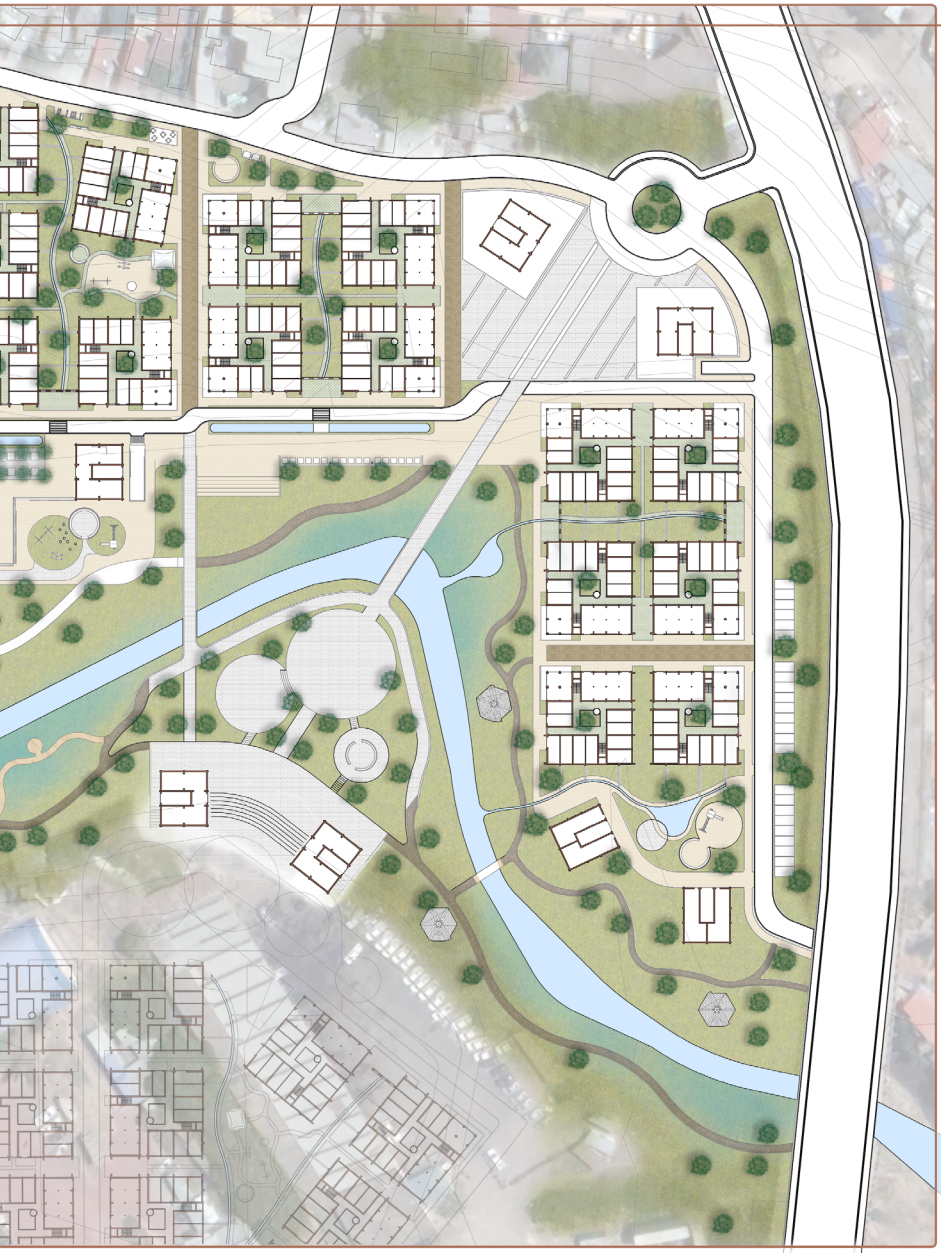
The design of the masterplan is based on several key goals that all refer to the statement made during the design hypothesis; **to create urban integration and revitalization of the Bulbula river**. Those key-goals are;

On the following pages the masterplan that resulted from those key-goals will be explained. The masterplan has been designed according to a general urban strategy, on which also will be elaborated on. The urban strategy can be divided in 4 different subjects, see “Urban Strategy” on page 56, of which each of those will be extensively elaborated on in the following chapters of the booklet.

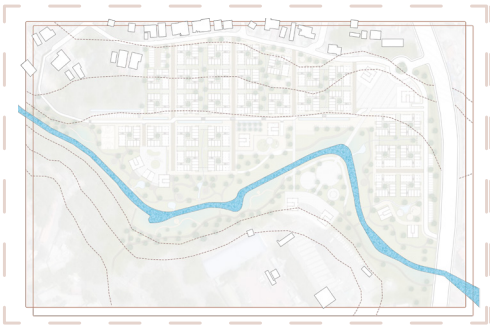
- Create Space for the Bulbula River
- Remove the Barriers between the Existing Urban Fabric and the New Riverbank Neighbourhood
- Integrate the River- and Dwelling Landscape

The Masterplan

Figure 6.1 The Masterplan

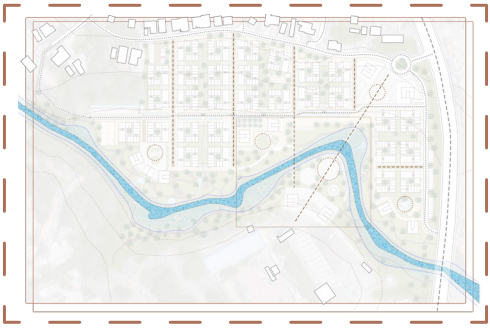


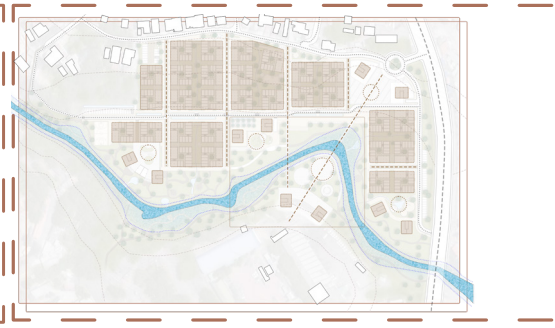
Urban Strategy



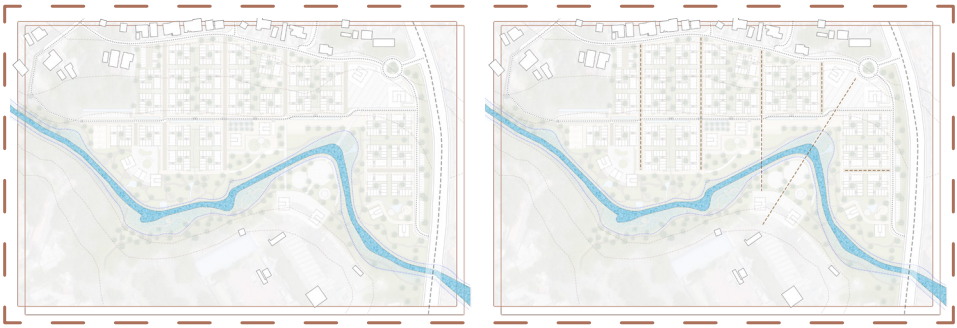
Site Introduction

Revitalized Riverbank

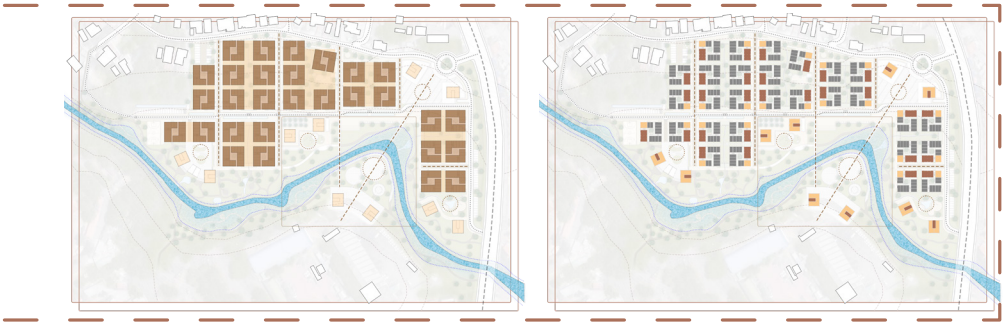




Public Squares & Towers

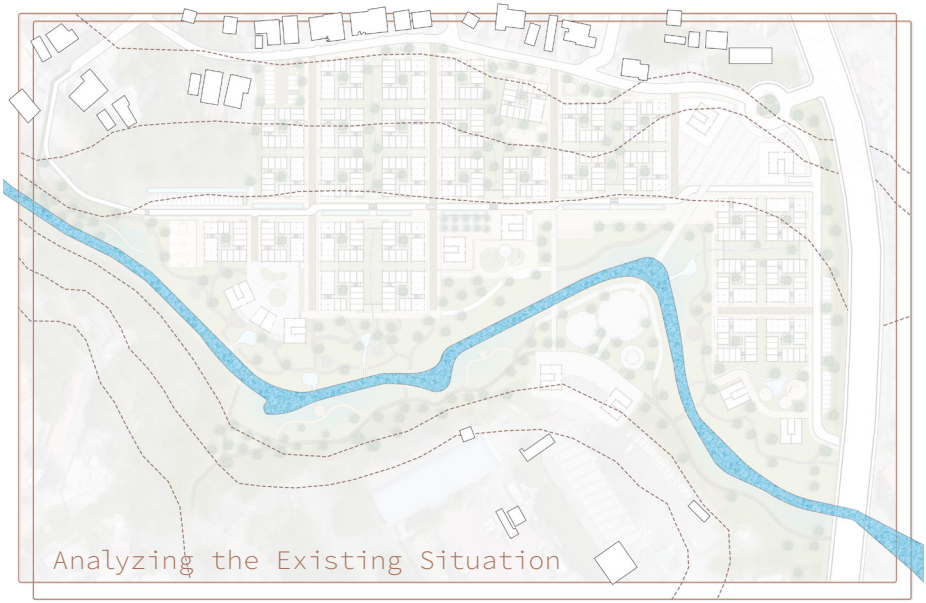


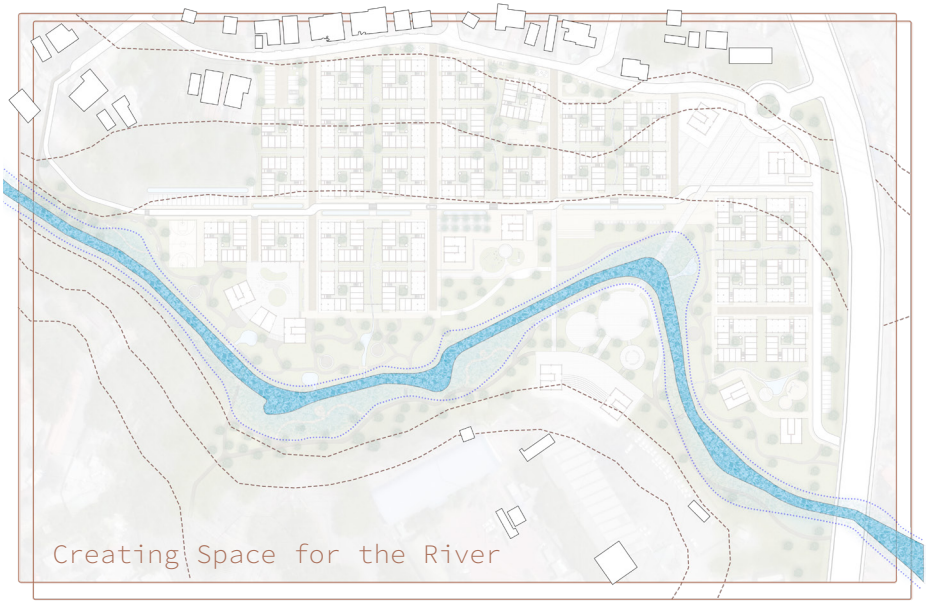
Urban Integration & Street Hierarchy

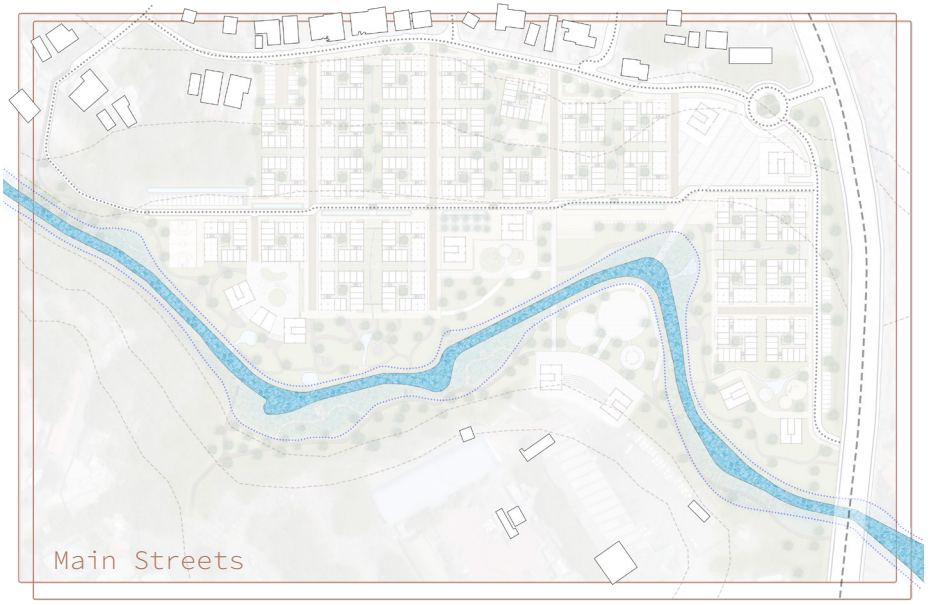


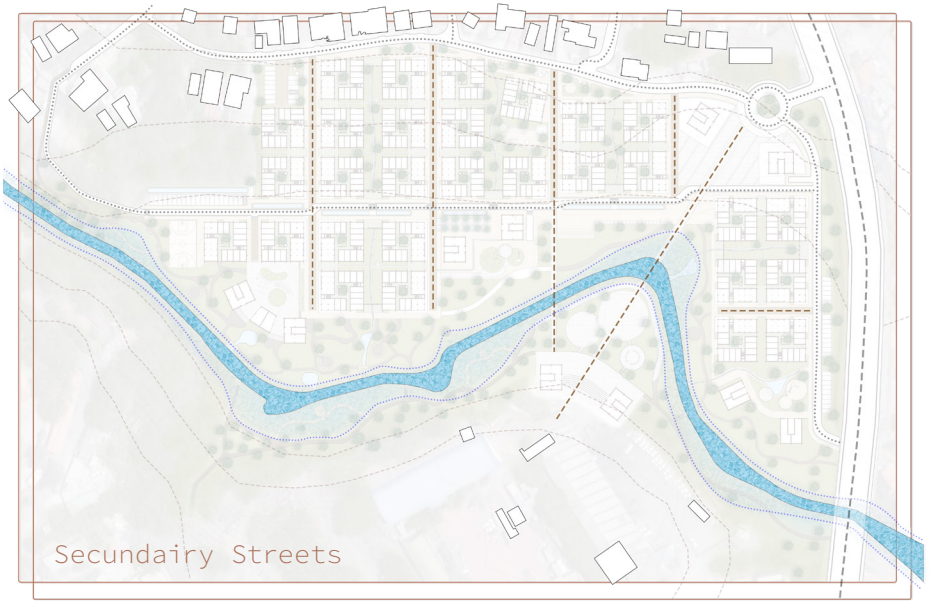
Low-Rise Courtyard Block

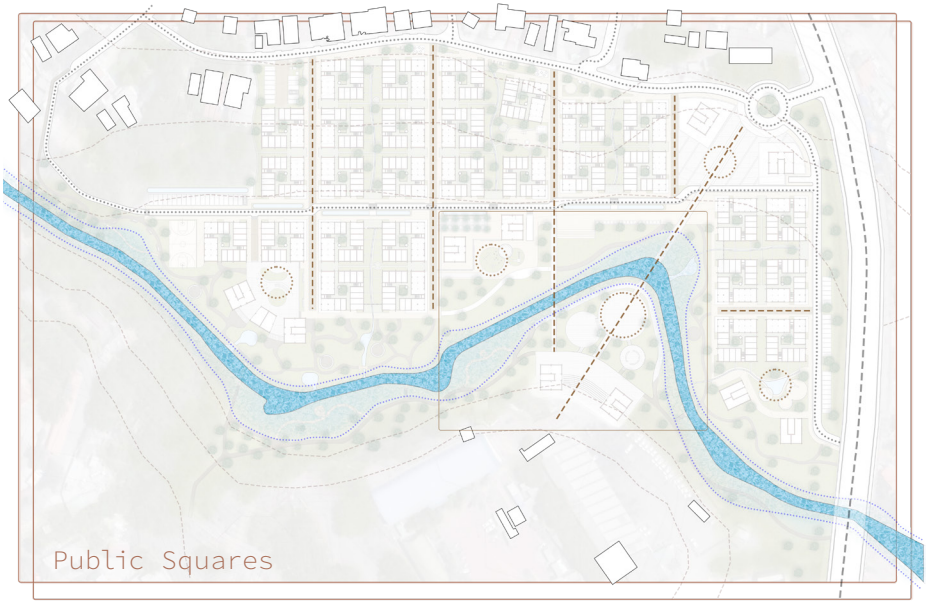
Urban Strategy; 8 Step Approach

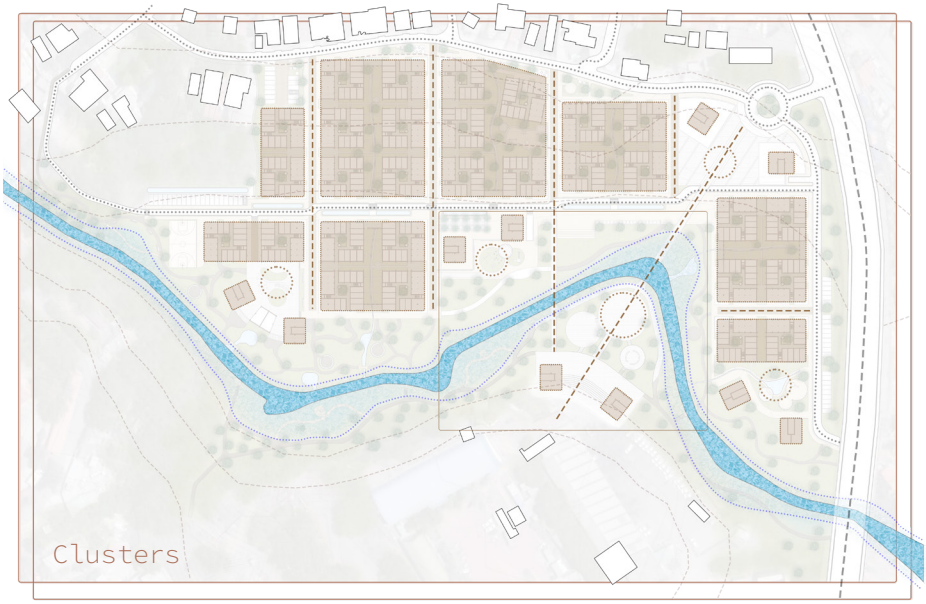


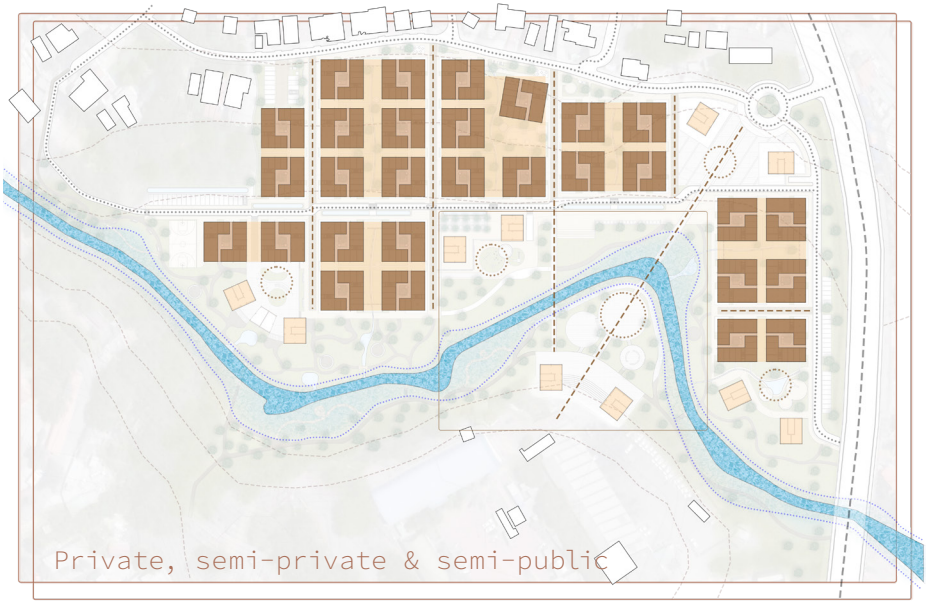


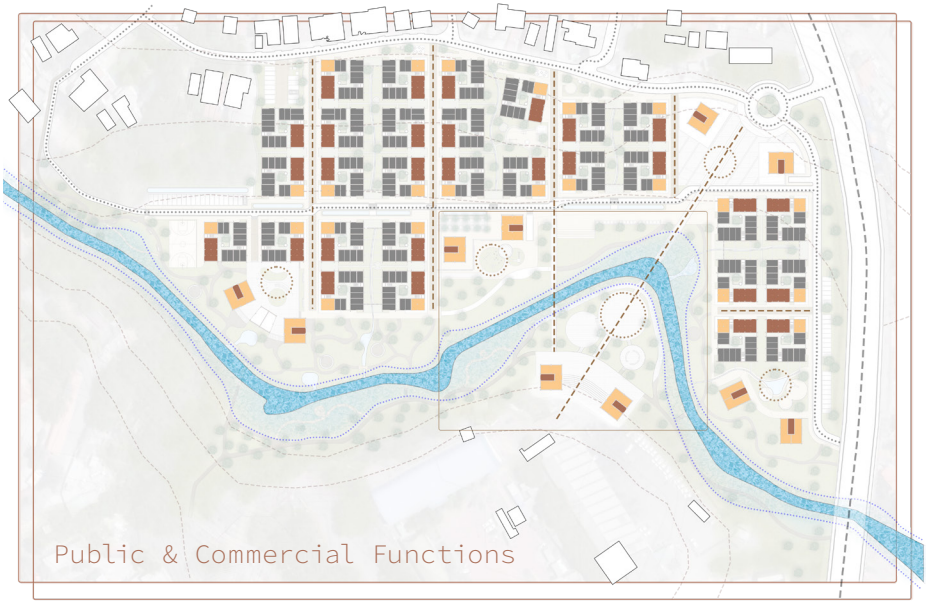

Main Streets


Secundairy Streets


Public Squares


Clusters


Private, semi-private & semi-public


Public & Commercial Functions

CHAPTER 7

Revitalized Riverbank

Introduction

The current status of the rivers have come forward already a few times in the booklet. Its existence in the city of Addis Ababa is on many locations totally neglected by the informal riverbank settlements and the rivers really became the armpit of the city, rather than one of its strengths. The informal riverbanks settlements caused various problems such as the waste dump in the rivers, the degradation of the soil and the inaccessibility of the riverbank by the public. Also, floods are becoming more and more a problem.

Annual Flood

Waste Dump & Sewerage

Inaccessibility of the Riverbank

Landslide due to Degradated Soil

Figure 7.1 Current Status of Addis Ababa Rivers

In the context of those riverbank informal settlements, water management is one of the most important topics to deal with. During the rainy season (the Kremt) often floods occur at the riverbanks. These floods have intensified the previous years since rapid urbanization has increased. The emergence of those informal settlements causes the dump of drainage & waste into the rivers, as well as creates unstable soils which can lead to riverbank erosion.

Also the rapid urbanization causes that Addis Ababa is getting a higher percentage impervious land surfaces (concrete city). Most new developments consist of concrete pavements and, also, the dense riverbank settlements are creating a surface which is impermeable for rain water. All this rain water will somehow flow to the lower points, often being the rivers. As a result of that, the rivers get overflown with water and the floods during the Kremt intensify. [28]

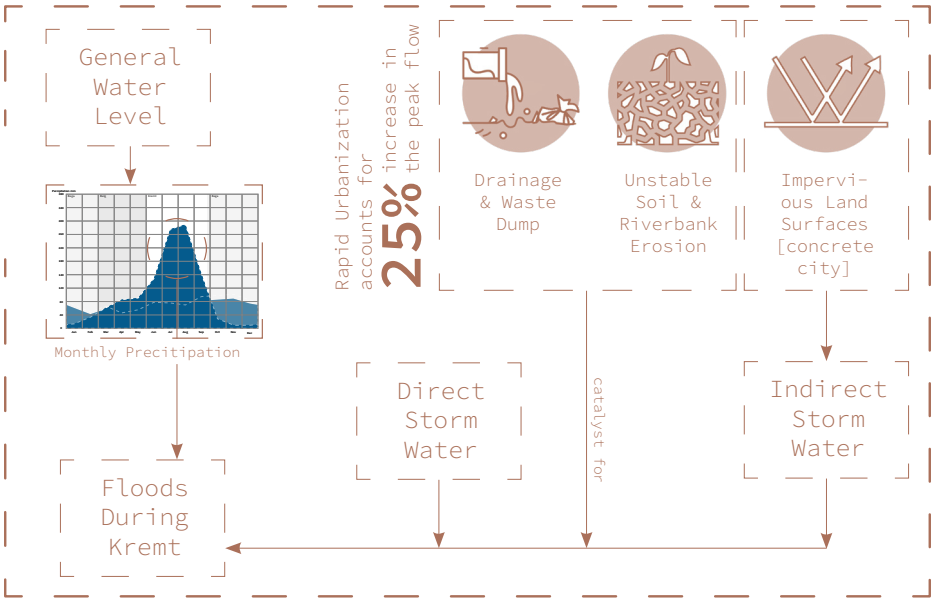


Figure 7.2 Floods Explained

Figure 7.3 The Danger of Neglecting the Rivers; Floods [29]

Vision Statement

In my vision for the revitalized riverbank, the main goal was to **give back the riverbank to the rivers**. The disturbing effect the informal settlements have on the water flow, river quality and soil quality needs to be solved in the design. By giving space to the river, you create buffer zones for the flood water and thus reduce the flood risk. Further goals where to **purify and restore the river and riverbank** and to **create an activated river landscape**.

These goals are translated into a design for the riverbank, which is already shown in the masterplan. Based on the meandering character of the river, I defined different riverbank types. The image on the right shows the places with the biggest risk for floods, based on the speed of the water in a meandering river. Further, this image shows the stream of 'Indirect Storm Water' / run-off water. The informal settlements cause an unstable soil and these streams of indirect storm water can cause landslide and also this additional run-off water causes that the river will overflow.

Both aspects have been deliberated on in the design of the masterplan (see next page). Zones with high flood risk along the river are designated as the urban wetlands. Here, more space will be given to the river. Since these zones will function as a buffer, the pressure on the other parts of the riverbank will be reduced. Here, more public functions can be placed in closer relation to the river. In the masterplan I have designed two further possible functions for those riverbanks; a 'commercial riverbank' and a 'natural riverbank'.

The run-off water flowing from the ridge towards the river is an additional and unnecessary load for the rivers capacity. The solution for this was to increase the permeability of the soil, before the run-off water could reach the river. By implementing bio-swales at the bottom of the ridge, where it flows over into the lower plateau, I created a option for the water to be buffered and infiltrate the ground. In that way, not only the pressure on the river is reduced, thus reducing the change for floods, but also

the soil will be rehabilitated since the soil will be hydrated again which makes the soil more stable and fertile.

In this way, a responsive and sustainable riverbank environment is created which faces the current problems of the riverbank. The danger for floods will be reduced and the riverbank itself can be used for functional purposes instead of being the armpit of the urban fabric. The river and riverbank will get back its ecological function and will become a vital organ within the city of Addis Ababa again.

Figure 7.4 Vision Statement Water Management & Revitalized Riverbank

A Riverbank Strategy

Figure 7.5 Different Riverbank Typologies

Urban Wetlands

On the location with higher flood potential, the outer corners of the meandering river, the design decision is made to create riparian wetland zones. Those zones have the function to cleans the water, naturally filter pollution from the river and function as a flood buffer for the river during the rainy season. [30]

An analysis on indigenous vegetation types of Addis Ababa, showed that certain types are good to grow in the wetlands. Those plants function as a purifier of the water, filtering out plastic- as well as other pollution in the rivers. [31]

At the same time, the cleaning of all this pollution that will be collected in those wetlands can create job opportunities for the community, while also, step by step, fight the pollution of Addis Ababa's water bodies.

During the rainy season, those urban wetlands will function as a water-buffer and in that way the floods will happen more regulated and on areas where it won't harm the dwelling landscape.

"Elevated trails above the wetlands will be proposed along the river, to cater for an active and functional landscape."

Figure 7.6 Artist Impression of Urban Wetlands

Indigenous Vegetation Types _ Wetland

- Searsia pendulina
- Kniphofia
- Phygelius aequalis
- Eragrostis capensis

Commercial Riverbank

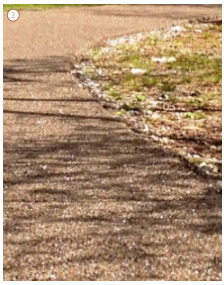
Since the urban wetlands reduce the pressure on other places of the riverbank, these riverbanks can be designed using different riverbank typologies. For instance, around the public squares (see *chapter 9 - Public Squares & Towers*), I created a more urban riverbank. Here, the paved squares reach closer to the riverbank and public functions are placed in close relation with the river-landscape. The site really becomes a place that caters for both formal as well as informal job opportunities, creates places for relaxation or can create places where people can sport or play, in short; really a commercial riverbank.

Since those places will have a more urban character, they will have a higher percentage of pavement. To accommodate the problems of impervious land, higher quality permeable pavements are chosen that address those issues. Projects such as the just build 'Sheger Park' in Addis Ababa, which makes use of such materials, show the willingness of the municipality of Addis Ababa to invest in such materials and spaces.

"The site becomes a place that creates formal & informal job opportunities; a landscape where people can shop, play & relax."

Figure 7.7 Artist Impression of Commercial Riverbank

Pavement Types



① Decorative Pervious Concrete
② Natural Rock Pavers
③ Gravel Lok Pavement

Natural Riverbank

Another riverbank typology that fits in the context of the chosen site in the centre of Addis Ababa is the typology of a more natural riverbank. On the locations of the riverbank which are in closer relation with the dwelling landscape, the riverbank is designed more naturally with pedestrian paths, seating places and more open greenery.

These public opens spaces cater for more spontaneous programs and increase the accessibility of urban green infrastructure in the city of Addis Ababa. Currently, the cities park per capita, a measurement to determine the amount of urban green infrastructure per person, is only 0.37 m^2, where the standard of Ethiopia is 15 m^2. Also, only for about 10% of the inhabitants of Addis Ababa, the urban green infrastructures are within the minimum walking distance thresholds. By creating long-stretched urban green riverbank infrastructure, a step to the solution to solve this lack of accessibility of urban green infrastructure can be made. [32]

“Public open spaces are provided along the river-bank to cater for spontaneous programs and usage.”

Figure 7.8 Artist Impression of Natural Riverbank

Indiginous Vegetation Types _ Riverbank

① Bamboo
② Acacia Tree
③ Giant Lobelias
④ Eucalyptus tree

The River as a Shared Resource

With all those different riverbank typologies, the river and riverbank gain the ability to accommodate different types of activities. The “greener” riverbank typologies such as the ‘urban wetlands’ and the ‘natural riverbank’ cater more for leisure and residential purposes. This while the ‘commercial riverbank’, as the name already suggests, caters more for economic activities.

This potential of the river and riverbank to cater for different types of activities makes this strategy very feasible and appropriate within the context of Addis Ababa and **makes it easier to implement the riverbank strategy as a piece of the urban infrastructure**.

Depending on specific urban locations and the needs that come with this location, the riverbank strategy can be continued along the whole river, creating a sequence of spaces and functions interconnected by the ongoing revitalized riverbank. In that way, the riverbank really becomes part of the urban infrastructure and the river can function as a shared resource accessible for everyone and from everywhere. ‘Figure 7.9’ shows a sequence of the graphic anatomy [‘The Story of Kofi Tadesse’] in which is shown how the riverbank and river is used by one of the characters, the 8-year old son of the family.

After School, *Yonas* and his friends often play outside. Sometimes they play at one of the playgrounds in the neighbourhood.

More often, they play at the riverbank. Here they have a lot of open space to play football. The trees function as the goals of their field.

Since the rivers are much cleaner now, they also often go for a swim, especially in the summer when it is to hot to play football.

19

Figure 7.9 The River as a Shared Resource

Future Development

Within the Masterplan, the chosen riverbank typologies are based on the needs of a location within the city centre of Addis Ababa. Where in the inner city the riverbank activities should be more oriented on urban functions (park landscape, commercial landscape, etc.), this riverbank strategy also gives space to implement other riverbank typologies at for instance the urban periphery. These locations have more open space, are more rural, and thus possible riverbank typologies can relate to a more productive dynamic landscape; a landscape where for instance agriculture or bamboo farming can happen in coherence with a new dwelling landscape.

Figure 7.10 Future Development along the Bulbula River

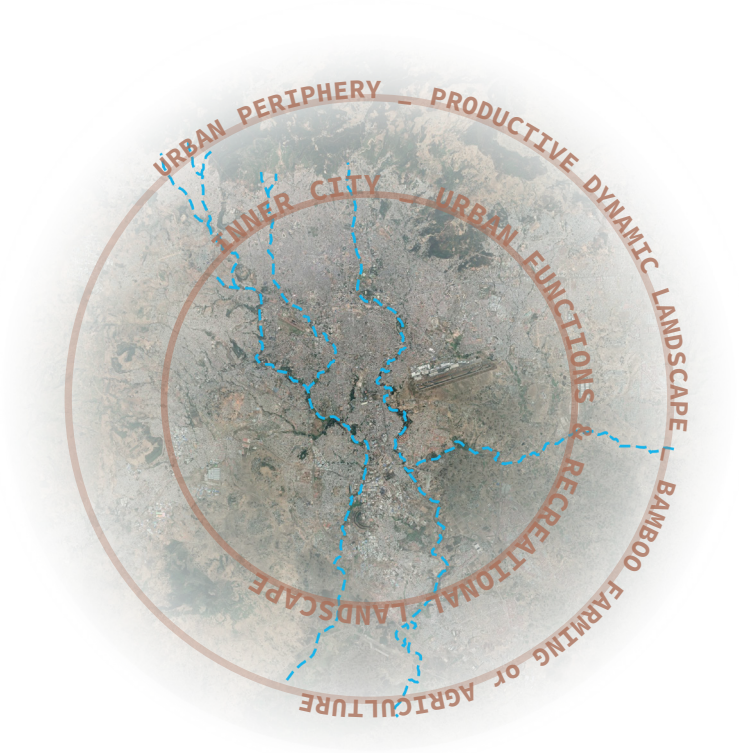


Figure 7.11 Shifting Riverbank Typologies Depending on Context

One of the possible riverbank typologies suggested on the previous page is 'bamboo farming'. Initially my idea was to implement a bamboo economy in my design. However, after deliberation and careful consideration of the needs and possibilities of the exact location of the site I have chosen to let this subject go.

Nevertheless, investing in such an economy and thus going along with ethiopia's ambitions can be interesting when the riverbank strategy is planned on the periphery of the city, where there will be more space for space consuming functions such as a bamboo farming.

Bamboo is known for its many different species. Some are suitable for structural appliance, while other species are weaker and thus, in natural form, can't be used in the building industry. The species that grows in Addis Ababa is Y. Alpina. In natural form, this species is not strong enough to use for multi-storey construction. In applied form (f.i. laminated bamboo lumber) it can be a suitable building material. Nevertheless, at the moment, the building industry of Ethiopia does not yet have the knowledge and the forces to create these stronger bamboo appliance on a bigger scale. [33]

Therefore, the 'Environment, Forest & Climate Change Commission of Ethiopia' [EFCCCE] composed the '2019 - 2030 Ethiopian Bamboo Development Strategy and Action Plan". In this strategy and action plan the ambitions with the appliance of bamboo on a bigger scale have been spoken out. Highly summarized, the strategy and action plan aims:

"to add higher value to Ethiopian's bamboo products, improve degraded land and contribute to attain Ethiopia's landscape restoration targets, attract investment increase Ethiopia's exports and reduce volume of wood product imports, create decent jobs and enhance Ethiopia's climate change adaptation and mitigation capabilities." (p. 5). 34

Related to my project, the application of bamboo can have several advantages. First of all, the crop, while being harvested, can be used to stabalize the deteriorated riverbanks. The harvest every three to five years will form a solid economical opportunity for the neighborhood. Investing on a bamboo knowledge base in these neighborhoods will create knowledge about the application of bamboo for structural appliance and there is demand for this type of market in Addis Ababa.

Further, the crop itself is very sustainable and can in the beginning (when the knowledge is not yey there) be used for smaller scale appliance, such as creation of furniture or infill walls. Applicance in this smaller scale will already create craftmanship in the neighborhood and gives all the necessary experience in the field of application of a very sustainable and future-proof material.

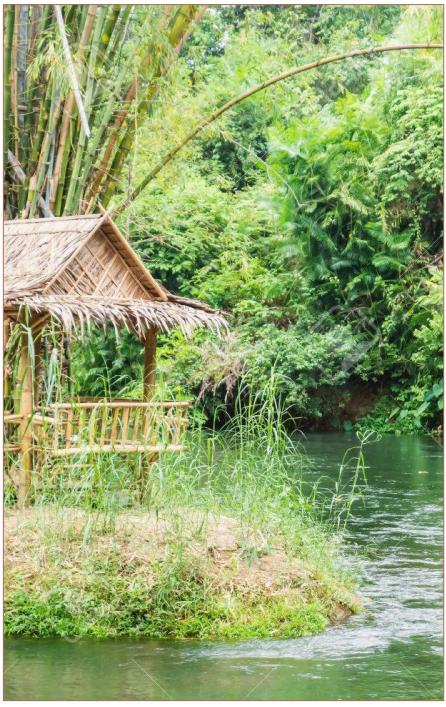


Figure 7.12 2019 Ethiopian Bamboo Development Strategy and Action Plan

Bio-Swales

In the vision statement for the revitalized riverbank, also the application of bio-swales have been mentioned. Eventhough these bio-swales are placed a bit further from the riverbank, the impact they have on the river is very important.

The bio-swales have as goal to reduce pressure on the rivers and thereby reduce the chance on floods by infiltrating the run-off water in the ground, instead of letting it flow into the river. A sollution to this goal is integrated in the design by creating those bio-swales at the bottom of the ridge. The run-off water that will go down the ridge will be collected at the bioswales, that at the same time function as an beautification of the main street by creating a green zone. Again, the water-management approach has not only the benefits related to the water-issue but will also have benefits for a better neighborhood.

The principle of the bio-swales is relatively easy. The run-off water is led into the bioswales via above-ground gutters / ditches. The bio-swale itself is then a bigger ditch in which vegetation can grow, thus improving the urban green structures and adding biodiversity to the neighborhood. The bottom of the bio-swale is porous and makes sure that the run-off water can infiltrate the ground. A heavy stormfall is estimated that it needs around 24 hours to fully infiltrate the ground. In the case of overflow, this residu of the water can be lead towards the wetlands through permeable gutters, thus further infiltrating the ground before it finally reaches the river. [35]

Figure 7.13 Artist Impression of Main Road with Bio-Swales

Figure 7.14 Picture of Bio-Swale in Urban Context [Hannover, Germany]

CHAPTER 8

Urban Integration & Street Hierarchy

Introduction

As stated in the urban strategy, one of the goals in my design was to remove the barriers between the existing urban fabric and the new riverbank neighbourhood. These barriers are formed by the informal riverbank settlements that, with their close knit street-scape, results in a fractured city consisting of different neighbourhoods with almost no connection between them. The orientation and placement of the streets can have a major impact on how to integrate the Bulbula river into the urban fabric.

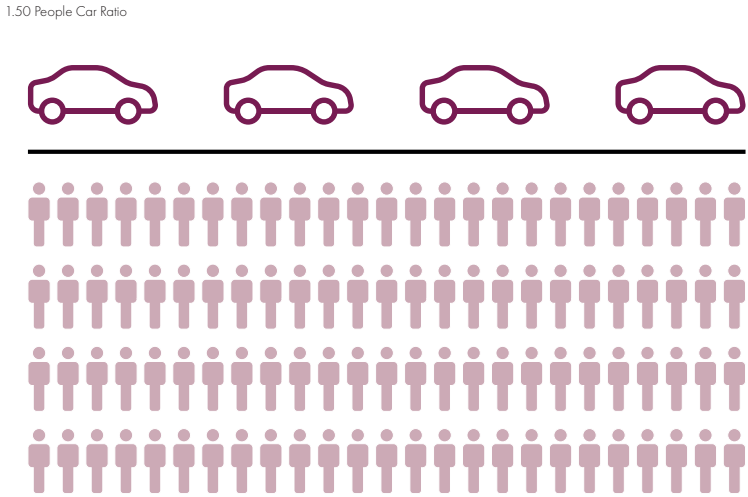
*Not exact location but clear representation of close knit streetscape of informal settlements

Figure 8.1 Existing Urban Streetscape of Addis Ababa

Modes of Transport in Addis Ababa

In order to specify the need for different types of road in my masterplan, I looked back at the group research on the modes of transport (*see 'Addis Ababa as a Palimpsest', chapter 'Facts and Figures'*). It showed that more than 50% of all transport is by foot, then around 30 percent is by smaller or bigger buses and only 15% of all transport is by car.

Thus, therefore the focus in my design is on the pedestrian activity as well as improving the accessibility of the neighbourhood by bus, thus bettering the connection of the neighbourhood with the city.



58

Figure 8.2 People vs. Car - ratio [11]

1.51 Models of Transport in Addis Ababa (Share of All Trips)

59

Figure 8.3 Modes of Transport in Addis Ababa [36]

Street Hierarchy

The street hierarchy within the masterplan consists of 3 “ranks”. First, we can identify the main road, located at where the current main road of the informal riverbank settlements also is. The entrance to the neighbourhood connects to the main road, and is emphasized by placing a round about right at the start. The traffic will be distributed from here to reduce traffic in the neighbourhood, and also a transit hub with bus stops or taxi stands is located at the roundabout to create an easily accessible neighbourhood and riverbank for everybody.

The second step in the street hierarchy are the secondary streets. Those streets are pedestrian roads with activated plinth for commercial activities that connect the new neighbourhood with the existing urban fabric.

The third “rank” in the street hierarchy are the green lanes. Those green lanes are places in between the building clusters. Thus, bettering the connection between the dwelling landscape and the riverbank landscape. Those green lanes play a major role in the water management of the neighbourhood. Further, these green lanes emphasize the communal inhabitation patterns of the cityness of the informal riverbank settlements, catering for communal activities such as small scale food cultivation, space for preparing food.

Main Road
The Solid Backbone

Secondary Road
Integrating the Existing
Urban Fabric

Green Lanes
Connecting the Dwelling
Landscape and Riverbank

STREET HIERARCHY

Figure 8.4 Street Hierarchy in 3 “ranks”

A Solid Backbone; the Main Road

The location of the main road is logically places at the point where the ridge flows over in the lower plateau. The initial main road of the current informal riverbank settlement is located at the same place. The main street functions as a solid backbone of the masterplan and is the only road accessible by cars.

Since I tried to reduce the traffic within the neighbourhood, I designed the main road as a single one-direction lane. To emphasize the street as this solid backbone of the neighbourhood, I created a wide street profile on which the focus mostly is on pedestrian activity. The plinths of the main street offers an activated urban realm on both sides of the street, thus allowing a commercially and socially activated street.

Further, the road is greened by implementing bio-swales on one side of the car-drive way. The function of these bio-swales is already mentioned in “Bio-Swales” on page 82.

Figure 8.5 Artist Impression of Main Road

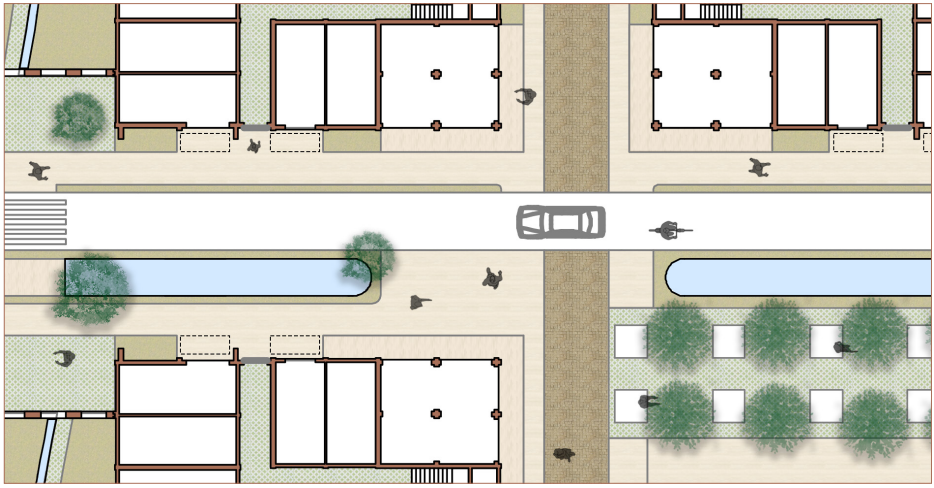


Figure 8.6 Segment of Main Road

Integrating the Existing Urban Fabric; the Secondary Streets

The main road creates an orthogonal grid with the secondary roads, in my design I called them the retail streets. Those streets walk perpendicular to the river and, thus, integrate and open up the riverbank to the existing urban fabric.

Those retail streets are focused on pedestrian activity. However, the width of the street is based on the width needed for emergency vehicles to be possible to enter the street (min. 3.5 m), based on the Dutch norms stated in 'het bouwbesluit'. [37]

Since one of the goals in the design for those streets was to create a feeling similar to the traditional informal retail streets in the sefer, I wanted to create a higher perceived density, and thus keep the street profile relatively narrow and shaded. This street profile reflects to the current cityness of Addis Ababa and offers perfect opportunities for the inhabitants to set up their own informal retail shop from out their own building block.

The building blocks that face those streets have their more public spaces / store fronts oriented towards these retail streets to further emphasize this informally activated public streets. Also, those small shops / restaurants / café's / etc. create attraction points for the public to enter the neighbourhood and proceed their stroll towards the revitalized riverbank.

Figure 8.7 Artist Impression of Secondary Street

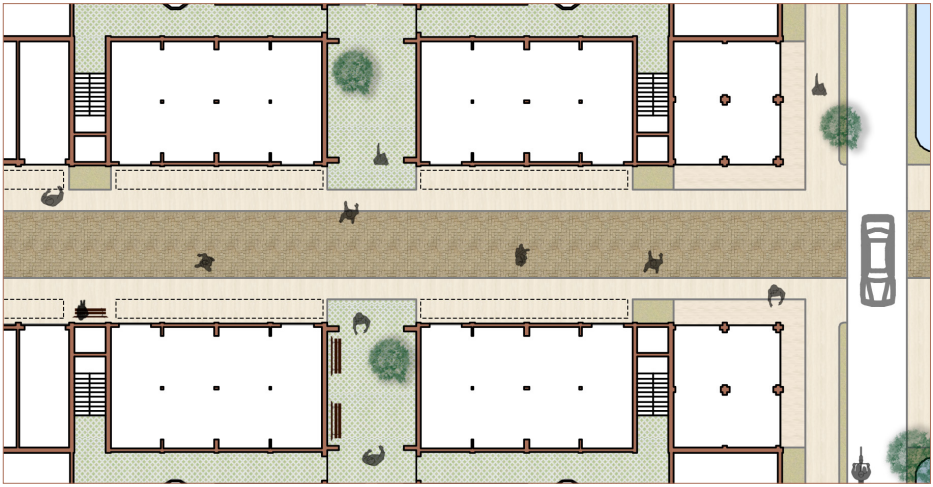


Figure 8.8 Segment of Secondary Street

Green Lanes Urbanely Integrating the Riverbank

As said before, the third “rank” in the street hierarchy are the green lanes in-between the building blocks. Those green lanes connect the riverbank with the building block clusters and thus interfere the riverbank landscape with the dwelling landscape.

The low-rise courtyard blocks are all connected with these green lanes. The dwellings are oriented towards this in between zone and the green lanes, thus, accommodate space for collective green gardens or other communal functions. In that sense, they form the transition from the pure public streets towards the pure private building blocks; a in-between space used and activated by the community.

Apart from this function, the green lanes are integrated in the water management system of the low-rise courtyard block. A broader explanation on how the water management system is implemented in the design of the green lanes can be found in “Chapter 12 - Sustainability; Water Management”.

Figure 8.9 Artist Impression of Green Lane

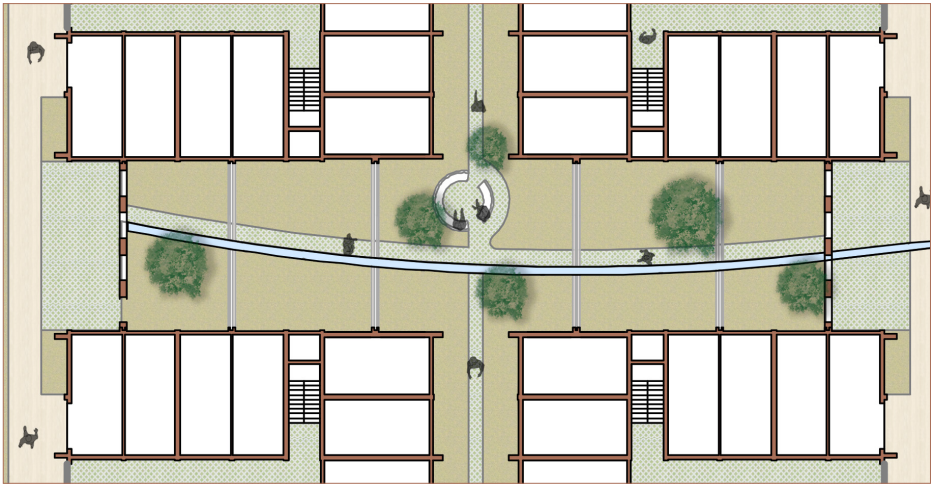


Figure 8.10 Segment of Green Lane

Residual Spaces

The existing urban fabric consists of a very irregular shape, shaped by previous spontaneous city development as well as by the meandering stream of the river. This is in contrast with the urban form of the designed master plan; an orthogonal grid. Implementing and combining those two types of urban fabric causes that along the “edges” of the neighbourhood residual spaces will form, left-over pieces of the urban fabric.

These residual spaces have, since the start of implementing master plans into existing urban situations, been an important topic in city planning. Literature and theories referred in different ways to those residual spaces, see ‘figure 8.13’. Often, these definitions and descriptions gave a negative assumption about those spaces [dead zones / cracks in the city / lost spaces / terrain vague]. This mainly has to do with how these residual spaces will developed when there is no clear strategy for the space. They are often modified by either formal bodies or informally by users.

The last will probably be the case in Addis Ababa when these spaces are left without any maintenance. They will be overlooked for a long time and can turn into negative spaces or spaces that will be fully built with informal settlements. [38]

To make sure that this emerging of informal settlement or emerging of neglected spaces won’t happen, it is very important to create a clear strategy for those residual spaces. A strategy that can comprehend multiple solutions and can deal with different shapes and sizes of those residual spaces.

Term Used by Theorist	Year	Theorist
Lost spaces	1983	Trancik
Found spaces	1986	Rivlin
Terrain vague	1995	Morallis
Cracks in the city	1996	Loukaitou-Sideris
Intermediate spaces	2005	Groth & Corjin
Sites out of sight	2005	Crisman
Loose spaces	2007	Stvens
Dead zone/ edge	2007	Doron
Leftover spaces	2009	Alanyali
Residual/ Neglected	2010	Carmona
Fortui-tous leftovers	2010	Akkerman & Cornfeld
Vacant urban land	2011	Kamvasinou

Figure 8.11 Definitions and Descriptions of Residual spaces [13]

In the master plan, two types of residual spaces can be found; ‘residual spaces near the existing urban fabric’ and ‘residual spaces near the river’. Both situation requires different approaches.

Residual Spaces near the Existing Urban Fabric

These spaces emerge on the locations where the orthogonal grid of the proposed masterplan meets the spontaneously formed existing urban fabric. There are different ways how there can be reacted to these circumstances. ‘Figure 8.14’ shows two different examples of how these residual spaces can be designed.

The first example is finding the solution in adapting the building blocks orientation (1), so that the building block allignes with the existing urban fabric. This shift in orientation creates space around the building block that by its shape are designated as more public attractive areas. However, such a change in orientation can be space consuming and can also have an adverse effect and create more residual spaces.

This would for instance happen, when I changed the orientation of the building block on the right side of the street. Therefore, I designed a different strategy for that residual space. (2) Here, I chose for an approach in which you give the residual space itself a distinctive function without really changing its surroundings. By placing a seating element, planing fixtures and places for trash bins I filled in the residual space with functions that activate the specific location within the masterplan.

Exemplary Situation 1

Boundaries: Spontaneously Formed Existing Urban Fabric
& Orthogonal Grid of New Masterplan

Potentials: (1) Adapting the Building Blocks Orientation
(2) Assigning Clear Functions to the Residual Space

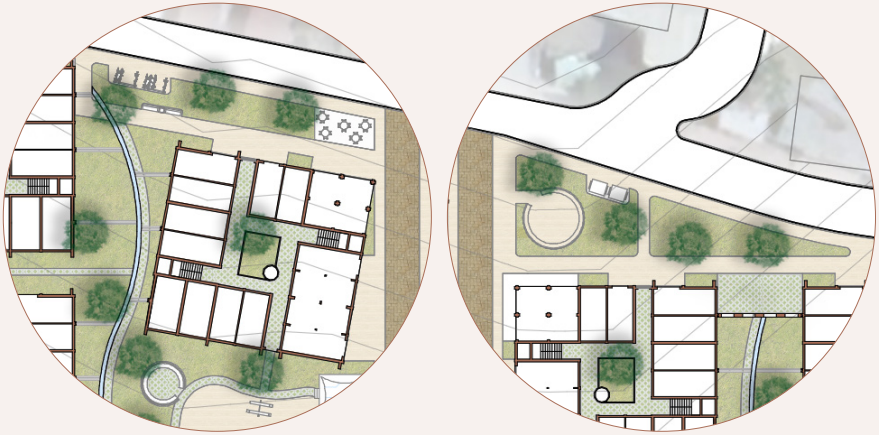


Figure 8.12 Residual Space near the Existing Urban Fabric

Residual Spaces near the River

The second type of residual spaces that can be found in the masterplan are the residual space near the riverbank. Those spaces are situated along the riverbank where they do not actively be a part of the dwelling landscape. To reduce this effect and to integrate those residual spaces with the dwelling landscape, I searched for functions that could connect those functions.

As the 'Exemplary Situation 2' shows, this piece of land was to small to further implement the dwelling typology on it, therefore, a residual space emerged. This space has been activated in the design by for instance placing an urban wetland that uses a pedestrian road to connect different dwelling landscapes and by placing a sports court that is in the vicinity of the school which can make use of it, thus activating the whole area by giving functions to this residual space that relate to the dwelling landscape and attract the people to also use and maintain the residual space.

Exemplary Situation 2

Boundaries: Meandering River, Main Infrastructure
& Orthogonal Grid of New Masterplan

Potentials: (1) Assign Functions that Retlate to Dwelling Landscape, such as Sports Facilities.
(2) Create Residential Riverbank Zones

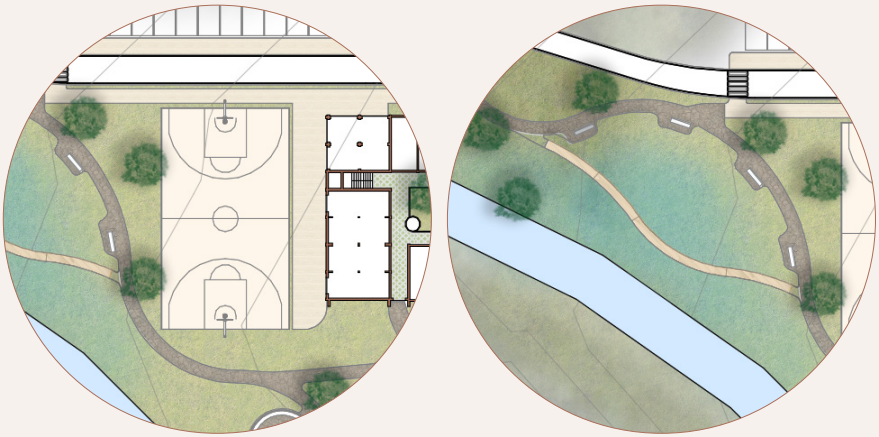


Figure 8.13 Residual Space near the River

CHAPTER 9

Public Squares & Towers

In the master plan, the public squares and towers have been placed along the riverbank. The development of those “special zones” functions as **an anchor for the development of an inclusive community** in my masterplan. The public squares and towers cater for the public and need to create an inviting and nice environment along the riverbanks. This is done by creating a landscape in and around the towers with functions that cater for the public.

The squares and towers are strategically chosen along the riverbank and next to the axis’s of the retail streets. (see ‘figure 9.2’) Based on its location within the masterplan, different public functions can be given to the plinth of the towers. The higher floors of the tower accommodate for medium- to higher income dwellings.

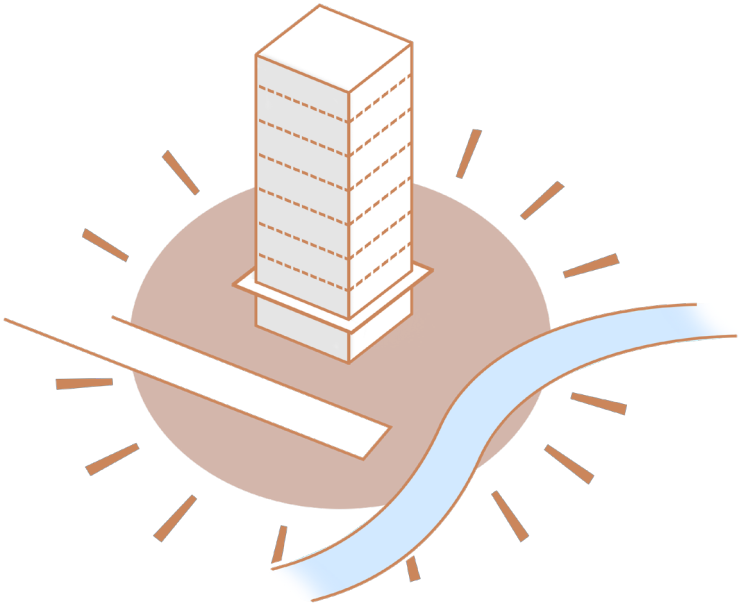


Figure 9.1 Vision Statement Public Squares & Towers

Figure 9.2 Chosen Locations for the Public Squares & Towers

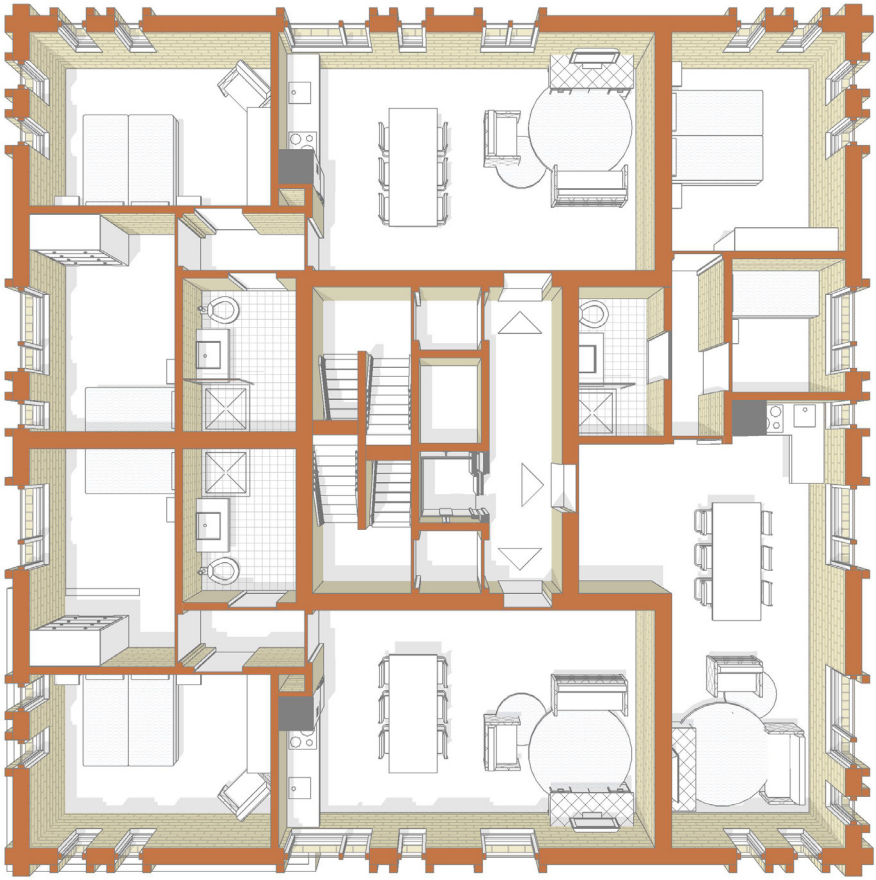
Floor Plans

The public squares and towers accommodate on the higher floors dwelling units with a floor area varying from 60 to 90 m^2, see the next pages. The target groups for those dwellings are the middle- to higher income segment. In the managerial strategy, these middle- to higher income towers are needed to cross subsidize for the lower income low-rise courtyard blocks (see “Operation; Cross-Subsidization” on page 206).

After deciding what target group is aimed at for the design of the towers, I started thinking about the amenities that where linked to these target groups. Research showed that most middle- to higher income people in the city of Addis Ababa are owner of a car. Thus, for them, the need exists to park close by there dwelling. Therefore, the public squares and towers cater for semi-underground parking which is in direct connection with the towers. At the same time, this semi-underground parking lot also creates a platform (the square) that creates safety from the annual floods.

This platform created by the parking lot functions as the public square. Connected on those public squares are the public plinths of the towers. On the following pages you will read how these plinths play a major role in the architectural definition of the public squares and towers.

Figure 9.3 Tower-Typology [Scale 1:200]



2-Bedroom Apartment

Floor Area: 60 M²

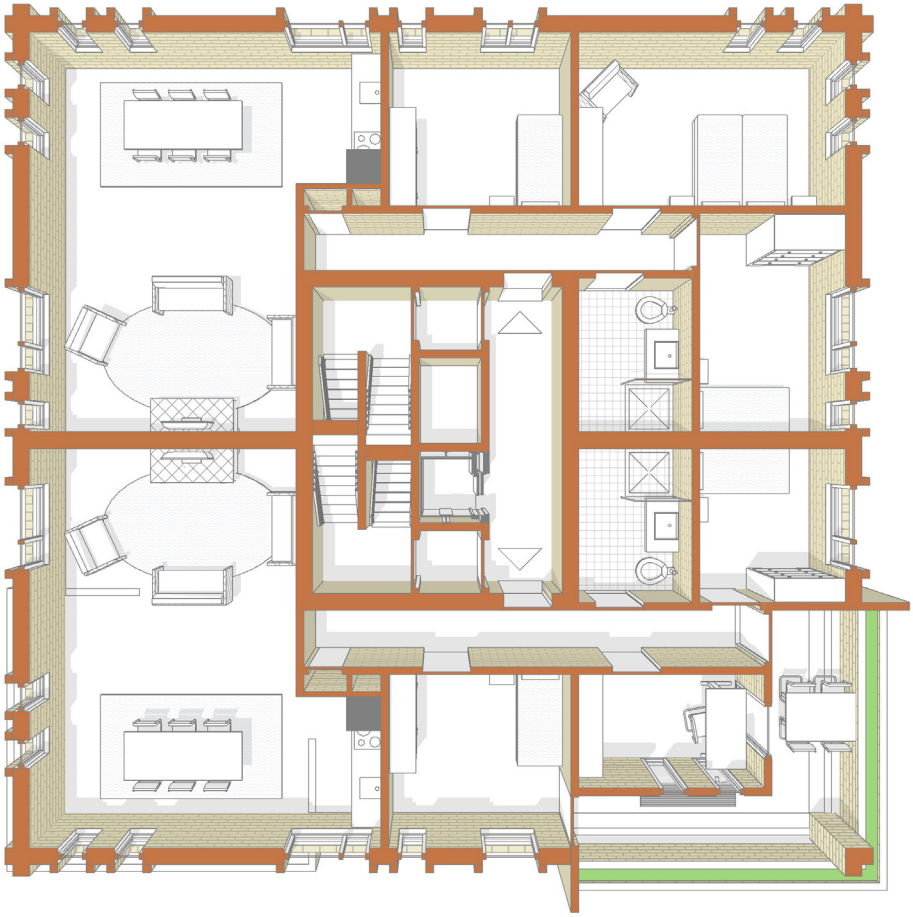
Income Group: MIDDLE- TO HIGHER INCOME

Payment: OWNERSHIP

① Corridor
② Living Room
③ Kitchen Area
④ Bathroom
⑤ Master Bedroom
⑥ Bedroom 2

Figure 9.4 Dwelling Floor with 3-Bedroom Apartments in Tower

Figure 9.5 Typical Floor Plan 3-Bedroom Apartment in Tower [Scale 1:100]



3-Bedroom Apartment

Floor Area: 90 M²

Income Group: MIDDLE- TO HIGHER INCOME

Payment: OWNERSHIP

① Corridor
② Hallway
③ Living Room
④ Kitchen Area
⑤ Bathroom
⑥ Master Bedroom
⑦ Bedroom 2
⑧ Bedroom 3

Figure 9.6 Dwelling Floor with 3-Bedroom Apartments in Tower

Figure 9.7 Typical Floor Plan 3-Bedroom Apartment in Tower [Scale 1:100]

Architectural Definition

The public squares and towers function as an anchor for the development of an inclusive community in my masterplan. Thus, the architectural definition of those “special zones” is of great importance to emphasize this effect.

Materiality

The materiality concept of the squares is already elaborated on in the section “Commercial Riverbank” on page 72. Here, I talked about how I made a choice for sustainable pavement types, pavement types that adapt to the current problems of impervious land. Those pavement types also create a certain atmosphere around the towers. A higher percentage of pavement suggest a differentiation of function in comparison with the greener riverbanks zones; a more publicly activated function. Thus, the landscaping is part of the architectural definition of those public squares.

As well as the materiality of the pavement, I made some design decisions regarding the materiality of the towers. The same materiality concept is used as the concept for the low-rise courtyard blocks. The usage of compressed earth blocks makes the buildings perfectly blend into the context of Addis Ababa. In contrast to the low-rise courtyard blocks, the towers have big balconies with “hanging gardens”, giving the towers an extinctive appearance while emphasizing it’s location within the new green zones of Addis Ababa.

Connection with the Ground

Special emphasis in the design of the tower is given on the foot of the building; the public plinth. The plinth of the building is where the urban realm connects with the building. It needs to show what happens inside the building and needs to attract people to those specific locations. Therefore, I designed the plinth very transparent and open for the public. Public functions can be placed in the plinth to further emphasize the anchor-effect of the tower.

Figure 9.8 Architectural Definition Tower-Typology [Scale 1:200]

A Stamp or a Type Form?

The basic concept of the public squares and towers is for every public square and tower the same. In that sense, the design for those zones can be seen as a stamp that spreads around the masterplan. However, the concept of the towers is better described as a type-form; a building typology that is open for substitutions and variations.

The architectural definition can vary per tower. Based on its location within the masterplan, the tower can adapt its appearance to this situation. So can the orientation of the tower change depending on it's location in relation with the river. The plinth can be made more public (transparent) or private (closed) depending on the need of that specific spot within the masterplan. The tower can be build higher (commercial zones) or lower (communal zones) to create emphasis whether you want to. And so on. The architectural definition, however, will stay the same in all of these circumstances, but the feeling of the space will change due to different perceived densities, different public functions, and so on.

On the following page, two different "designs" of the tower typology are shown. The first design is located on a more "communal location" within the masterplan, while the second design is located on the most central spot of the masterplan. By, for instance, making the plinth two-storeys high, the type-form creates the possibility to make the building much more open to the public.

For each tower in the masterplan I have looked which location specific needs where valuable for the design of the tower. The height, the plinth, and so on have been based on these needs. On the following pages, these different "special zones" within the masterplan have been elaborated on. In the masterplan, 3 different typologies of public squares and towers can be find; the "central district", the "school tower" and the "dwelling tower".

Figure 9.9 Flexibility of the Type-Form Tower

The “Central District”

The masterplan consists, in total, of five different “special zones”; public squares and towers. For each of those “special zones” a study is done on which functions could have the best purpose on each location. The three squares and six towers, indicated in ‘figure 9.11’, form the central district of the neighbourhood, based on the axis and connections to the urban fabric.

Those public squares and towers are in direct connection with the entrance to the neighbourhood and to the Rwanda street. Current pictures of Google Earth showed that street vendors started to set up their shops along the current entrance of the neighbourhood, see ‘figure 9.10’. The squares need to give space for these street vendors to create a secure and central location for them to sell their goods.

Further, this public entrance to the neighbourhood which flows seamlessly over into the “central district” along the riverbank activates the whole neighbourhood. The plinths of the towers will cater for formal businesses that can rent parts of the building while the public squares around the towers cater for the street vendors and thus informal businesses. Thus, these public squares and towers caters for both the informal as the formal business. This is important since both are virtues of the city’s economy and socio economic climate. Both the formal as well as the informal can co-create the space.

Architectural Definition

Since these squares and towers need to emphasize their central location within the masterplan, and thus their importance for the neighbourhood, the architectural definition of the “special zones” emphasize this. Those towers are designed the highest, varying from 8 to 12 floors. Also, the public plinth reaches the 2 floors, thus really showing it’s public character.

Figure 9.10 Emerging of Street Vendors along the Entry at Rwanda Street

Figure 9.11 The “Central District”

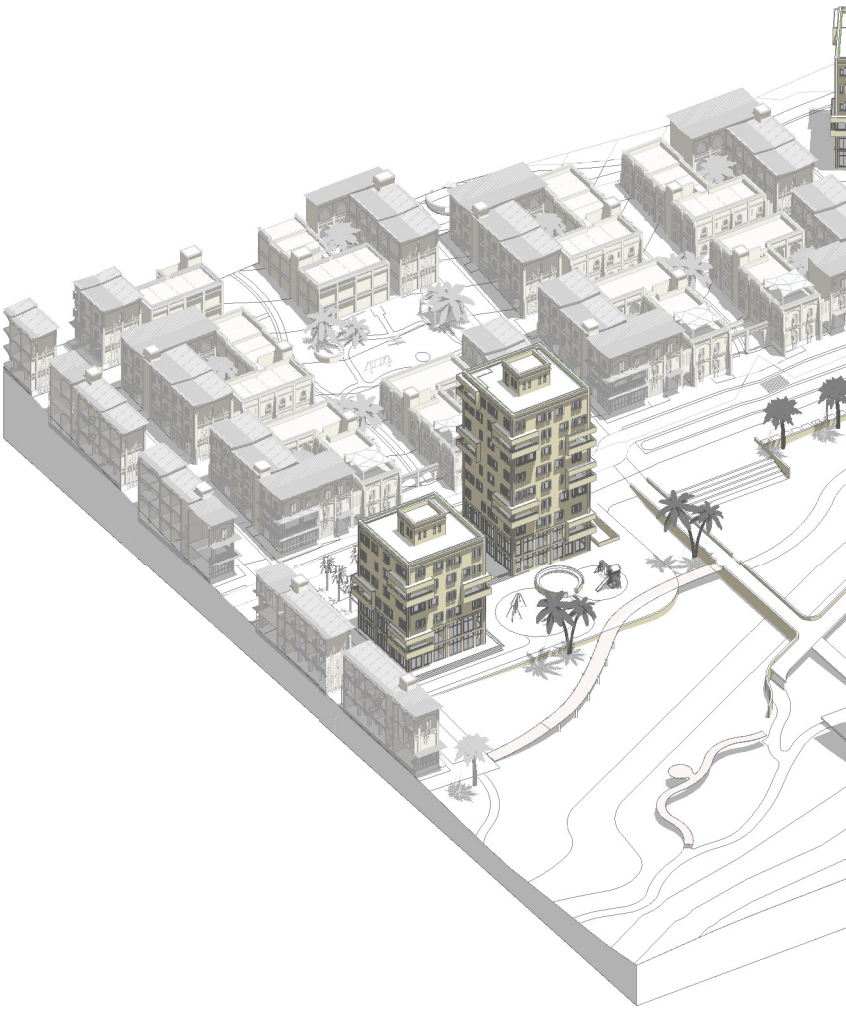
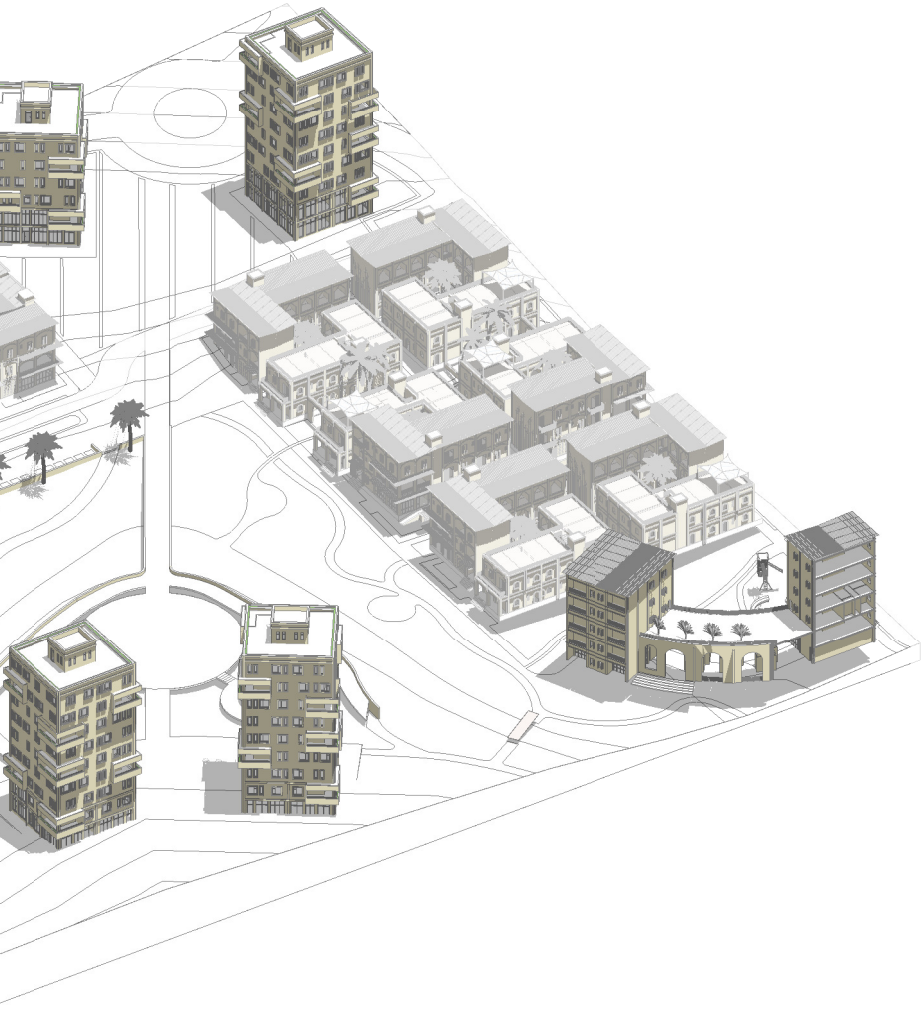


Figure 9.12 Architectural Definition of Central District [Scale 1:1250]



The “School Tower”

Located at the bottom left of the masterplan, see ‘figure 9.13’, the square and tower have been designated as a “school function”. The design decision to place a school function in these towers is based on its location within the masterplan, deep in the neighbourhood, enclosed by the low-rise courtyard blocks. This enclosed character fits the purpose of a school, where the pupils need to play and learn in a safe enclosed environment.

It’s location along the riverbank gives the opportunities to use the riverbank for interactive lessons, such as food cultivation practices or studying the urban wetlands. In this way, people learn from a very young age what the value of such an important eco system as a river and riverbank landscape can be.

Architectural Definition

In comparison to the previous squares and towers, this square and towers are more oriented on the neighbourhood scale, thus the architectural definition emphasizes this. These towers only reach up to 7 floors, giving them more the feeling of an ‘urban villa’. The plinth of the whole building is designed for the school.

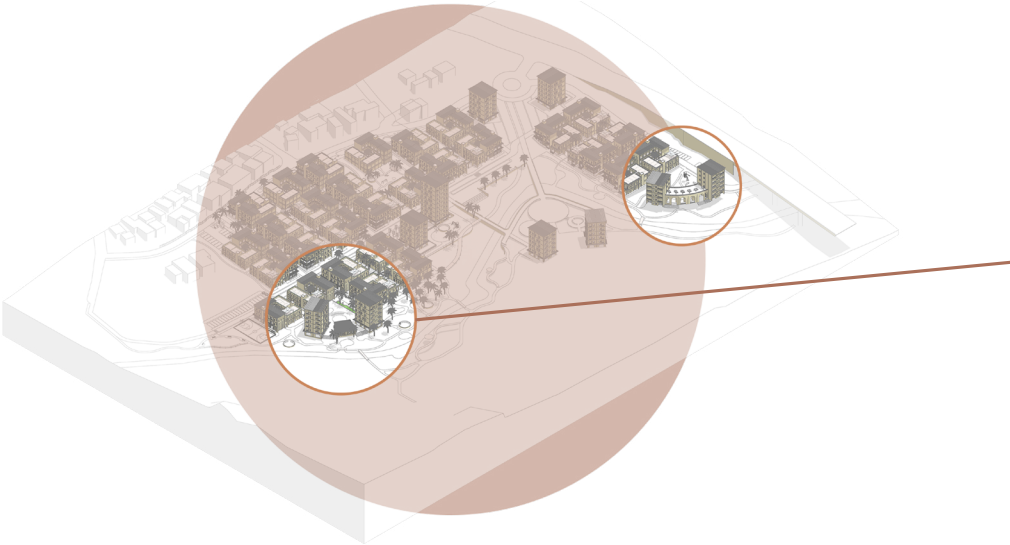


Figure 9.13 Location of “School Tower” within the Masterplan

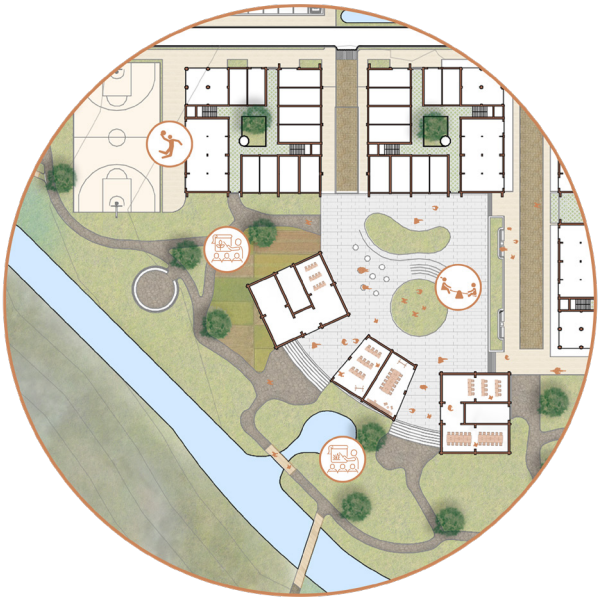


Figure 9.14 Floor Plan Ground Floor of the “School Tower”

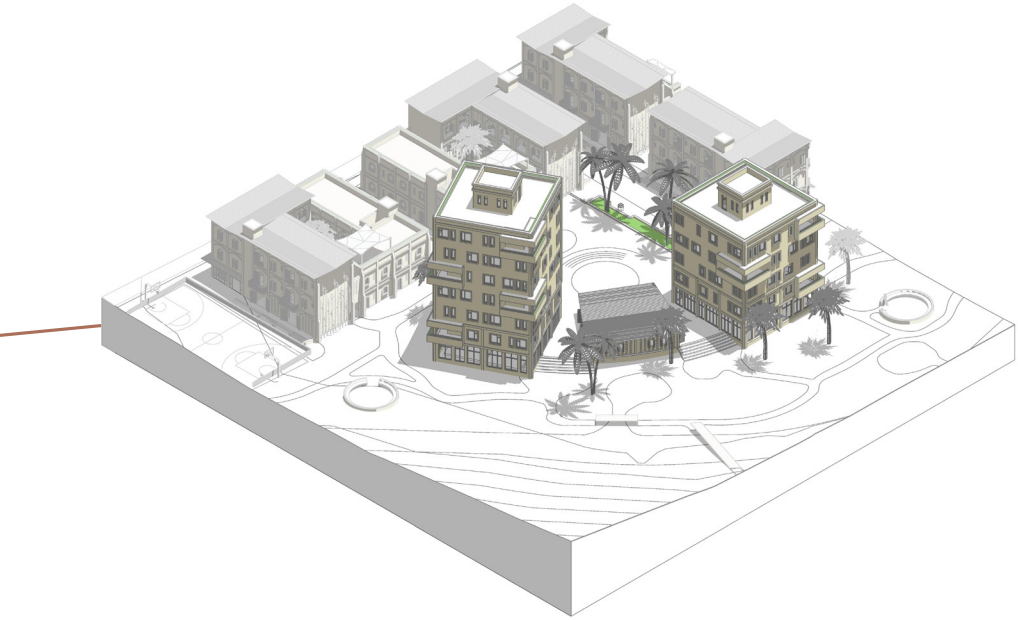


Figure 9.15 Architectural Definition of the “School Tower”

The “Dwelling Tower”

The next “special zone” is located at the bottom right of the neighbourhood. This zone is located slightly away from the “central district” on a spot where the public would be less likely to venture to. Thus, this part of the neighbourhood will likely be a bit calmer and therefore I designated the plinth of this tower with more communal functions (community house, event-space, and so on).

Architectural Definition

The “Dwelling Tower” is comparable in architectural definition to the “School Tower”; more oriented on the community, rather then the “Big Public”. However, this tower is located near the bridge of the Rwanda Street and thus will be one of the first buildings that will be seen by the public. Therefore, there is chosen to design the towers of the “Dwelling Tower” slightly higher than the towers of the “school tower”. In this way, the towers cater for the attraction of the neighbourhood.

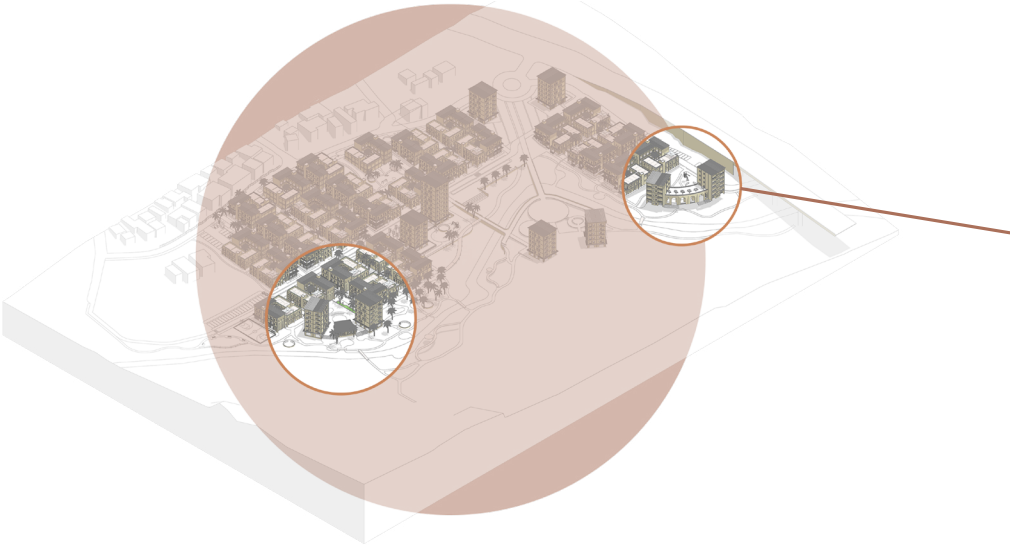


Figure 9.16 Location of “Dwelling Tower” within the Masterplan

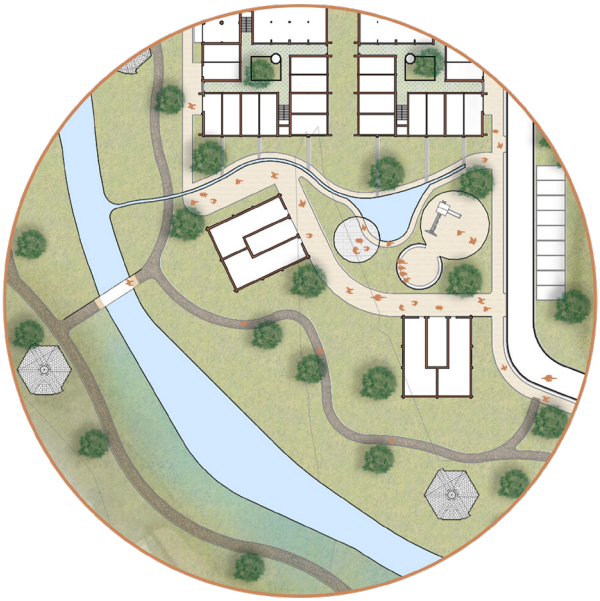


Figure 9.17 Floor Plan Ground Floor of the “Dwelling Tower”

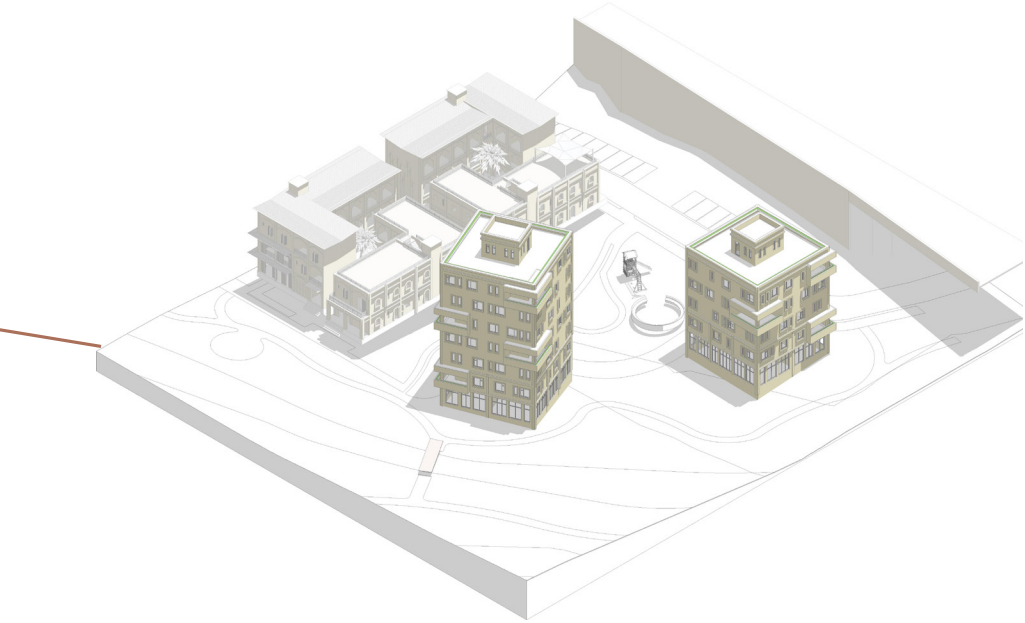


Figure 9.18 Architectural Definition of the “Dwelling Tower”

CHAPTER 10

Low-Rise Courtyard Block

Introduction

Whereas the public squares and towers really functioned as an anchor for the development of an inclusive community, does the 'Low-Rise Courtyard Block' solely function as the "urban DNA" / the dwelling landscape. This building typology blends more into its environment and forms the "urban net" that is placed over the whole neighbourhood.

The 'Low-Rise Courtyard Block' has been designed to cater for the lower- to middle incomes in Addis Ababa, especially focussing on the current informal riverbank settlement inhabitants. The building typology reflects their current habits and livelihood and is designed **to represent the cityness of the informal city of Addis Ababa.**

" The way of life, the culture, the work and the view of the world changed during the past century. So why should Ethiopia's architecture not change as well. Although new materials are being used, the facades have changed, taller buildings are being constructed; still the buildings' typology does not seem to have been influenced by these advancements. Instead of aiming for solutions that are already questionable in the oil-rich desserts of Dubai, Ethiopia now has the chance to use its thousands of years old architectural history to create a new, custom made solution for the needs and wishes of each building's time, place and user. Even now, when fast construction is needed to meet an ever-rising demand, architects have to develop a unique concept for each building task. Only then can these buildings last and change with its users to offer a sustainable solution over time. "

Figure 10.1 Quotation by Heisel on Housing Typologies

Vision Statement

In “APPENDIX B”, as well as in “What Once was a River Landscape” on page 38, I described the story of Kofi Tadesse, a (fictional) man who lived for over 15 years in an informal riverbank settlement. In this graphic anatomy I described various characteristics of these informal riverbank settlements and the way people lived in these neighbourhoods. The neighbourly relations and the communal presence and importance came forwards as one of the virtues of those neighbourhoods.

Since I designed the low-rise courtyard block as a representation of the cityness of the informal settlements, these kind of aspects where of great importance in the design. Spatial characteristics of the sefer that catered for the neighbourly relations and communal presence where;

- the courtyard as a semi-private space for every daily activities
- the possibility to open up dwellings to the public to cater for informal retail
- the high degree of ground boundness
- the close-knit (high perceived density) structures

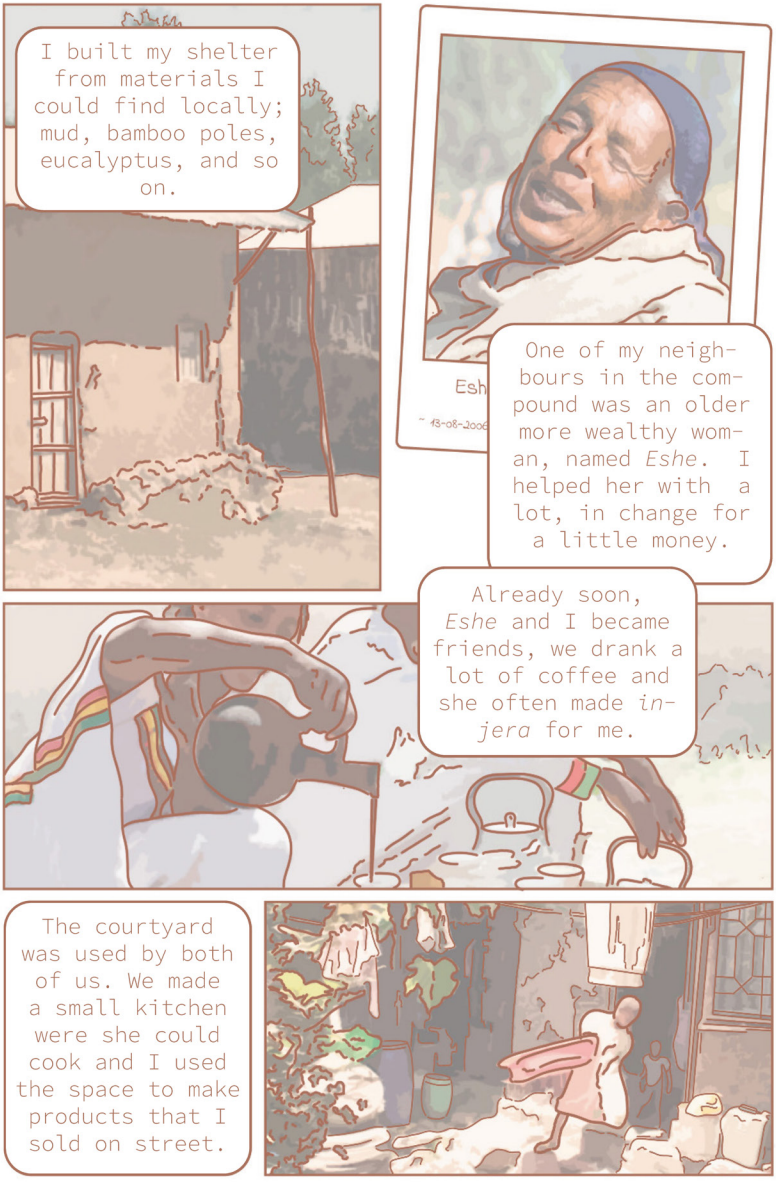


Figure 10.2 One Page of 'The Story of Kofi Tadesse'; Traditional Habits

Low-Rise Courtyard Blocks

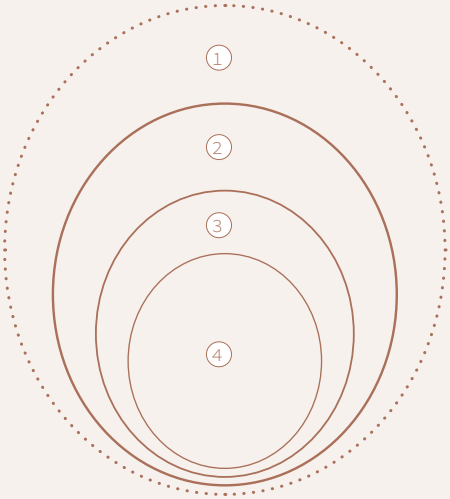
Figure 10.3 The Urban Net

LOW-RISE COURTYARD BLOCK

Building Cluster

The spatial characteristics stated in “Vision Statement” on page 126 have been translated in the design for the low-rise courtyard block. The neighbourhood consists of clusters in different shapes and sizes. ‘Figure 10.5’ shows one such cluster. The cluster can be seen as a sequence of “community levels”. The cluster it self is part of the bigger informal riverbank settlement community. Then, the cluster itself can be seen as a smaller, little more private, community. The last level of community is the neighbourly communities which are all grouped within each housing block.

Those different levels of communities are based on the levels of community which can be found in the current informal riverbank settlement as well. Here, also the same levels of community can be found; the full neighbourhood community (with the iddir as the main organ) till the small scale neighbourly relations, which are also described in “The Story of Kofi Tadesse”.



① Macro-Level;
City / Region

① Meso-Level;
Neighbourhood

① Micro-Level;
Building Cluster

① Individual;
Building Block

Figure 10.4 Different Layers of “Community Levels”

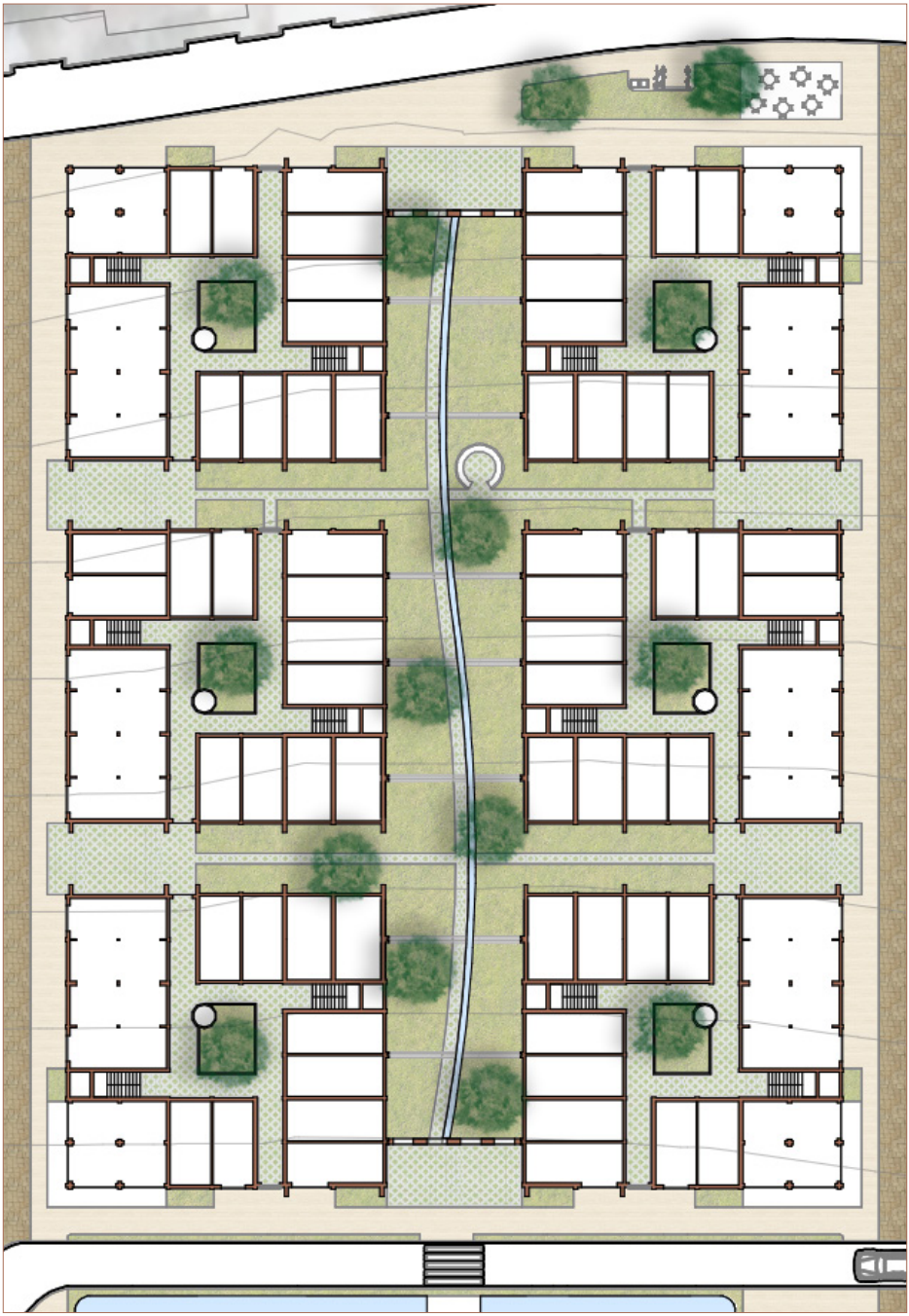


Figure 10.5 Building Clusters

Floor Plans

Each housing block has an own shared communal courtyard. This courtyard is accessible by everybody from the building block and can be used for most daily activities that nowadays also happen in the courtyard of the sefers. Connected to the courtyard, each building block has its own shared communal space oriented towards the public streets. This space contains a water-basin that collects rainwater harvested on the roofs, as well as a shared kitchen alongside the street. The inhabitants of the building block can use this space and the zone in front of the building to set up their informal shops, restaurants or other informal activities.

Further, the building accommodates a shared green roof terrace. This roof gives additional private outdoor space to the inhabitants for daily functions or can in a later stage be used to increase the buildings volume.

The infill of the dwelling parts of the low-rise courtyard block is very flexible. Depending on the target group, different housing typologies can be placed within the low-rise courtyard block. The following pages give an overview of my research on housing typologies and target groups in the current context of Addis Ababa. Based on this research, I designed various floor plans that can be accommodated in the low-rise courtyard blocks. Those floor plans are also shown on the following pages.

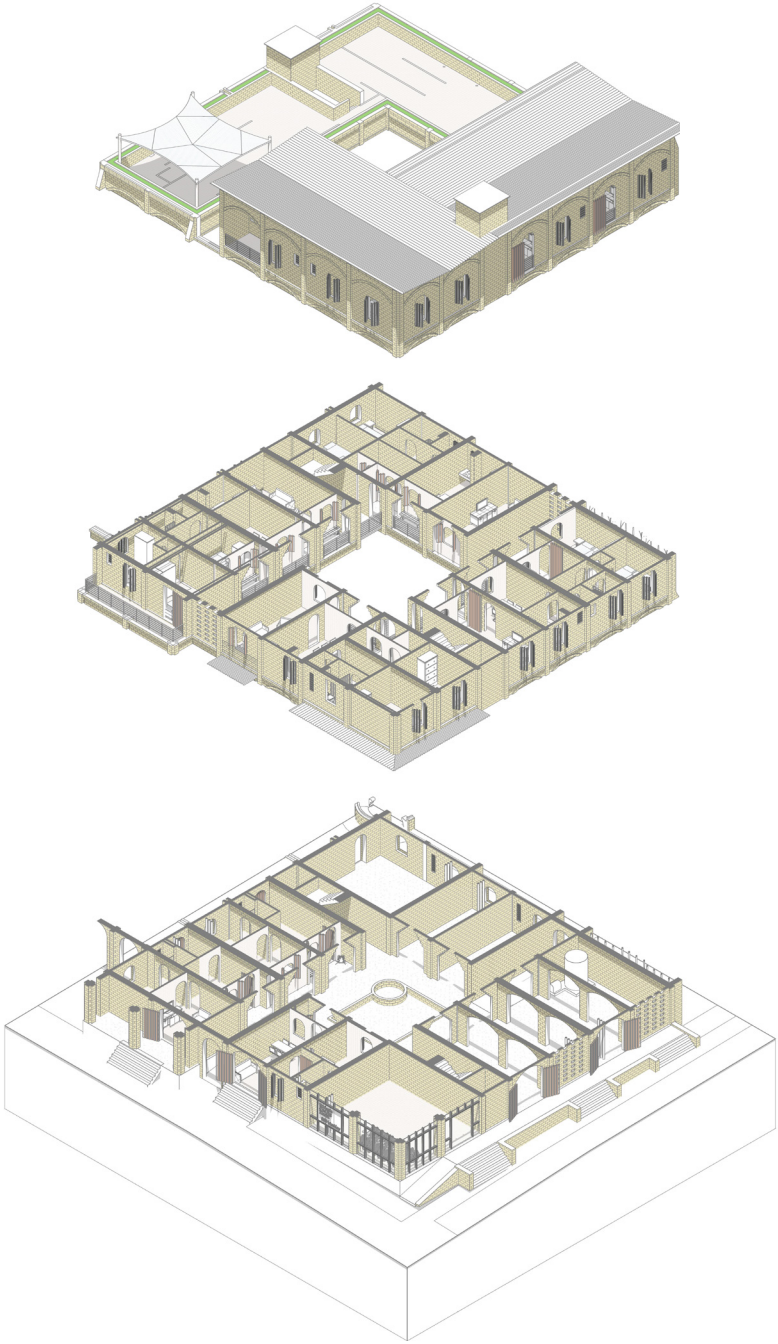


Figure 10.6 Axonometry Low-Rise Courtyard Block

Housing Typologies & People's Demands

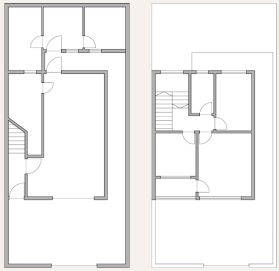
Felix Heisel [39] wrote his paper 'Housing Typologies - A Case Study in Addis Ababa' in which he explored five types of housing typologies in Addis Ababa. He noticed that floor plans in Addis Ababa are more based on income than on social trends (which is more the case in western countries). Over time, the typologies "belonging" to various income groups have not changed much, the floor plans stayed the same. The five different types he looked at in his research where the villa, the row house, the apartment, the condominium and the small houses / sheds (respectively higher- to lower-income).

For the design of my housing typologies in the project I summarized and used some of the important information about the typologies Heisel explored. The housing typology of the villa has stayed out of focus since this typology doesn't apply to my project.

The current houses on the chosen location are mostly smaller houses and sheds. As can be notified from the characteristics of housing typologies on the right, these houses have a low amount of rooms and most of these rooms have several functions. As can be seen in the typical floor plan, this is made possible by creating a very open floor plan. Spaces can be divided using curtains or other flexible objects which make it easy to transform your house to these several functions it is used for. **This flexibility of the floor plan is a virtue for the traditional lifestyle of the current dwellers.**

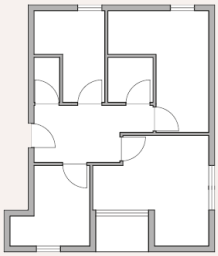
Row House

Avg. M² (p/dw):	76.19
Avg. Inhabitants (p/dw):	6.55
Avg. M² per Person:	13.49
Avg. Amount of Rooms:	7.79
Rooms have several functions:	0.00 %



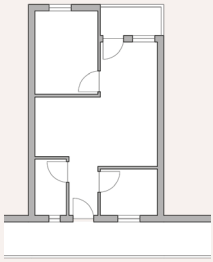
Row House

Avg. M² (p/dw):	53.17
Avg. Inhabitants (p/dw):	4.77
Avg. M² per Person:	14.38
Avg. Amount of Rooms:	4.68
Rooms have several functions:	34.85 %



Condominium

Avg. M² (p/dw):	49.71
Avg. Inhabitants (p/dw):	4.13
Avg. M² per Person:	14.58
Avg. Amount of Rooms:	4.35
Rooms have several functions:	30.43 %



Smaller Houses / Sheds

Avg. M² (p/dw):	23.83
Avg. Inhabitants (p/dw):	5.74
Avg. M² per Person:	5.11
Avg. Amount of Rooms:	2.75
Rooms have several functions:	77.52 %

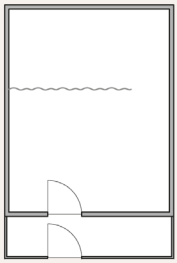


Figure 10.7 Characteristics of Housing Typologies in Addis Ababa

New Housing Trend

A relatively new form of housing is ‘shared housing’ or ‘co-living’. Co-living is a growing trend in big cities, since it makes living more affordable by sharing common living spaces. Often, apartment buildings dedicated to co-living consist of clusters of 3- to 4-bedroom units with shared living room, kitchen and dining area.

Co-living is a principle which not have been implemented widely in Addis Ababa. In 2019 the ‘Addis Ababa City Administration Housing Development and Administration Agency’ launched its first new housing scheme based on the co-living principle. However, till now not many examples of appropriate floor plan solutions can be found.

Based on Dutch standards and the booklet ‘de menselijke maat’ a general assumption for the room layout can be made. A one-person bedroom can be designed following the measurements in the picture on the right [Figure 10.5]. Here, the room will give space to a one-persons bed, a small table and a wardrobe. In the design, bigger solutions will be sought since this becomes the only real private living space in a co-living situation. Therefore the aim will be to create bedrooms with an area around 10 square meters.

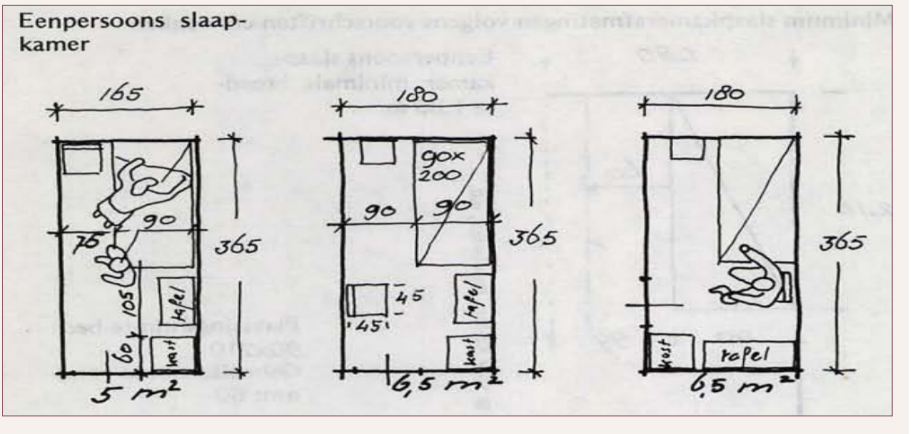


Figure 10.8 Minimal dimensions for an one-person bedroom

Typologies and Target Groups

The project tries to relocate all current inhabitants within the site. Most of these inhabitants are informal settlers and have a lower income. Their current living situation is like the smaller houses / sheds shown on the previous page. Their "new" typology should relate to the current small houses and have the same or even better spatial quality.

Apart from the current inhabitants also other target groups need to be attracted. Medium- and higher income groups need to be housed on the location to create a system of cross-subsidization and make the project feasible.

In the design I have created 6 housing typologies which all address certain target groups. The scheme below shows the different residents relating to the different housing typologies in the project. On the next pages the different housing typologies of the Low-Rise Courtyard Block will elaborated on and target groups will be linked to each typology.

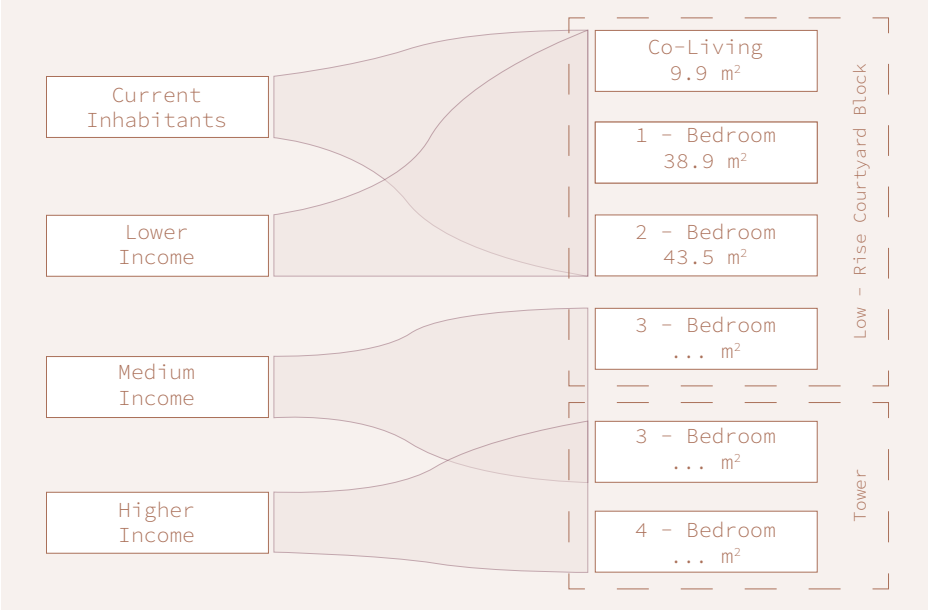


Figure 10.9 Target Groups in Relation to Housing Typologies

Urban Migrant

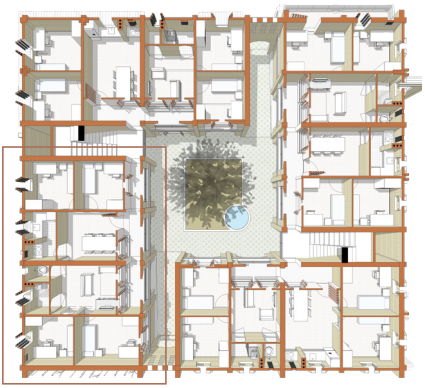
Current Residential Starus: NEW IN THE CITY

Family Composition: SINGLE
Social Network: LOW

Job(s): CONSTRUCTION WORKER

Average Monthly Income: 623 BIR / MONTH

* THIS IS A FICTIONAL CHARACTER AND THE DISCRIPTION IS BASED ON ASSUMPTIONS AFTER CHARACTER RESEARCH



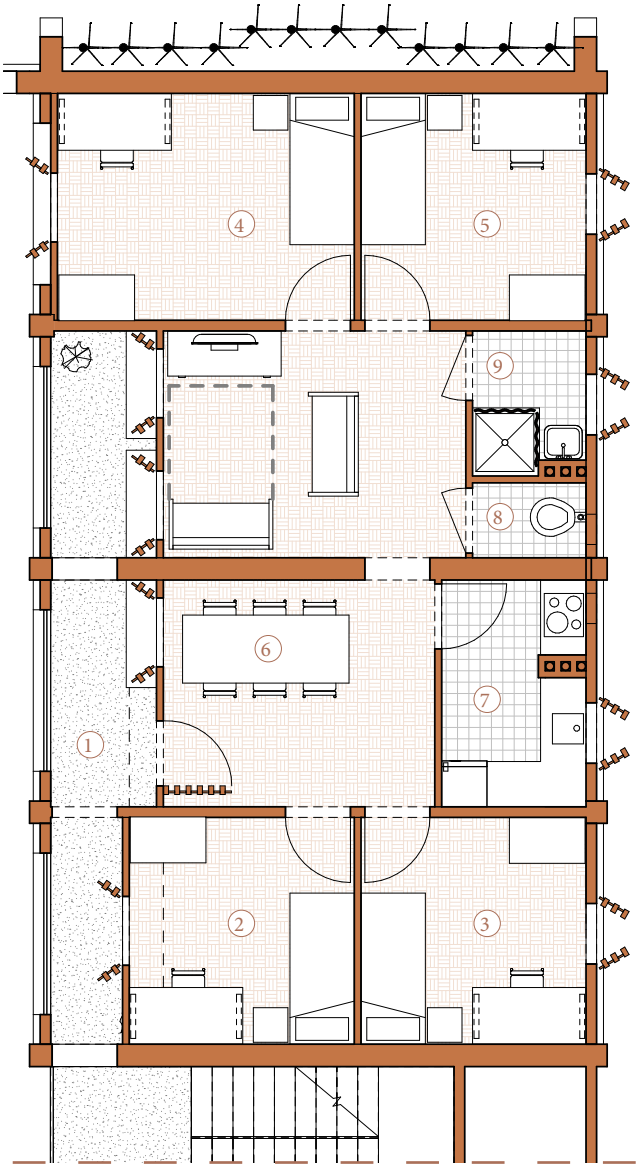
Co-Living Apartment

Floor Area: 10 M²

Income Group: VARIED (Focus on low income)

Payment: SOCIAL RENT

Figure 10.10 Target Group for Co-Living Apartment



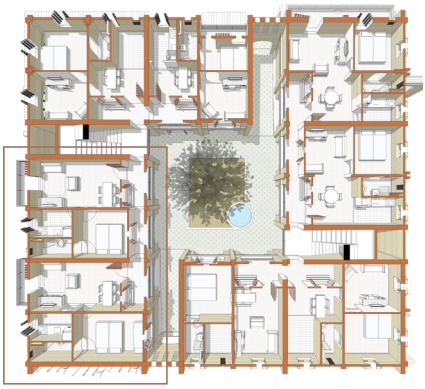
① Gallery
② Private Bedrooms
③ ④ ⑤
⑥ Shared Living Room
⑦ Shared Kitchen
⑧ Seperate Toilet
⑨ Bathroom

Figure 10.11 Floor Plan Co-Living Apartment [Scale 1:100]

Current Informal Settlement Family

Current Residential Starus:	LIVING IN THE INFORMAL RIVERBANK SETTLEMENT
Family Composition:	2 ADULTS & 2 CHILDREN
Social Network:	HIGH
Job(s):	INFORMAL STREET VENDOR / HOUSE MAID
Average Monthly Income:	306 BIR / MONTH

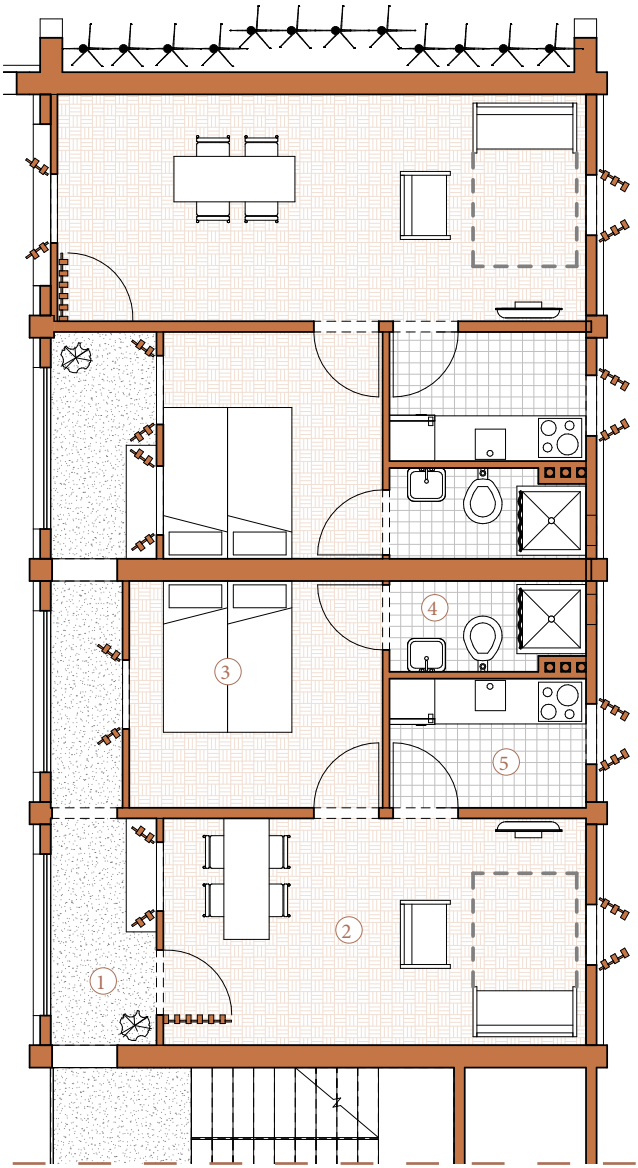
* THIS IS A FICTIONAL CHARACTER AND THE DISCRIPTION IS BASED ON ASSUMPTIONS AFTER CHARACTER RESEARCH



1-Bedroom Apartment

Floor Area:	35 M^2
Income Group:	LOW TO VERY LOW INCOME
Payment:	SOCIAL RENT OR RENT TO OWN

Figure 10.12 Target Group for 1-Bedroom Apartment



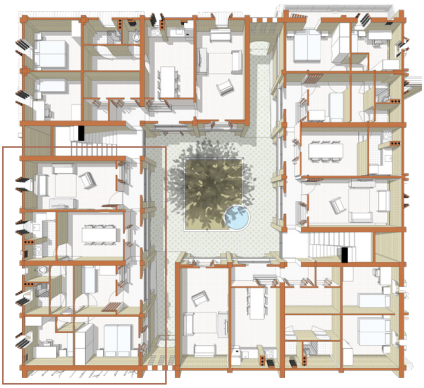
① Gallery
② Living Room
③ Master Bedroom
④ Bathroom
⑤ Kitchen

Figure 10.13 Floor Plan 1-Bedroom Apartment [Scale 1:100]

Middle Income Family

Current Residential Starus:	2-BEDROOM APARTMENT
Family Composition:	2 ADULTS & 1 CHILD
Social Network:	MEDIUM
Job(s):	SALESMAN
Average Monthly Income:	2.603 BIR / MONTH

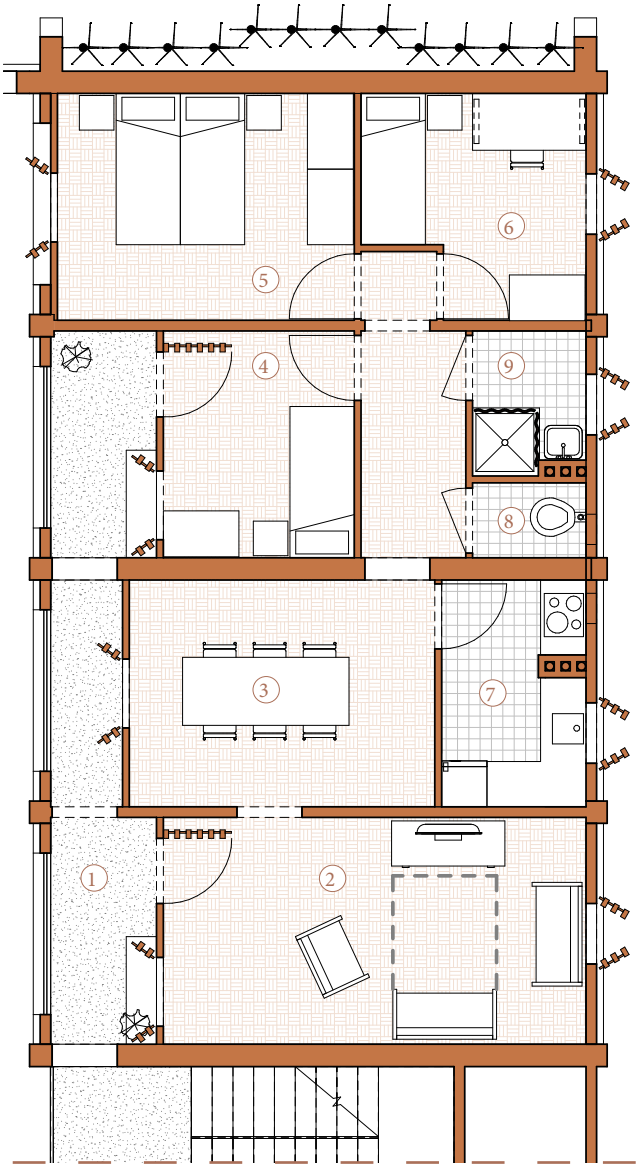
* THIS IS A FICTIONAL CHARACTER AND THE DISCRIPTION IS BASED ON ASSUMPTIONS AFTER CHARACTER RESEARCH



3-Bedroom Apartment

Floor Area:	70 M^2
Income Group:	MIDDLE INCOME
Payment:	RENT WITH DOWNPAYMEN OR OWNERSHIP

Figure 10.14 Target Group for 1-Bedroom Apartment



① Gallery
② Living Room
③ Diner Room
④ 1st Bedroom
⑤ Main Bedroom
⑥ 2nd Bedroom
⑦ Kitchen
⑧ Seperate Toilet
⑨ Bathroom

Figure 10.15 Floor Plan 1-Bedroom Apartment [Scale 1:100]

Architectural Definition

Where the public squares and towers should have the architectural definition of “special zones”, the concept of the architectural definition of the low-rise courtyard block is different. This block forms the urban DNA of the new neighbourhood and the concept of the architectural definition is that the building blocks should blend way more into its environment.

Materiality

For the materiality, there is chosen for a very local material, compressed earth blocks. These blocks give the building blocks a rich appearance which blends nicely into its environment and into the context of Addis Ababa. Also, it is relatively easy to construct and by using the material in efficient ways, embellishments can be made with the material without the need for additional materials or difficult building techniques, see “Infill Walls” on page 174.

Connection with the Ground

As explained in this chapter, the connection between the retail streets and the communal space is of great importance for the inhabitants of these building blocks. The livelihood of many current inhabitants of the neighbourhood relies on the possibility to open up informal shops from out their own homes. Therefore, in the design this connection with the “ground” was very important since it caters for the possibility to continue the traditional patterns of life in their new profound living conditions. The entrances to the building block via the communal space are all levelled ór a wide entrance in front of the building is created. This to create the possibility to set up the shops in front of the building. Emphasis on these “informal shops” is given by perforating the façade, so that the space invites for social interaction with the public street.

Figure 10.16 Architectural Definition of Low-Rise Courtyard Block

Figure 10.17 Construction Site Oskam **Figure 10.18** Design for Afr. School

Figure 10.19 Starbucks Café Old Dubai; use of Earth / Mud & Wood

Figure 10.20 Reference Project Oskam V/F

Figure 10.21 Reference Project Oskam V/F

CHAPTER 11

Materiality & Construction

Vision Statement

Before formulating specific goals and criteria for the technical solutions chosen for the design, I looked at the condominium project as a reference. Even though the scheme is not known to score very high on sustainability, durability and quality, the scheme can also learn us a lot. In terms of planning and construction the scheme have been really efficient. Through on-site production by the local building sector and unskilled workers, jobs have been created while keeping the construction costs low.

The choice of materials within my design should also be based on this *locality;* making use of local labor and local materials is cost efficient and gives as a benefit that it can support or create local economies.

Further key-principles on which the choice of the materiality will be based are *sustainability;* the building's ecological footprint should be as low as possible, thus using materials with for instance a very low carbon oxide footprint, and *low-tech(nology);* the building should be able to be constructed with low skilled labor and no need for expensive equipment, thus making it possible to propose an active user participation in the process.

LOCALITY

SUSTAINABILITY

LOW-TECHNOLOGY

Figure 11.1 Key-Principles for Choice of Materiality

Step Aside of the “BIG-3”

The big three materials: concrete, steel and timber have been the mainstay of structural appliance in architecture. Almost every building in developing, as well as developed countries / cities, relies on one of these materials. But, the **environmental impact** of these materials is huge. The BIG-3 -materials are carbon-intensive materials to produce and, alone, account already for about 11 percent of the global greenhouse gas emissions. Further problems due to the use of these materials are **impermeability** of “concrete land”, **degradation of affordable building materials** and **scarcity** of the BIG-3 -building materials.

Also in Ethiopia, the usage of these BIG-3 -materials has grown due to the rapid urbanization and the need for fast and standardized building styles. Building structures built with reinforced concrete or cement blocks are becoming common. For instance, the multi-story condominium buildings are being built and even gradually substitute the vernacular architecture. The locality of architecture, for instance local building cultures, are suppressed of in favour of standardized building styles.

In an age filled with sustainable challenges, do alternative structural materials need a chance to be explored and developed? Are their more sustainable materials, materials that could allow the same stresses, but have a lower environmental impact? And do we really need to explore ‘new’ materials for that, or are these “new” techniques already used?

Figure 11.2 Modern Architecture of Ethiopia

The Past as an Example for the Future

~ Vernacular architecture is a modest style of building that is specific to a region and period. It relies on the use of local materials and knowledge to construct buildings, and it's usually done without the supervision of a professional architect. ~ [40]

The vernacular architecture of Ethiopia can mostly be found in the rural areas, also because of the fact that modern architecture has erased the vernacular in the more urban areas. The materials used in these shelters are all local materials and the building techniques are based on local traditions. These techniques and materials can be an inspiration for future developments.

On the next page three types of Ethiopia's vernacular architecture can be seen. The first building is a, so-called, Tukul made from natural stone and compressed earth. The second building is a Chikka house, consisting of a wooden structure filled in with earth and straw. The building type on the bottom of the page is the most traditional form of the Tukul, and is made of earthen mortar and a thatch roof.

Figure 11.3 Vernacular Architecture of Ethiopia

The “BIG-3” of Ethiopia

As already described on the previous page, the vernacular architecture of Ethiopia uses several local materials. In ‘Figure 11.4’ these materials are shown and an indication of theirs locality [its occurrence in Ethiopia] is given. The BIG-3 of Ethiopia consists of *bamboo*, *straw / thatch* and *earth / clay*.

Bamboo

There is estimated one million hectares of natural bamboo forest in Ethiopia. Currently, this is not used to it’s potential and is only used for roofing, furniture or other non-load bearing structures.

Straw / Thatch

Agriculture is the mainstay of the Ethiopian economy in the rural areas. Since straw is the leftover of the harvesting process in these rural areas, this material is present in abundance. Currently, straw is mostly used as infill, rather than load bearing structures.

Earth / Clay

The BIG 3 of Ethiopia - material that is most used for structural appliance is earth / clay. In compressed or dried form, earth or clay is widely used for load bearing structures. Earth and clay can be found everywhere, but the quality depends on the soil-type.

Figure 11.4 The “BIG-3” of Ethiopia

Choice of Materiality

To make a choice of the materiality of the project I created a scheme which compared different materials from the BIG-3 and the BIG-3 of Ethiopia. These different materials are assessed against the key-principles for the choice of materiality; locality, sustainability and low-technology.

Figure 11.5 Comparison Scheme Choice of Materiality

Compressed Earth Blocks

Based on the comparison scheme (figure 11.5) I decided to make use of **earth / clay** as my main material for construction. Earth and clay is available in abundance in Ethiopia and Addis Ababa. Also, depending on the way earth / clay is used the sustainability of the material can be very high and last, Ethiopian people have worked for ages with the material, thus the local knowledge of construction with earth / clay is already there or can easily be learned using principles they already know.

Within the usage of earth / clay as main material, there are many options in which way you use the earth / clay. Different building techniques are possible. Think about rammed / compressed earth, adobe blocks, fired bricks, compressed earth blocks and so on. While keeping in mind the three key-principles for the choice of materiality, I chose to use the compressed earth blocks [now referred to as CEB] as structural material. Huge benefits above the other options were the **resistance to running water** and rising damp, the **smooth appearance**, the **low costs** and the **good strength** which makes it possible to easily build higher than 1 or 2 storeys.

Further, CEB has a very **high thermal mass**. This makes it appropriate for the climate of Addis Ababa. During day time the heat will be stored in the blocks, thus keeping the temperature inside the dwelling low. During night time, when the temperature drops, this stored heat will be radiated into the home, thus heating and cooling the building passively and providing a constant temperature throughout the day.

Another benefit of CEB is its **resistance to termites**. Termites are abundant and widely distributed throughout Ethiopia. Termites can cause serious damage to not only crops or plants, but can also ruin buildings. Compressed Earth Blocks have such a high density that it won't be an appropriate place to life for the termites, in contrast to for instance bamboo or wooden buildings.

Composition Compressed Earth Blocks [CEB]

Earth (clay, sand, salt)
Approx. 4,5 or 6% lime or cement (to make waterproof)

Shape, dimensions and weight

Dimensions:	295 x 140 x 90mm
	295 x 140 x 70mm
Weight:	90mm thick = 7.5 kg
	70mm thick = 6.3 kg
Specific weight:	2200 kg/m^3

Appearance

Color: usually brown, redish color

Durability

Compressed earth blocks are not flammable
Compressed earth blocks are resistant to running water and rising damp

Mechanical properties

Compressive strength dry: 8.5 - 16 N/mm^2
[depending on age, earth and stabalizer of the block]

Thermal properties

Heat conductivity coefficient:	λ = 1.13 W/mk
Thermal reistance at 40 cm thick wall:	R = 0.345 W/m^2K
Specific heat capacity:	C = 1.0 kJ/kgK

Figure 11.6 Specification CEB Water-resistant [41]

Building System

The building system on itself is kept relatively easy, this to keep the required construction skills low and thus reduce the total costs of the project. I managed to design a building system only using one material, earth / clay. The structure consists of single or double CEB-walls and masonry vaults of CEB for the floors and roofs. These vaults are levelled using compressed earth.

Walls

In the design of the low-rise courtyard block, the structure consists of single and double CEB-walls. The single- and double walls are placed alternately, with the double walls always placed at the gables to create additional strength, acoustic comfort and a high thermal mass.

Floors / Roofs

The floors and roofs are designed as masonry vaults made from CEB. The total span of the masonry vaults are 3 meters because of the limitation this type of construction gives.

The vertical forces created by the vaulted floors and roofs are either cancelling each other out within the structure, or are supported by buttresses placed at the gable walls. In that way I was able to not depend on the usage of concrete to create a solid ring beam to cancel these vertical forces out.

On the following pages, the “standard” details of this building system will be shown; foundation, gable wall & masonry vault, roof (non-accessible), roof (accessible).

For calculation on the strength of the building system, see “APPENDIX C” on page 228.

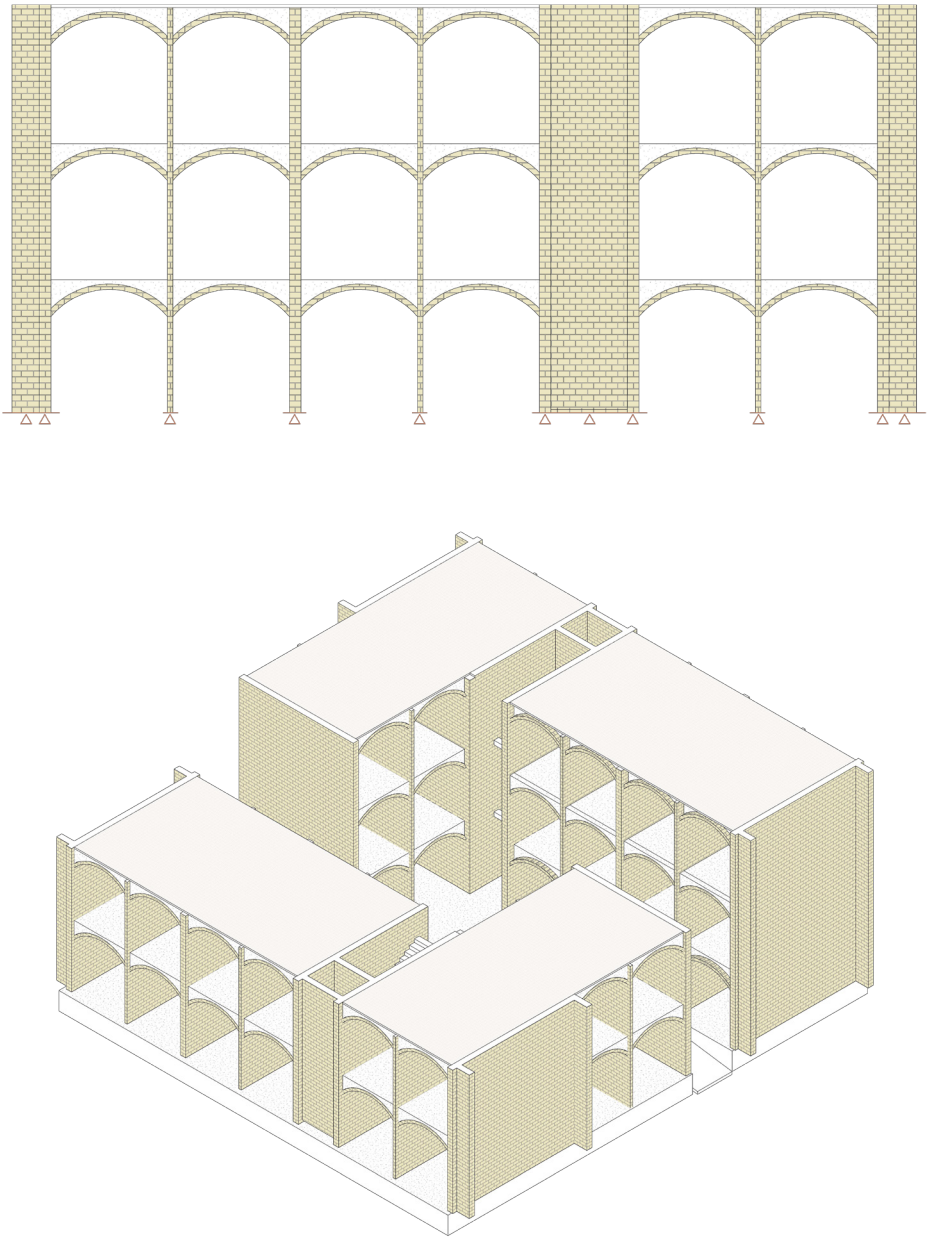


Figure 11.7 Building System made of CEB

Detail 1; Foundation

Interior Flooring (Ground Floor)
- Floor Finish _ Choice for CEB, Ceramic Tiles or Woven Bamboo
- Topping _ Sand Layer
_ Backfill Soil _ Well Compacted / Rammed Earth

Compressed Earth Blocks
(290 x 140 x 90mm)

Zinc Cover for Thermite Protection, with Damp Layer

Adobe Render for Water Protection

6 % Lime Compressed Earth Blocks
(290 x 140 x 90mm)

Tamped Earth _ Surface Stabalization

Natural Stones in Earth Mortar
(+) Waterproof Coating

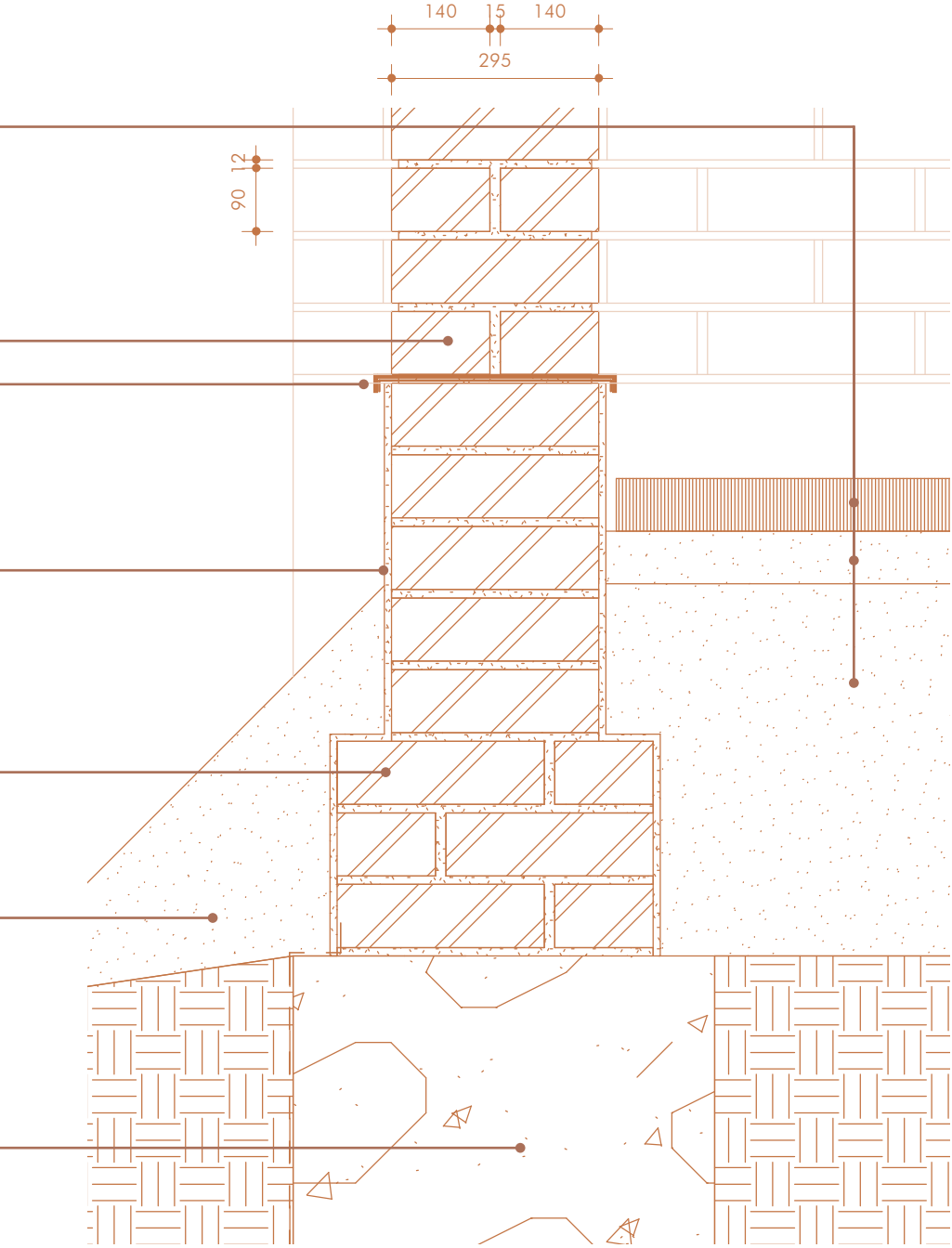


Figure 11.8 Detail Foundarion [Scale 1:10]

Detail 2; Gable Wall & Masonry Vault

Compressed Earth Blocks
(290 x 140 x 90mm)

Interior Flooring (Higher Floors)
- Floor Finish _ Choice for CEB, Ceramic Tiles or Woven Bamboo
- Screed Layer _ Earth Mortar (20 mm)
_ Levelling Sand Layer _ Well Compacted / Rammed Earth
- Masonry Vault of CEB

Linear Facade Embellishment to Create Relief in the Facade & prevent Moisture on Underlaying CEB (see materiality and construction)

Earth Mortar Fill

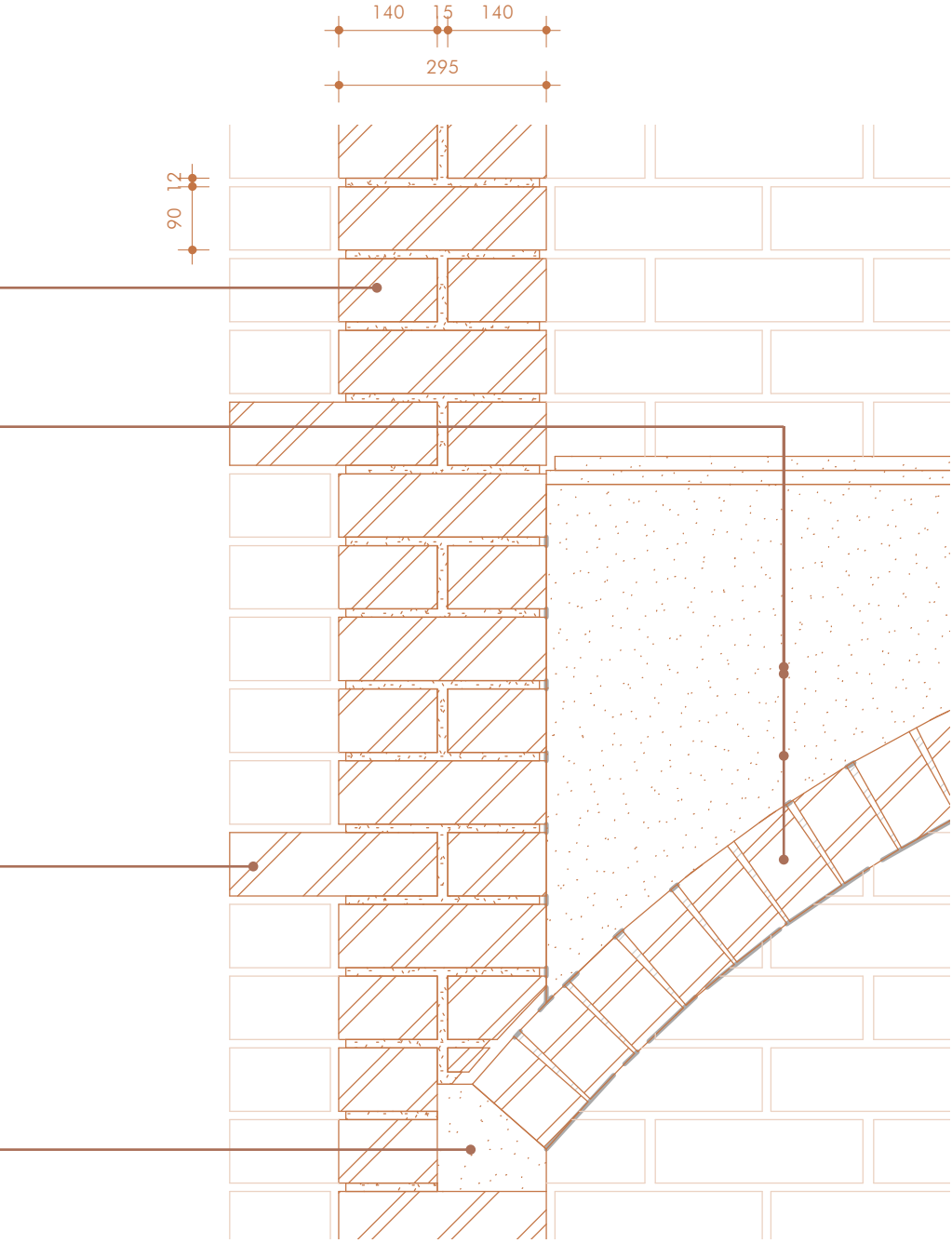


Figure 11.9 Detail Gable Wall & Masonry Vault [Scale 1:10]

Detail 3; Roof (non-accessible)

Roofing (non-accessible roof)
- Re-Used Corrugated Metal Sheets on Bamboo Framework
- Screed Layer _ Earth Mortar (20mm)
- Levelling Sand Layer _ Well Compacted / Rammed Earth
- Masonry Vault of CEB

Compressed Earth Blocks
(290 x 140 x 90mm)

Bamboo Framework Roof Anchored in CEB Wall

Linear Facade Embellishment to Create Relief in the Facade & prevent Moisture on Underlaying CEB (see materiality and construction)

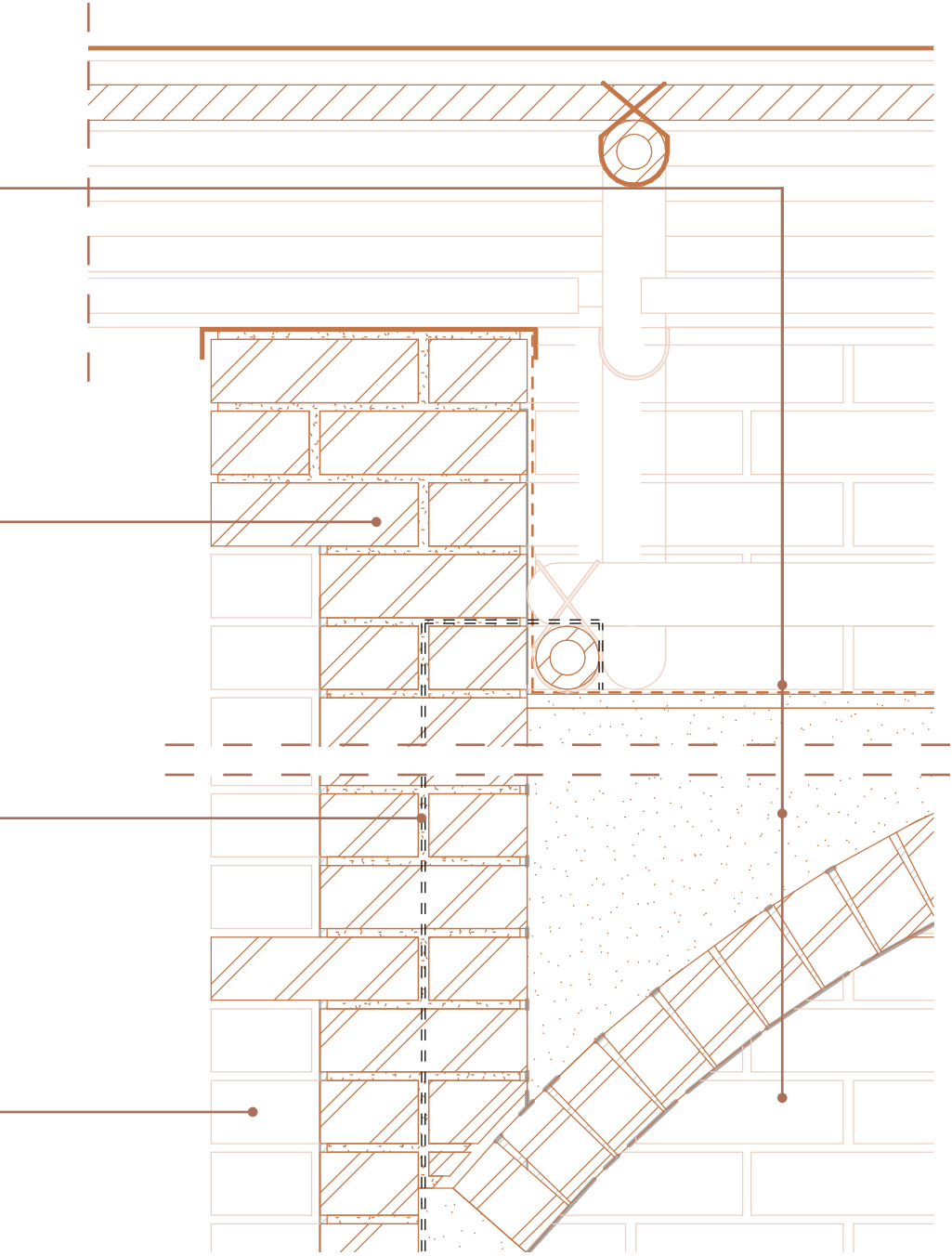


Figure 11.10 Detail Roof (non-accessible) [Scale 1:10]

Detail 4; Roof (accessible)

Planting

Shared Roof
- Floor Finish _ CEB Tiles (300x300)
- Rubber Strips
- Waterproof Layer _ EPDM Membrane
- Screed Layer _ Earth Mortar (20mm)
- Levelling Sand Layer _ Well Compacted / Rammed Earth
- Masonry Vault of CEB

Rainwater Duct
- every 2 m a small maintanance door is placed

Window Frame of CEB to prevent Direct Sunlight

Wooden Mounting Frame

Single Glazed Window in Bamboo Framing

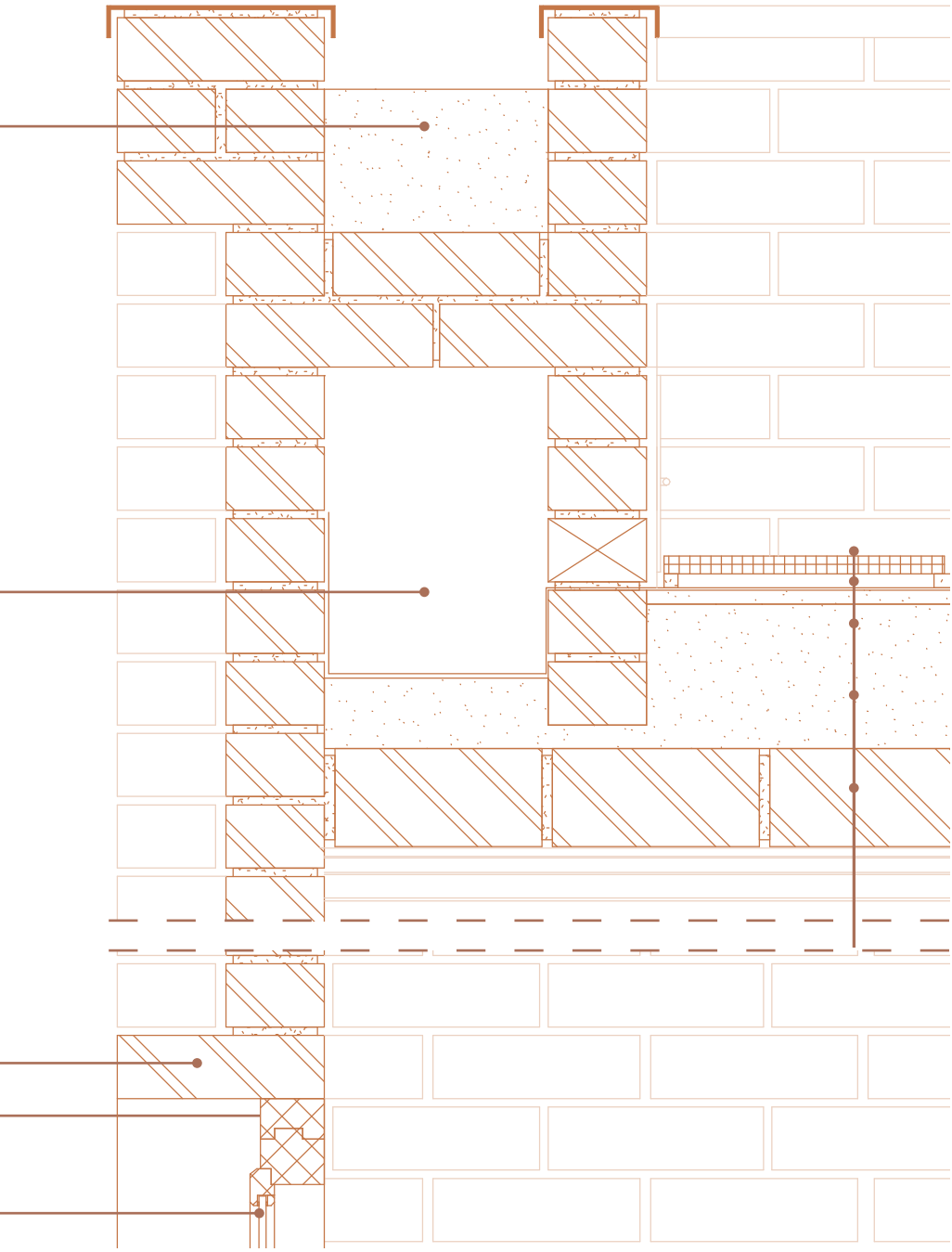


Figure 11.11 Detail Roof (accessible) [Scale 1:10]

Exception in Building Structure; Street Corners

The flexibility of the building structure caters for great adaptability to specific urban situations. On two most influential situations in the masterplan is further elaborated.

Firstly, on street corners, there can be the need to open up the building towards two sides to allow for a more commercially and socially activated street corner. Therefore, a slight adaptation in the building structure can adapt the building to its environment. By using a compressed earth block column structure with bamboo flooring in the corner, the possibility is created to open up towards both sides and create an activated corner. [*see "Detail 5; Exception in Building Structure" on page 170*]

Figure 11.12 Impression Activated Streetcorner

A second building adaptation can be found along the whole ridge. Building along a riverbank means building in an area with a lot of height differences. The building structure can adapt easily to these height differences by making small jumps that go along with the shape of the ridge. In that way, the low-rise courtyard block crawls up the mountain and visually embeds itself in its surroundings. At the same time, the front doors facing the streets always connect to the ground level, thus activating the retail street with possible informal activities.

Figure 11.13 Activated Plinth by Entrances Facing the Street

Detail 5; Exception in Building Structure

Whole Bamboo Culms Floor Structure
- Floor Finish _ Woven Bamboo
- Bamboo Frame Spacing about 30 - 40 mm

Overhang Structure
- Re-Used Corrugated Metal Sheets
- Continued Bamboo Culm of Floor Structure

Arched Opening in CEB Facade

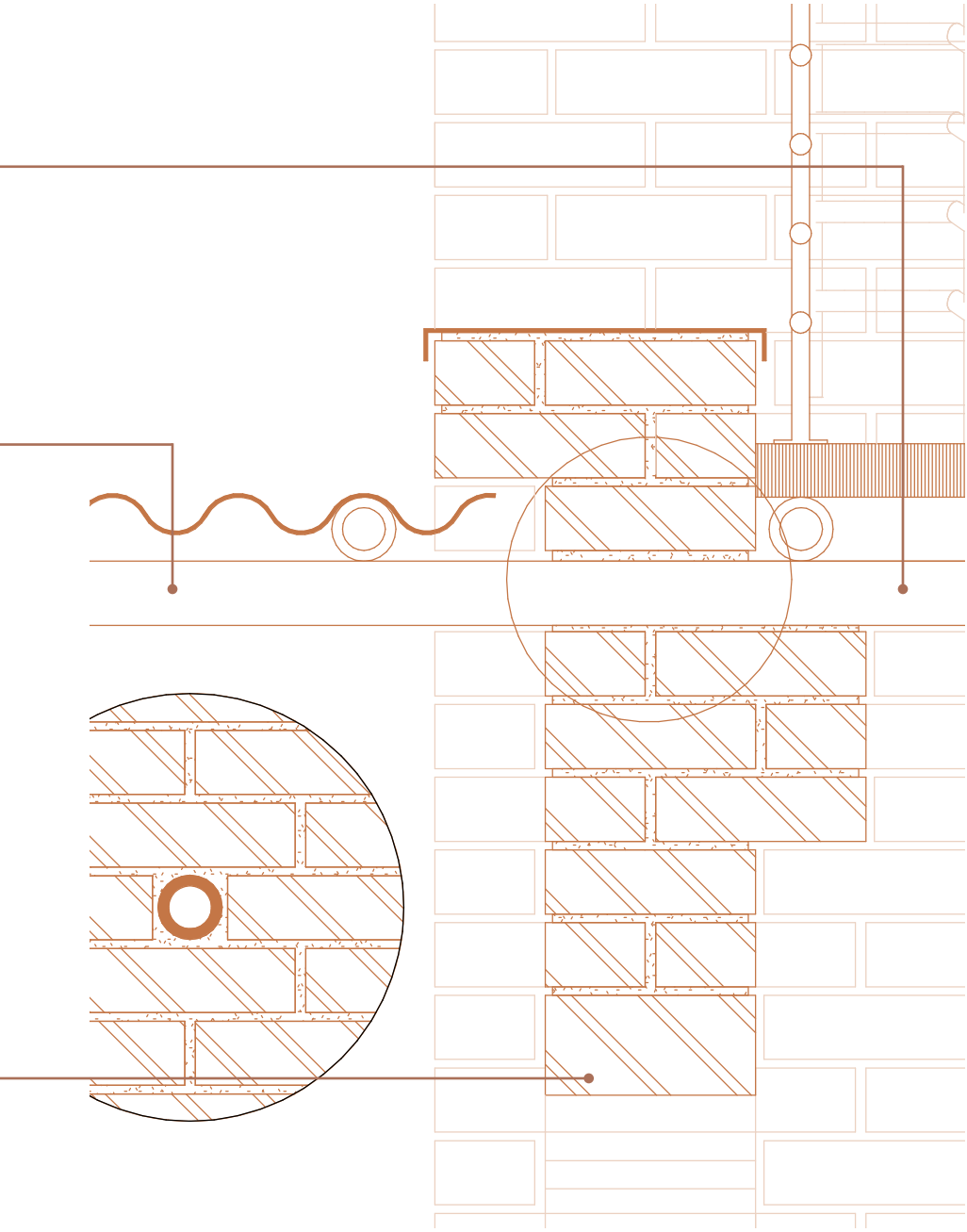


Figure 11.14 Detail Exception in Building Structure [Scale 1:10]

Facade Openings and Embellishments

Within the design of the low-rise courtyard block, a few special facade openings or embellishments have been designed. For these openings and embellishments my intention was to use the material to **its fullest potential by using the material in an aesthetically pleasing way only using its natural strengths.**

I did research on how “simple” construction techniques can result in a very rich looking building. In that way, a regular flat wall can be made into an architectural appealing wall without making more costs or needing much more labour. This section shows different wall openings or embellishments which are used in the design. Also, there’s explained how this can be build without making use of other materials or difficult building techniques.

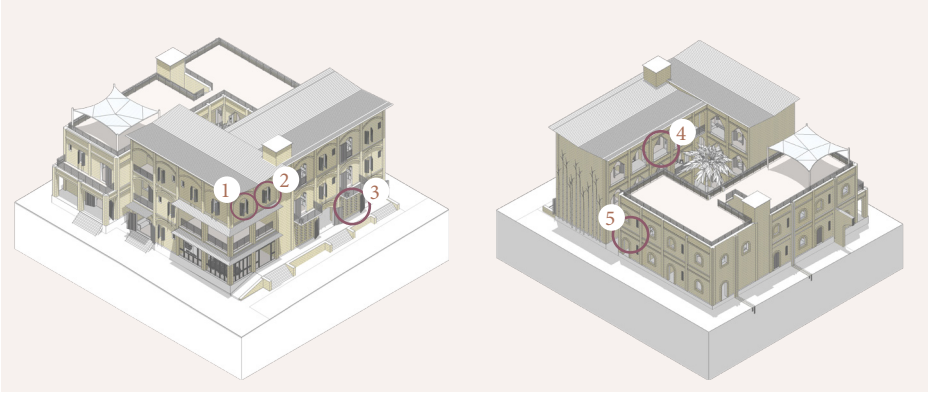


Figure 11.15 Indicator for Special Openings / Embellishments in Facade

1 - Arched Window / Door Opening

Figure 11.16 Car-Tire Used as a Formwork

In the design, I made a distinction between arched window / door openings and rectangular window / door openings. The width of the arched openings is based on the diameter of a car tire. This is done, so that during the construction phase car tires can be used as a form work. This is a cheap, simple and efficient way of creating arched openings in brickwork. The car-tire will be placed in-between the walls and the bricks that form the arch can simply be placed on top of the tire. Due to the flexibility of a car tire, it is easy to remove the tire after the mortar has hardened.

2 - Rectangular Window / Door Opening

Figure 11.17 Rectangular Window / Door Opening

A variant on the arched window / door opening is the rectangular opening. Using compressed earth blocks, layed in vertical direction, the brickwork can form the lintel. Important is to keep the opening relatively small, otherwise the lintel will collapse in the middle and the structure will crack and fall down. In my design the maximum width of these openings is therefore 900 mm.

3 - Perforated Brickwork

Figure 11.18 Perforated Brickwork at Reference Project Termitary House, Vietnam

I wanted to create extra attention on the side of the shared communal space which can be used for informal retail. Since this space doesn't need to be wind-proof, I chose to create a perforated brickwork facade. During the day this provides a fresh air stream towards the courtyard, while in the evening the lights behind the perforated brickwork shine through and soften the boundary between the street scape and the more private interiors of the low-rise courtyard building block.

4 - Corbelled Arch

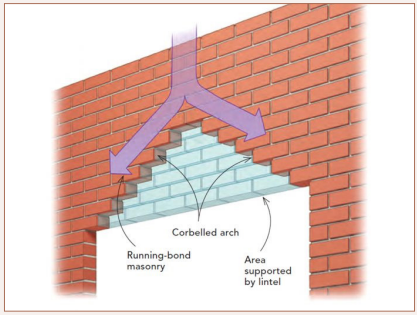


Figure 11.19 Principle of the Corbelled Arch Explained

The Compressed Earth Blocks are laid in a running-bond pattern in which every course is offset by half its length from the course below. Above openings, this pattern naturally creates a corbelled arch. A lintel which is often used to create rectangular openings, only caries the triangular section in-between the lintel and the corbelled arch formed by the running-bond pattern. In my concept where I want to use as minimum as possible different materials, lintels are tried to be avoided. Therefore, I chose to expose the natural corbelled arch as a facade opening.

5 - Linear Facade Embellishment

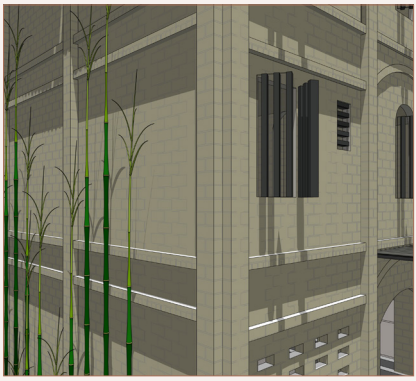


Figure 11.20 Linear Facade Embellishment

The lasts peculiarity that will be discussed are the linear facade embellishments. These are added for two reasons. First of all, I wanted to emphasize the floor levels and thereby create a clear feeling of scale. By showing these horizontal lines on the facade, people can always relate to the height of the building, and height differences for instance on the ridge are emphasized in that way. Secondly, these linear facade embellishments functions as moisture prevention for the underlying compressed earth blocks. The moist / water is is kept away from the facade, so that the facade is less likely to become obsolete and marked by nature

Production and Construction Process

Compressed Earth Blocks can be made on-site using special mobilized machines (f.i. of Oskam V/F). **These machines can produce, in a time span of 1 hour, up to around 360 blocks. This equals in 1 week around 10.000 blocks.** After the production, the stones need to be stored and kept moisturised for about 1 week to give them their maximum strength.

The production process takes times and can take a lot of space for drying and producing. On location with little free space this can cause some logistical difficulties. Therefore it is important to define the scale of the production line and accurately calculate the amounts of material needed. Often, sites at the periphery of the city are used to produce the blocks and the blocks are then transported on pallets in a truck to the production site. [first steps of production process of CEB on next page]

After the infrastructure for production is made clear, it is important to set the infrastructure up as well as to choose the staff. Since the production process of these Compressed Earth Blocks is relatively easy to learn, often **trainings are given to the community so that the people can be involved during the whole building process**. Community-involvement can be the key to making such redevelopment project feasible. Also, these “newly skilled labours” can give **new job opportunities** for the community even after the project is finished.

Figure 11.21 Production Site

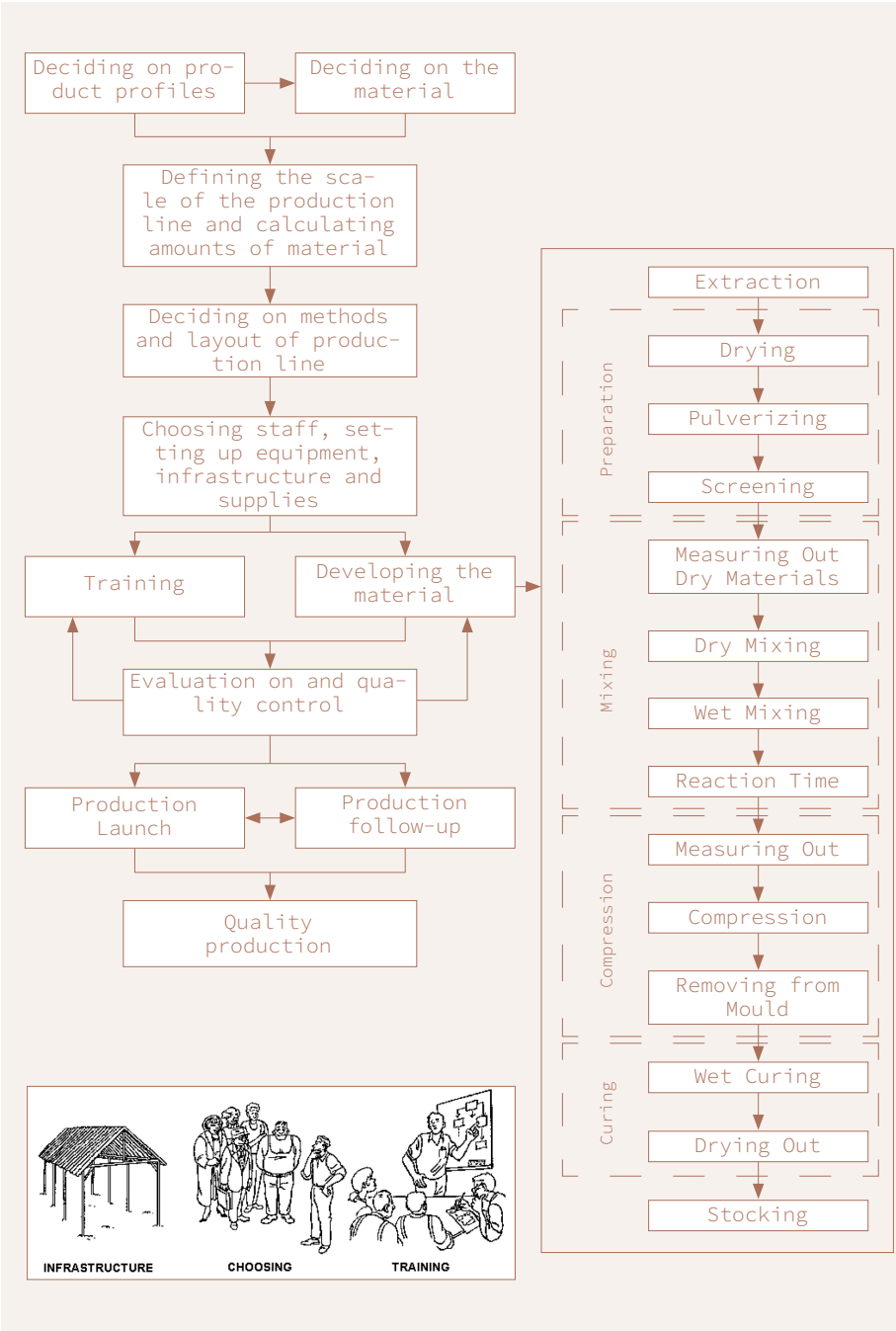


Figure 11.22 Production Process [42]

Phasing

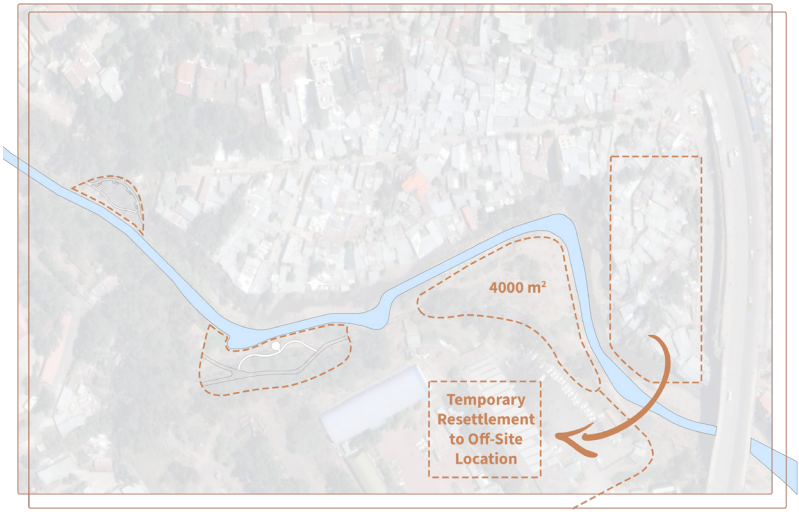
To apply the previously gained knowledge of the production and construction on my specific project, I created a phasing of the whole building process. A vacant piece of land of 4000 m^2 at the periphery of the site is chosen to locate the production line for the CEB-blocks. This piece of land is easily accessible for heavy vehicles, since the plots behind are owned by construction companies and car dealers who use heavy roads.

The total phasing consists of 7 phases. The first two phases contain the preparation of the site. In phase 2 also a group of 30 households need to resettled to an off-site location. In phase 3 they will be relocated into their new dwelling on the site. Each building phase consists then of building a certain amount of low-rise building blocks as well as the building of one “special zone. This has to do with the cross subsidization.

Phase 1

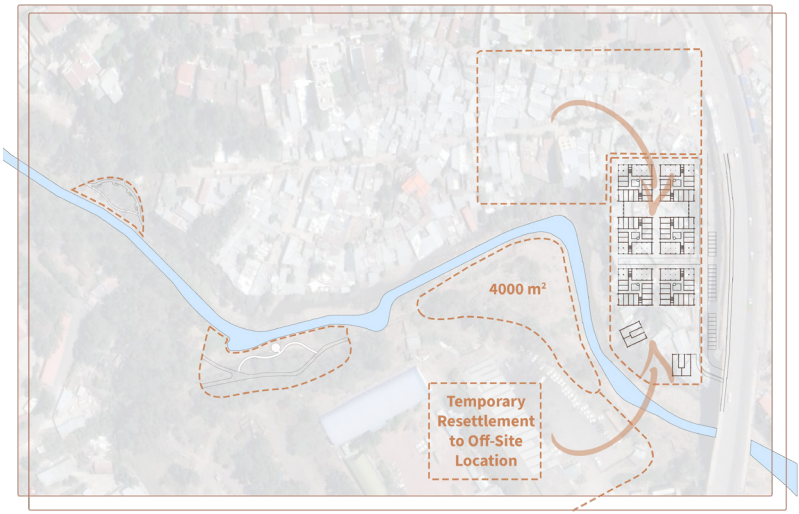
- Starting Up Production Line at Vacant Plot of Land

Phase 2



- Creation of Urban Wetlands 1 & 2 to Create Flood Buffer and Start Revitalization of River
- Ca. 30 Households Resettled to Off-Site Location

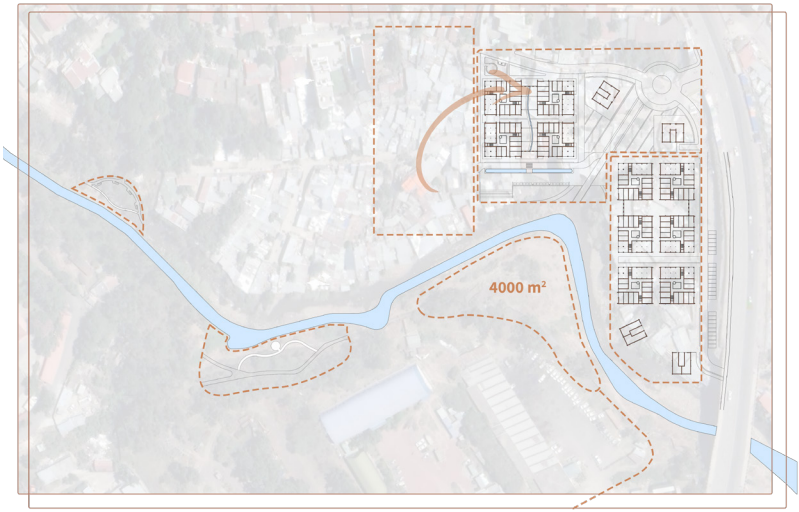
Phase 3



+ 6 Low-Rise Courtyard Blocks (ca. 90 dw.)
+ 2 Towers (ca. 30 dw.)

- Ca. 70 Households moved to New Dwelling
- *Vacant: 20 Low-Rise ... 30 Tower*

Phase 4



+ 4 Low-Rise Courtyard Blocks (ca. 60 dw.)
+ 2 Towers (ca. 30 dw.)

- Ca. 50 Households moved to New Dwelling
- *Vacant: 10 Low-Rise ... 30 Tower*

Phase 5

+ 5 Low-Rise Courtyard Blocks (ca. 75 dw.)
+ 2 Towers (ca. 30 dw.)

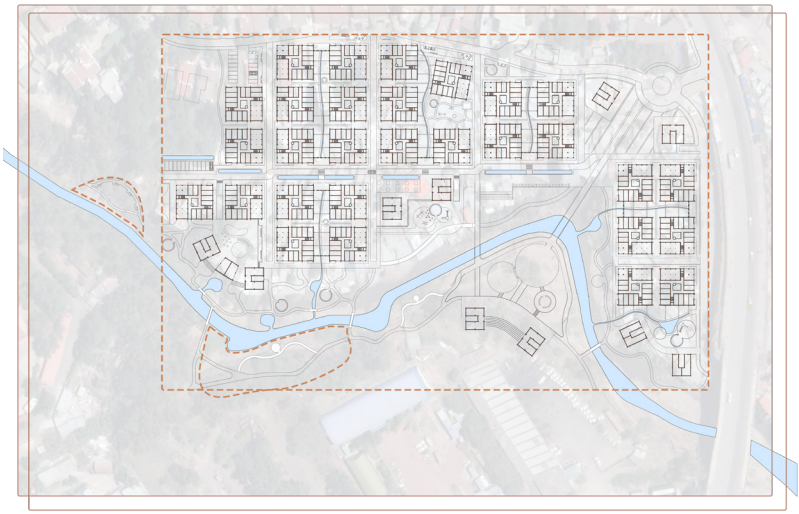
- Ca. 55 Households moved to New Dwelling
- *Vacant: 20 Low-Rise ... 30 Tower*

Phase 6

+ 10 Low-Rise Courtyard Blocks (ca. 150 dw.)

- Ca. 20 Households moved to New Dwelling
- *Vacant: 130 Low-Rise ...*

Phase 7



+ 6 Low-Rise Courtyard Blocks (ca. 90 dw.)
+ 4 Towers (ca. 60 dw.)

- *Vacant: 90 Low-Rise ... 60 Tower*

CHAPTER 12

Sustainability

Vision Statement

In the previous chapter I stated to design according to three key-principles; locality, sustainability and low-technology. With these three key-principles I wanted to achieve a certain location-specificity, an architecture bounded to its environment. For the sustainability, I wanted to achieve the same goal, creating a sustainability concept based on a location-specific principle. Therefore, I looked at an ideology / theory firstly implemented by Charles Correa, to design according to the principle of *'Form follows Climate'*.

The design of the building is adapted to the climatological influences that are present in Addis Ababa, thus making fully use of the power of nature. The focus in the design laid on the following climatological influences;

- Sun / Light
- Wind / Ventilation
- Water / Rain
- Temperature

Further topic that need clarification on the topic of sustainability are;

- Fire Safety
- Noise

Sun / Light

Since Addis Ababa is located near the equator, the city has a very high average hours of sunlight per year (2439 of possible 4383. On average, 55.6% of the day there is a clear sky, meaning a higher sun intensity. The sun intensity can be measured by the Sun Index and is measured in UV. The UV Index does not exceed 8 in the Netherlands, while Addis Ababa has an average of around 11, with a minimum of 9. **The UV Index, and thus the sun / light intensity is extremely high in Addis Ababa.**

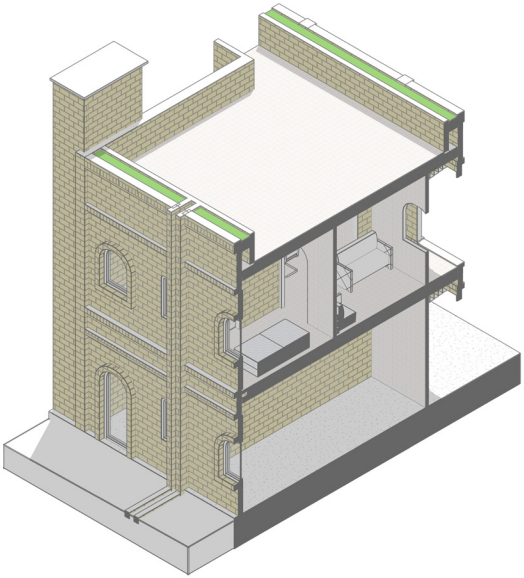
Dealing with an extremely high sun intensity means that it is important in the design to **create enough shadow spaces and places with indirect sun light** rather than direct sunlight.

For the low-rise courtyard block I have creates shadow in two different ways, also relating to the street hierarchy. Along the informal retail streets, shadow is created by **bamboo shutters**. The shutters can manually be opened or closed from within the dwelling. Thus, people themselves can decide whether to let the sun and light in by keeping the shutters open, block the sun partially, or keep it totally out by closing the shutters. Additionally, the shutters can provide privacy for the inhabitants and thus serve multiple purposes.

Along the green lanes, the communal streets, this feeling of privacy is less important. Here, a different sun shading mechanism is used. The **openings** are designed **with more depth**, by means of a thicker window / door frame. The deeper the opening, the less sun will shine inside the dwelling. I did a solar-study on this principle, and as shown on ‘figure 12.3’, during summer time, when you want to keep the heat of the sun out, the frame blocks the sun. During winter time, when this additional sun heat can be used for heating the dwelling, the sun will go underneath the frame and will get into the dwelling, thus heating it up. Detail 5 in chapter 14 - Building technology shows how this frame is made by only changing the orientation of the compressed earth blocks.

Figure 12.1 Manually Operatable Sun Shading at Retail Street

Figure 12.2 Fixed Sun Shading at Green Lanes



Summer

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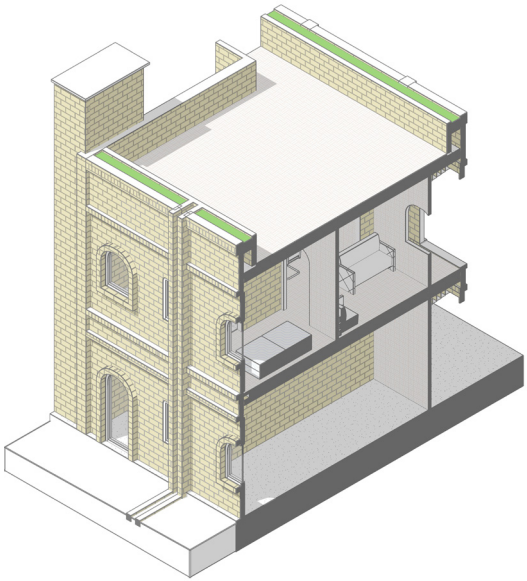
14:00]



Winter

[21-12-2021,
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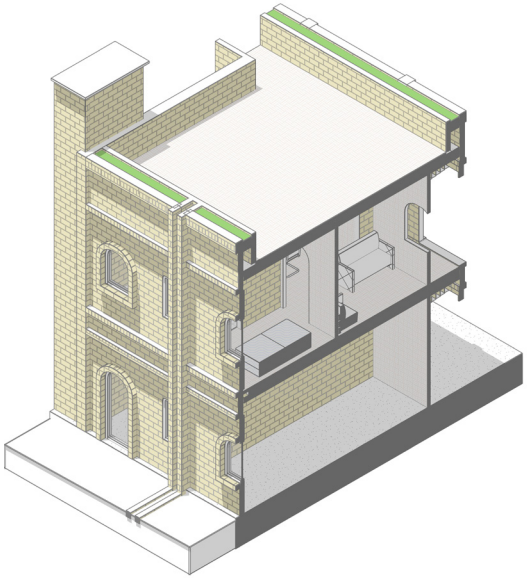
Figure 12.3 Solar Study on Fixed Sun Shading at Green Lanes



Spring

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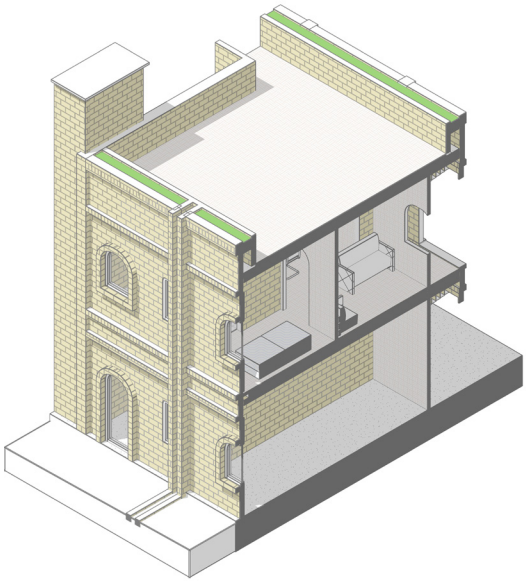


Fall

[09-11-2021, 14:00]

Wind / Ventilation

The goal stated for the sustainability concept was to design following the principle ‘Form follows Climate’, thus relying on natural principles. This concept is continued in the design for the ventilation concept. I did analysis on possible solutions for passive ventilation systems and looked among others to passive ventilation systems such as cross-ventilation, single-side ventilation or stacked ventilation. Soon, I came to the conclusion that most of these systems will lack its functionality due to the high density of the neighbourhood. The air wouldn’t have enough space to circulate and won’t provide enough ventilation capacity that is needed.

Therefore, I had to think about other solutions. The building form of the low-rise courtyard block seemed, on the first glance, applicable for a traditional courtyard concept which is commonly used in architecture of African and Asian countries. Nevertheless, since Addis Ababa is located at a very high height, and thus has lower temperatures throughout the year, this temperature difference in- and outside the courtyard wouldn’t possibly be enough to create the air flow.

Solar Chimney

The final solution I researched was using a **solar chimney**. At the end, this system of a solar chimney creating the air flow through the building block is implemented in my design. Also, *ideas of the traditional courtyard ventilation concept have been implemented in the design for my ventilation principle*. ‘Figure 12.4’ shows the principle of the solar chimney implemented in the Low-Rise Courtyard Block.

The air enters each dwelling unit through the courtyard. In the courtyard, the air is cooled down or warmed up, depending on the outside temperatures, and the vegetation that grows in the courtyard removes dust and pollution out of the air. From out the courtyard, the fresh air moves first through the rooms that need the freshest air; the living room and the bedroom. After that, the air flows into the kitchen and bathroom where the air will be sucked out.

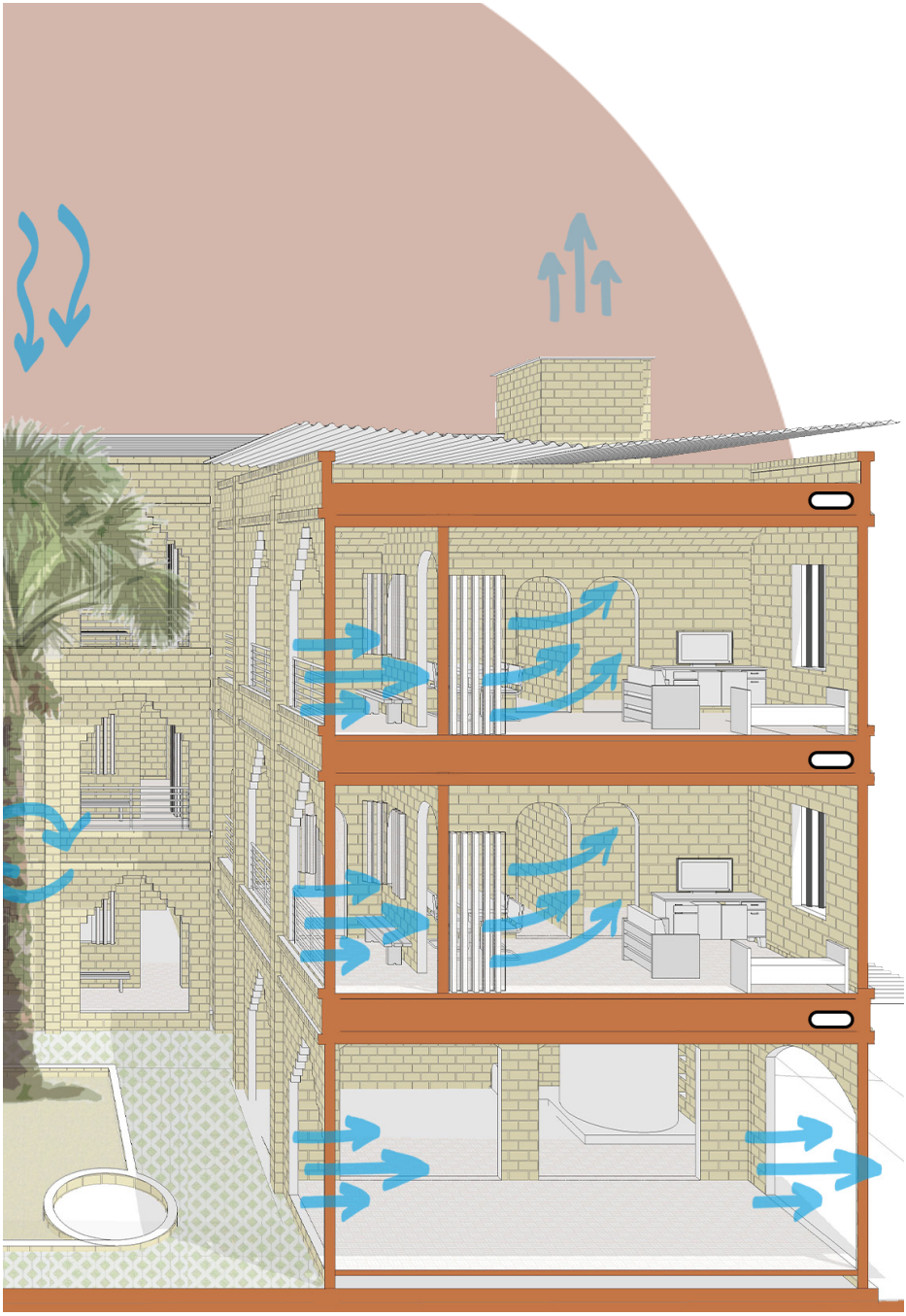


Figure 12.4 Ventilation Concept in Section [Scale 1:100]

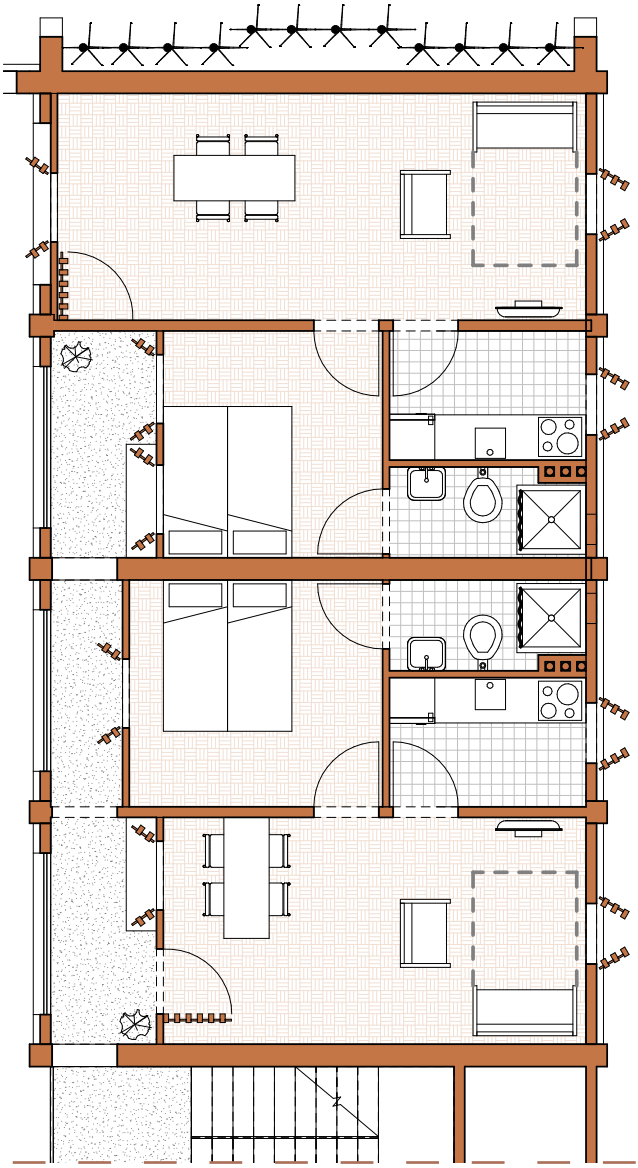


Figure 12.5 Ventilation Concept in Dwelling (1-Bedroom) [Scale 1:100]

‘Figure 12.5’ shows the same ventilation concept in floor plan. This figure shows how the ventilation concept works in case of the 1-bedroom dwelling type. However, for each other possible dwelling type, the concept stays the same and the location of the shafts and “wet cores” will be located on the same spots.

So, as stated on the previous page, the air enters the dwellings through the courtyard and the gallery. It first enters the living room and the bedroom, after which the air flows through these rooms towards the “wet cores”. Here, the overhead shafts are located that suck the air out of the room and transport the air towards the solar chimney, located behind the staircase.

The height of this solar chimney have been designed based on the calculations for the solar chimney, see “APPENDIX D” on page 230. The height is of great importance since this influences the total possible air suction and thus the total ventilation capacity of the solar chimney.

Additional ventilation can always be created by opening the windows. Each room will have open-able windows.

Water / Rain

In the context of Addis Ababa, water management is one of the most important topics to deal with. During the rainy season (the Kremt) often floods occur at the riverbanks. Other water relating disturbances Addis Ababa has to deal with are the bad water conditions, the river pollution, the dry ground due to impervious land surfaces and the enormous amounts of indirect storm water. All of these factors are catalysts for the floods that occur in Addis Ababa. [see “Floods Explained” on page 64]

Many of these problems can be related back to the idea of the “concrete city”, a city consisting of huge areas of impervious land surfaces made of concrete. Most new developments, for instance, consist of concrete pavements which are impermeable for rain water. All this rain water will somehow flow to the lower points, often being the rivers. Not only the rivers get overflown with water, causing the floods during the Kremt, but also the sub-soil water levels have decreased, since the concrete and even informal settlements only allows water to flow to the rivers instead of infiltrating the ground. This causes a unstable and dry soil which can lead to landslide. Therefore, the vision relating to water management on the scale of the masterplan is: **reducing water load on the rivers by creating permeability and buffers.**

The sustainability concept relating to water / rain can be subdivided in two scales; the *neighbourhood scale*, and the *building block scale*.

The sustainability concept of water management on the neighbourhood scale is already explained in ‘Chapter 6 - Revitalized Riverbank’. Bio-swales and urban wetlands function on the bigger scale to reduce the water load on the rivers by creating zones of permeability and buffering.

The concept on the building scale have not yet been elaborated on. This concept relies on two principles; *efficient re-use of drinkable rain water* and *efficient re-use of polluted water for “grey water purposes”*.

Water Collected on Corrugated Metal Sheet Roof and Let to Shared Communal Space

Filtered Water Basin in Shared Space to Provide Drinking Water to Residents

Figure 12.6 Efficient Re-Use of Drinkable Rain Water

Open Rainwater Drainage System [Kéré Reference]

Facade Embellishments, also to protext CEB from weathering (moist)

Figure 12.7 Efficient Re-Use of Polluted Water for “Grey Water Purposes”

Efficient re-use of drinkable rain water

On the scale of the building block, the goal is to use the water in an efficient way. Rain water that is being collected by the corrugated metal sheet roof will be harvested to create safe drinking water. The rainwater that is collected will flow automatically to the water basin placed in the communal shared space. Every inhabitant of the building block will have free access to this water source. On the next page a calculation is done on the capacity needed of the water basin based on the monthly rainfall in Addis Ababa.

Efficient re-use of drinkable rain water

Rain water that falls on the shared roof will flow towards the green alley via the open rainwater drainage system. This water won't be applicable for drinking water, since the floor area of the shared roof will be more contaminated since the roof is accessible. Therefore, this water can be used for small scale food cultivation in the green alley. The residue of this water will be lead to the bio-swales.

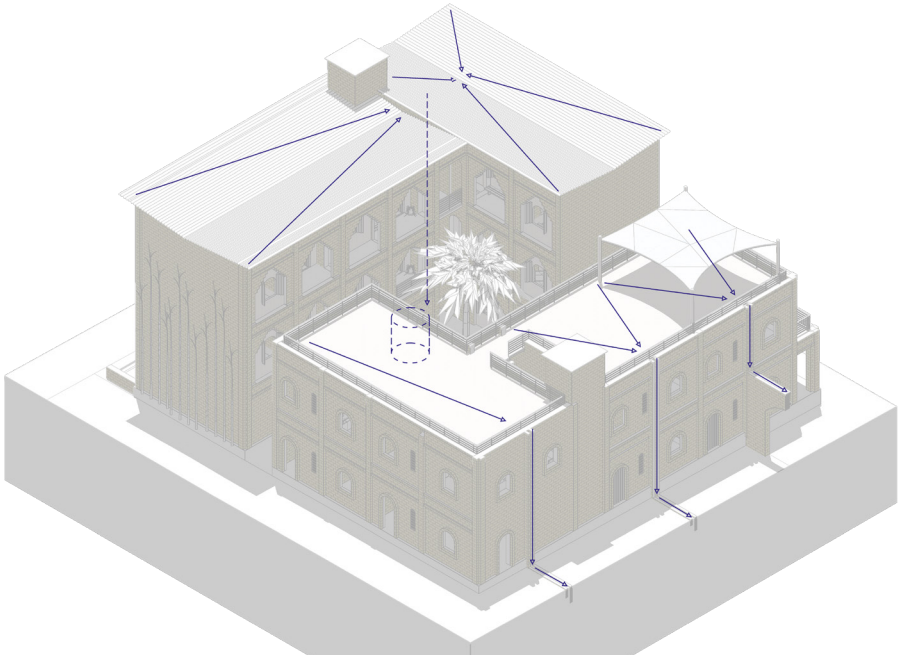


Figure 12.8 Water Management Low-Rise Courtyard Block

Monthly Precipitation

[Month]	[mm]	[Month]	[mm]
January	18	July	386
Februari	28	August	419
March	72	September	286
April	147	October	51
May	178	November	11
june	271	December	7

Maximum Possible Amount of Water to Harvest

Total Roof Area: 250.79 m^2

[Month]	[m^2]	[L]
January	4,5	4.514
February	7,0	7.022
March	18,0	18.057
April	36,9	36.866
May	44,6	44.640
June	67,9	67.964
July	96,8	96.805
August	105,1	105.081
September	71,7	71.725
October	12,8	12.790
November	2,8	2.758
December	1,8	1.756

Determination of Water-Capacity Water Basin.

Average water use in Addis Ababa: up to 30 lcpd (litres per capita per day)

Water Basin size recommended inbetween 10.000 to 15.000 litres. This shall be enough to provide drinking water and to be used for other daily activities in the courtyard.

Figure 12.9 Calculations Water Capacity Water Basin

Fire Safety

Since I couldn't find the regulations on fire safety of Addis Ababa, I have made my design based on Dutch rules ['Bouwbesluit 2012']. Both building typologies are made of Compressed Earth Blocks. This **material is** known to be **not flammable** and thus, is a good material for fire safety.

Low-Rise Courtyard Block

In the design of the low-rise courtyard block each staircase is surrounded by double thick walls of compressed earth blocks, and thus will provide enough safety to function as a separate fire compartment. People only have to pass a maximum of one door to reach the stairs or the exit of the buildings and thus, this is in line with the Dutch fire regulations. The maximum distance from door to the stairs is 9 metres and thus people can easily escape safely in case of fire.

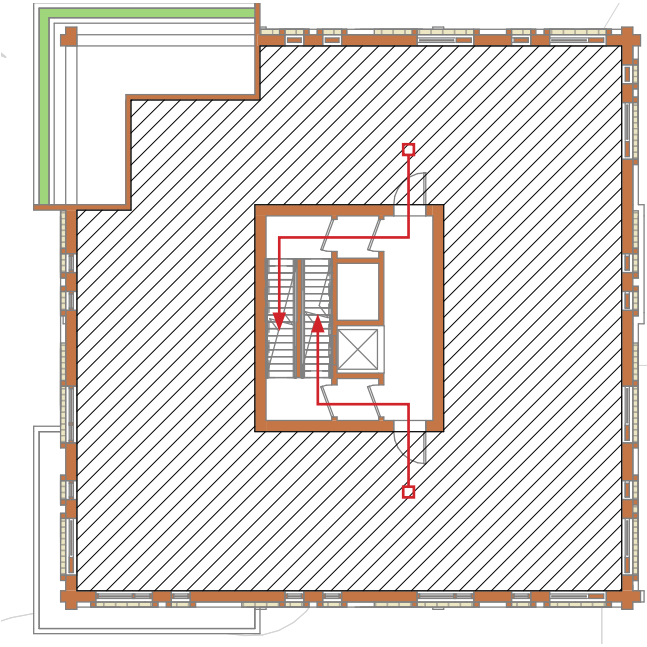
Tower

In the case of the tower-typology, I had to design with a lot more levels, thus the escape routes should be designed with even more detail. For the tower I decided to design a 'wokkeltrappenhuis' or scissor staircase [see 'Figure 12.10]. This is a staircase principle where two separate fire staircases surround each other to turn. An important point of attention while designing these staircases is that at all times, the escape routes should be independent spaces and remain separated from each other till the ground floor. [43]

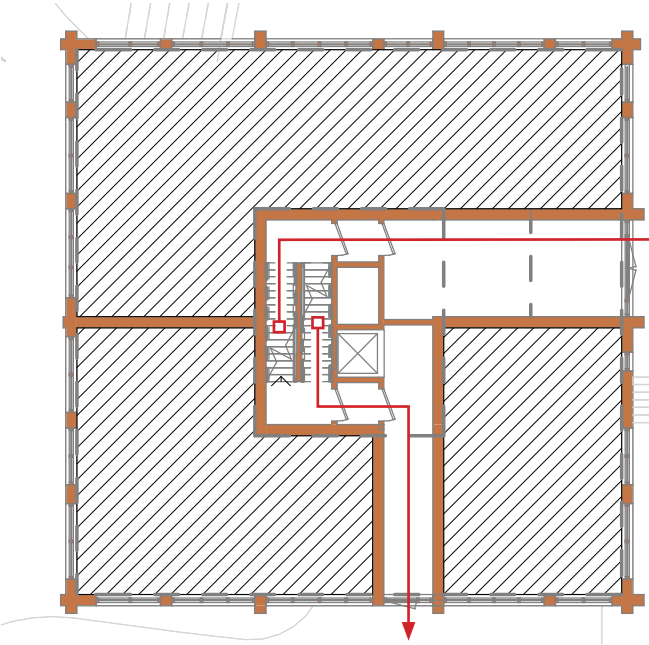
Adaptations in Masterplan

In case of fire, it is not alone important to be able to escape the building, but it is also very important to be able to stop the fire before it spreads to other buildings. Therefore, I made a few adaptations in the masterplan.

In the design of the neighbourhood, every building is accessible for the fire department. All streets and corners are measured on a minimal dimension (3.5 m width) that a fire truck could enter the street and get as close as possible to the fire source. Also, the buildings are located on a distance from each other that the fire won't spread easily (> 1.5 m).



+ 1 Levels
Max. distance from dwelling to stair = 3.5 m



Ground Floor
Max. distance from stair to exit = 8 m

Figure 12.10 Fire Staircase in Tower-Typology [Scale 1:200]

Sound / Noise

The last topic of sustainability is ‘sound / noise’. In the design of the revitalized riverbank informal settlements I have taken into account the issues of sound / noise on different levels of detailing.

In the design of the streets, materiality was a very important design decision relating to sound / noise disturbance. The main road, only road accessible by car, is materialised in a different way then all the other roads. Since cars can use this road, the disturbance of noise can be way more when for instance applying cobblestones. Therefore, I have chosen to give the main road a more massive (asphalt) material. This prevents reverberating the noise to the dwellings, and thus prevents possible disturbances of the noise.

Further, on the building scale, I have looked at how noise from neighbours (above or adjecent) could be cancelled out as much as possible. To prevent “horizontal noise” I created dubble thick walls of CEB (295 mm) between different dwellings and at the gabbles. The acoustic properties of CEB are, per 40 cm, a sound insulation of 56 dB. Thus, with the double thick walls implemented in the design, I create a sound insulation of 41.3 dB, which is slightly lower than the Dutch regulations. Also, I made sure that in the floor plan the bedrooms of two different dwellings where facing each other, so that these less noisy spaces function as a buffer for the noise.

The impact sound through the floor does meet the requirements stated in the Dutch regulations. A thick layer of sand on top of the vaulted CEB ceiling creates high acoustic properties.

CHAPTER 13

Managerial Strategy

Introduction

Using a "physical model" of a huge paper and sticky notes, I developed the managerial strategy, see 'Figure 13.1'. A Stakeholder Analysis and a Managerial Strategy have been developed onwards. In general, the strategy aims to ***use strong existing structures within the context of Addis Ababa***. Therefore the condominium system has been used as a reference. Systems such as the loan with down-payment and using strong existing social networks, community iddir, are integrated in the managerial strategy to create a social safety net.

The managerial strategy is based on two focus points: ***the development and operation of the building construction***, and ***the development and operation of the urban space and riverbank***. The key stakeholders, shown in the Stakeholder analysis, will play a major strategic role in this development and operation. They need to continuously interact with each other and make decisions keeping in mind each others interest as well as the interests of external stakeholders.

The managerial strategy is based on vision and feasibility and therefore the motto will be: keep costs low during the development, to create affordability and feasibility during operation by using local strengths of the urban space and riverbank.

One of the most important aspects in keeping the costs low is ***creating locality***. The choice of materials is based on this aspect and thus makes it also possible to use local labour, this all can, even with participation of the community, reduce the costs of the projects a lot. ***Reduction of costs means, simply said, also a reduction in selling / rent prices***, thus creating more affordability and thus feasibility for the project. The third aspect of the motto, creating a local production and market, is focused on the growing bamboo market in Ethiopia. This growing market presents an enormous potential for riverbank settlements, since the crop can be used for retail, while at the same time can increase the riverbank quality, and thus livelihood of these environments.

Stakeholder Analysis

The stakeholders analysis shows all the stakeholders that are involved in the process. The first scheme, 'Figure 13.2' makes a distinction between the internal and external stakeholders. This scheme is then translated into 'Figure 13.3' which shows the 'power / influence' against the 'interest' of each of those stakeholders. This scheme concludes which stakeholders will be the key-stakeholders; those with high power and high interest, and thus who will play a major strategic role in the development and operation of this project. Also, it divides the rest of the stakeholders in three groups; 'Keep Informed', 'Keep Satisfied' and 'Minimal Effort'.

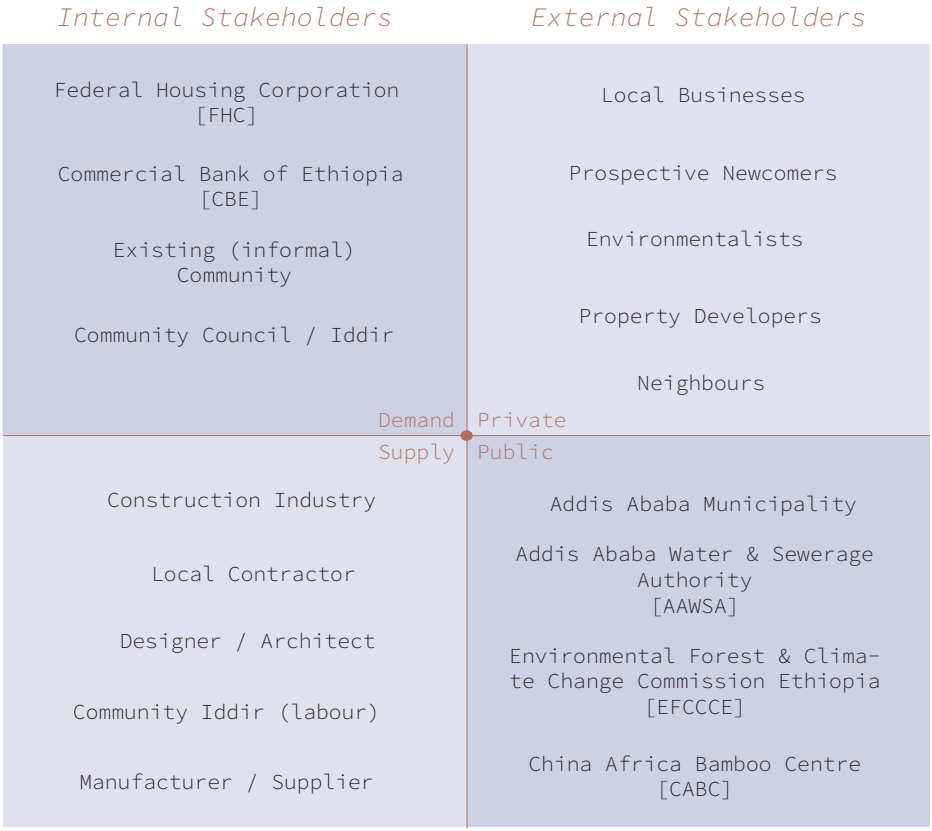


Figure 13.1 Internal & External Stakeholders Analysis

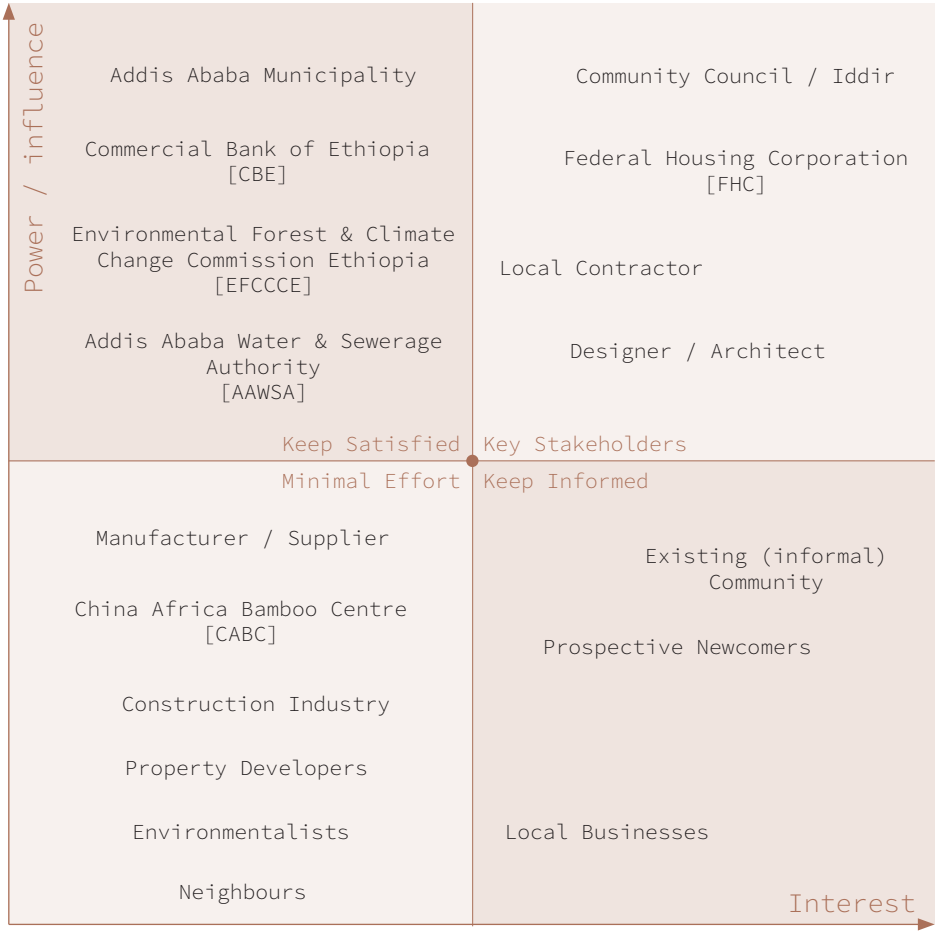


Figure 13.2 Key Stakeholders Analysis

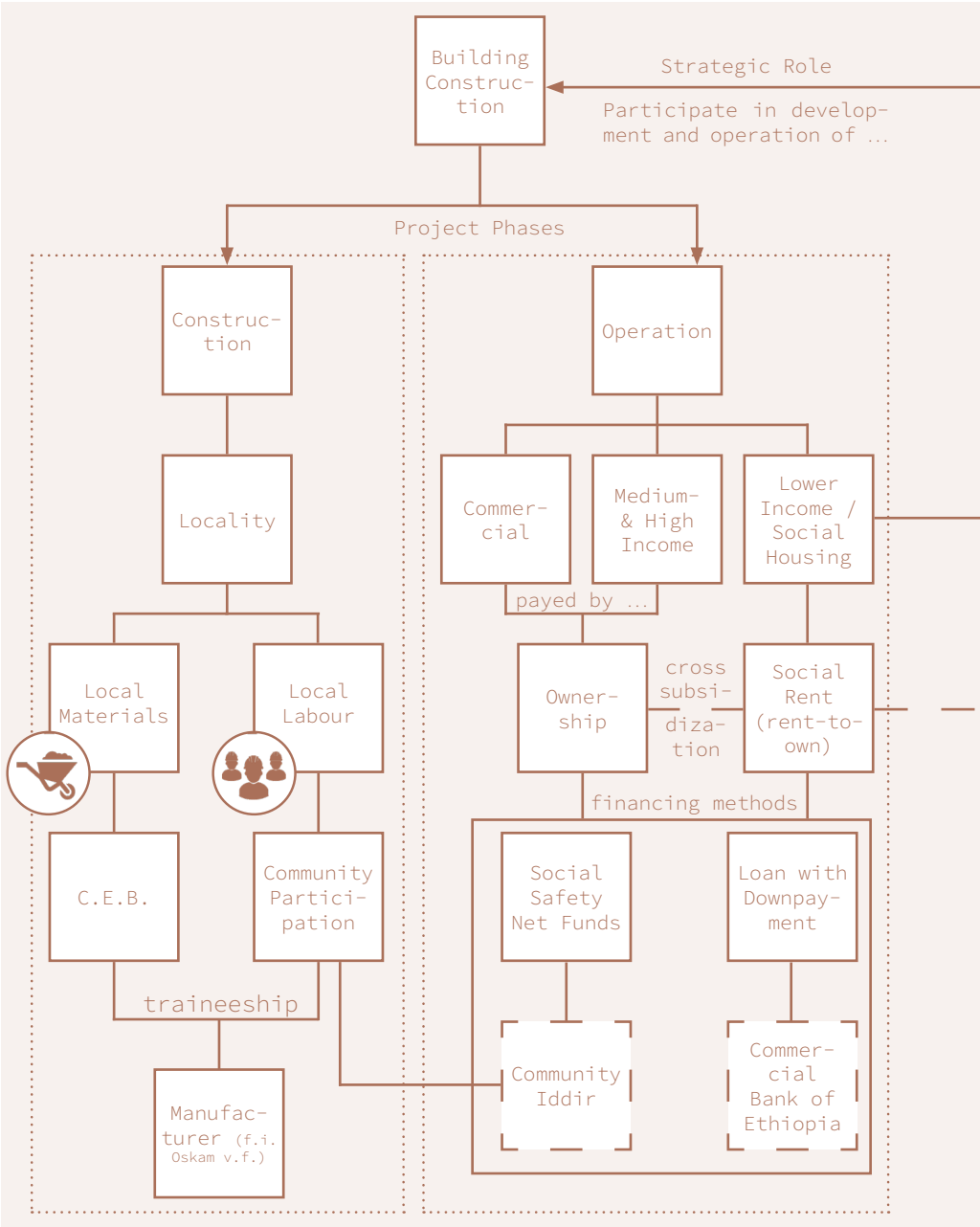
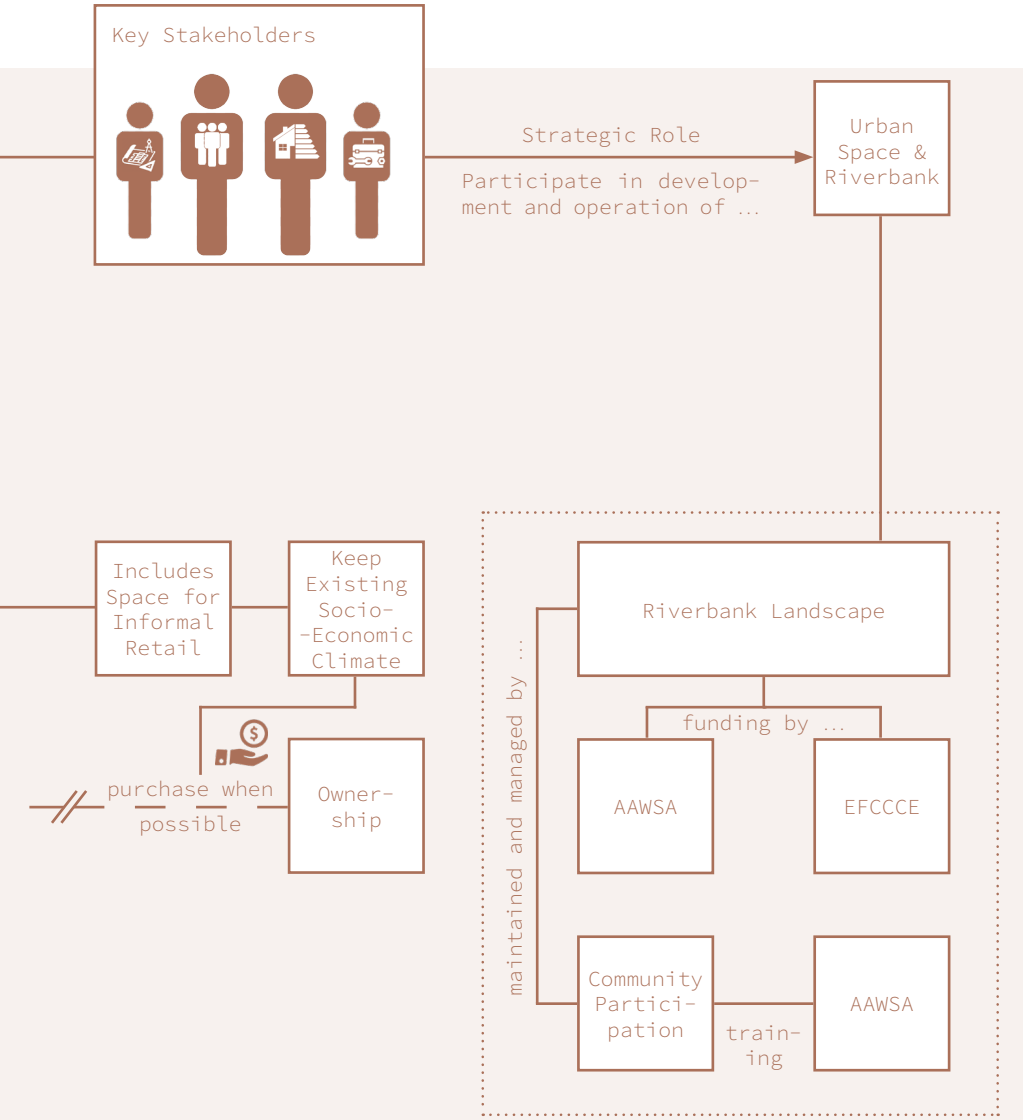


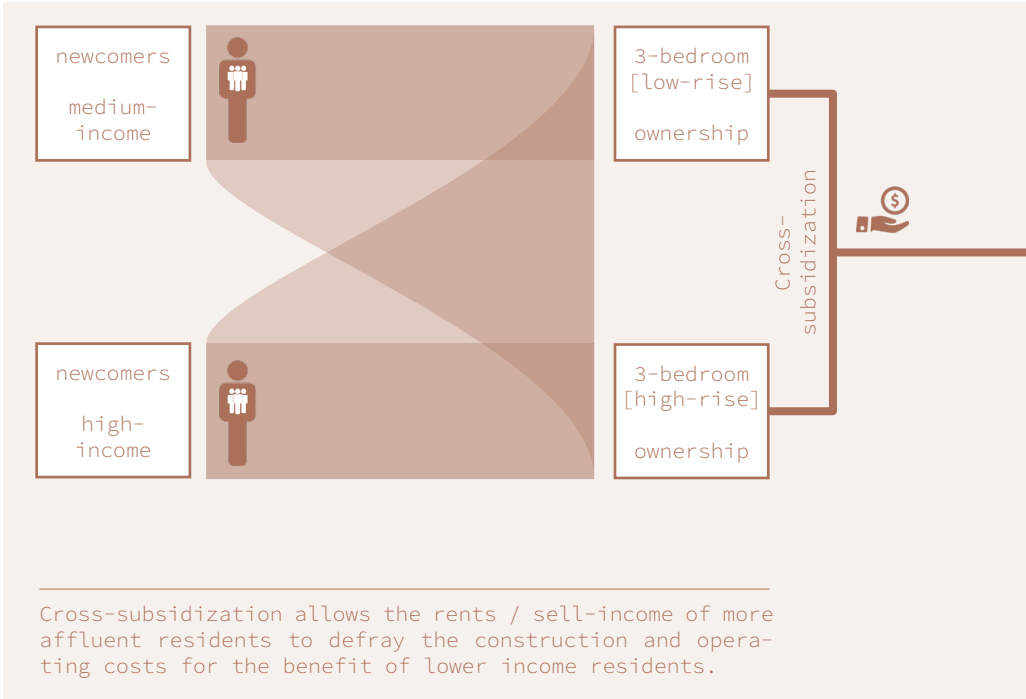
Figure 13.3 Managerial Strategy


Key Stakeholders
Strategic Role
Participate in develop-
ment and operation of ...
Urban
Space &
Riverbank
Includes
Space for
Informal
Retail
Keep
Existing
Socio-
-Economic
Climate
purchase when
possible
Owner-
ship
Riverbank Landscape
maintained and managed by ...
funding by ...
AAWSA
EFCCCE
Community
Partici-
pation
train-
ing
AAWSA

Operation; Cross-Subsidization

As one of the key-stakeholders, the FHC, Federal Housing Corporation, will play a major role in providing the dwellings. The ownership of all buildings will, during construction, be by the FHC. The main goal of the FHC will be to create 'return on investment'. Therefore, the best and quickest way to get this return is by selling the dwellings. But, since housing the current informal settlers is one of the main goals of this managerial strategy, it is important to create affordable (rent-able) housing for them. So, this means that the FHC won't be possible to sell all the dwellings that are being build. To still create that 'return on investment', the managerial strategy proposes a system of Cross-Subsidization [see 'Figure 13.4'].

Cross-subsidization allows the rents / sell-income of the more affluent residents to defray the construction and operating



Cross-subsidization allows the rents / sell-income of more affluent residents to defray the construction and operating costs for the benefit of lower income residents.

Figure 13.4 System of Cross-Subsidization

costs for the benefit of the lower income residents. Thus, by selling (creating ownerships) amongst the medium- and higher income, you create a buffer to lower the rents for the lower income. In that way, the lower income and current inhabitants of the neighbourhood will also get the change for affordable housing.

Further, the construction of down-payments, also implemented at the condominium project, creates further 'return on investment' for the FHC. Inhabitants who are not able to currently buy their dwelling will have the possibility to rent-to-own the dwelling. Depending on the dwelling typology the inhabitant will pay a certain down-payment (percentage of the total construction costs) and will later pay rent to further own the dwelling. At the time the total construction costs are covered, the inhabitant get the home-ownership of the FHC and will officially be home-owner of the dwelling.

Ownership

The land of the whole neighbourhood is owned by the state, which is represented by the Federal Housing Corporation. The maintenance, however, will be regulated by the community iddir. They will select people of the community to keep the neighbourhood clean and take responsible for cleaning up the streets, the riverbanks and the river against a fee.

The riverbank and rivers are owned by the Ethiopian Government. They will subsidize the redevelopment of this river ecology and will keep the ownership over these river areas. Again, the community can play a major role in maintenance here.

The buildings themselves are owned by the home owners or the FHC, as stated in the previous section. Both the home owners as well as the FHC have to maintain the building blocks / towers and are responsible for keeping them in good state.

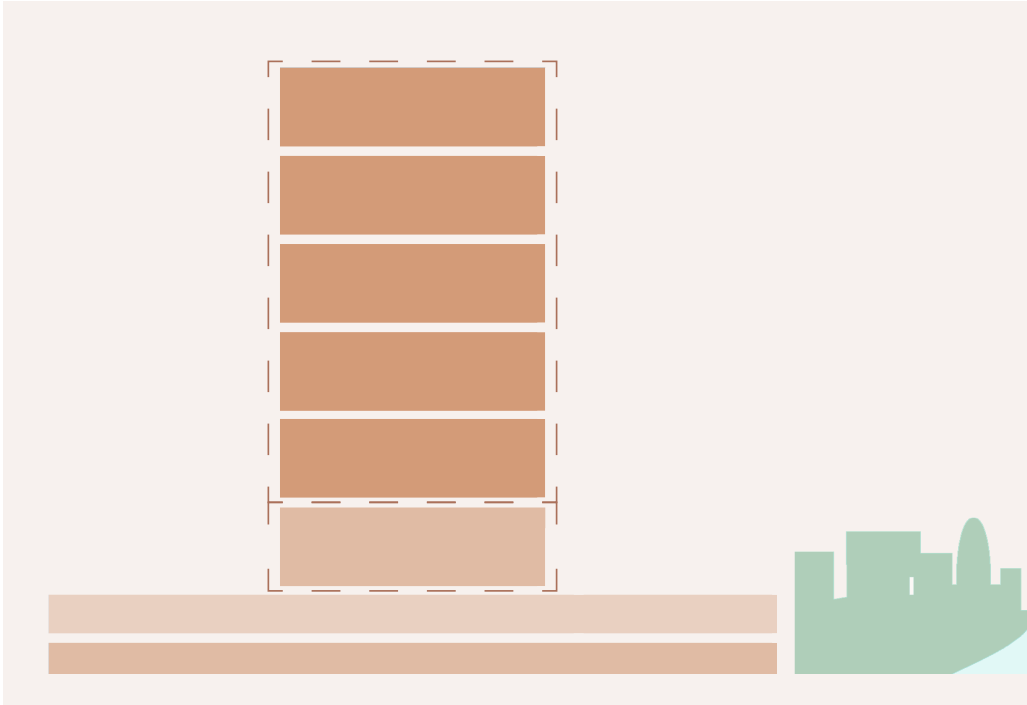
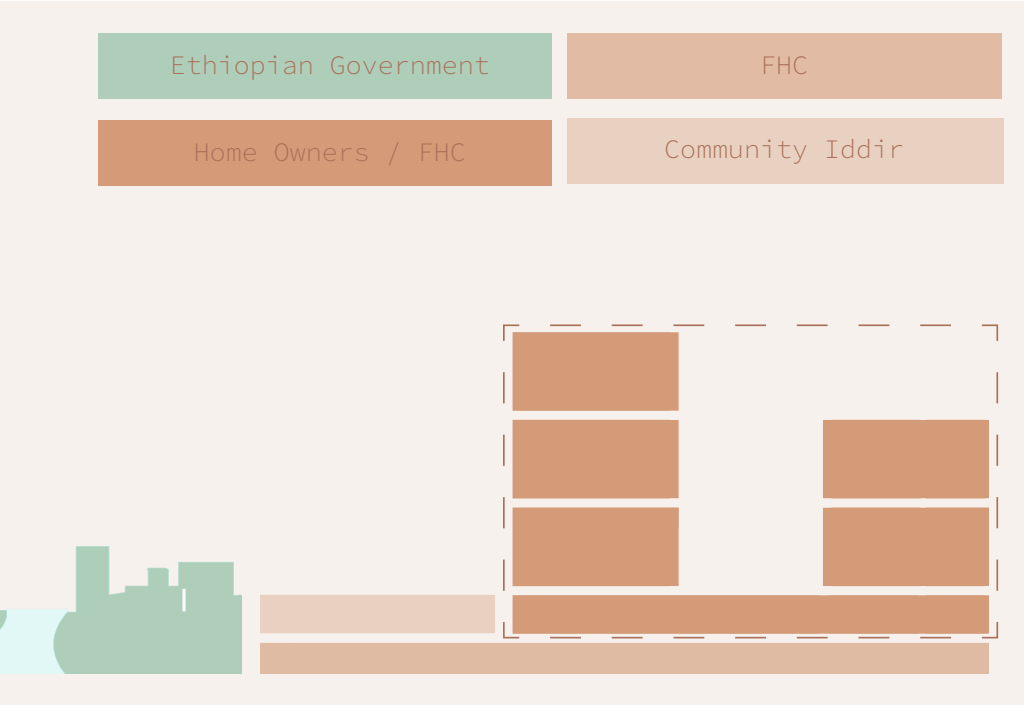


Figure 13.5 Ownership of Land / River(bank) / Buildings / etc.

The ground floors of the towers will cater for public functions. The ownership of these spaces will rest with the Ethiopian Government, that can rent out these spaces and in that way create a return on investment on the revitalization of the riverbank. Maintaining the riverbanks, cleaning the plastic pollution that is caught in the wetlands as well as building up the riverbanks and amenities on the riverbank can create job opportunities. The Addis Ababa Water & Sewerage Authority will together with the community iddir play a major role in coordinating and managing this. By involving the community in the planning and design of the riverbank you further increase the connection and feeling of responsibility of the community towards the riverbank.



CHAPTER 14

Conclusion

In the problem statement and design hypothesis, I came up with the following research question: ***'How can Addis Ababa implement a strategy to densify the city, that caters for the rehabilitation of the riverbanks as well as creates a dwelling landscape that takes into account the cityness of the informal city of Addis Ababa?'***

The proposed design takes into account both the challenges caused by the rapid urbanization (degradation of rivers and riverbanks, forming of informal settlements, rupture from traditional ways of life), as well as the challenges of rapid urbanization itself (dwelling deficit, informal businesses, etc.). A design is proposed in which a dwelling landscape with around 5 times the density of the current situation is combined with a revitalization plan for the river and riverbanks. In this design, the specific focus lays on both the rehabilitation of the rivers and riverbanks, as well as the creation of safe and adequate housing for the current informal settlers.

The dwelling landscape in the design is formed by two building typologies. The low-rise courtyard block, which resembles the traditional habitation patterns of the current informal riverbank settlements, and the towers, which cater for the attractiveness of the neighbourhood and are necessary to create a feasible project. Both building typologies are placed in cohesion with each other, what should stimulate equal changes and the possibilities to benefit from each other (in a positive way). Just like the current cityness of the informal city of Addis Ababa, where the socioeconomic climate consists of a juxtaposition of luxury and squalor.

The rehabilitation of the river and riverbanks is the second specific focus of the design. It proposes the river as a shared resource and let the river, again, be part of the city as a piece of urban infrastructure. This is emphasized by creating "special zones" (squares and towers) along the riverbank to attract the public and create those important axis.

CHAPTER 15

Reflection

The aim of this reflection paper is to look back at the overall process and results of this 'Addis Ababa Living Lab graduation project'. Initial goals, proposed approaches and envisioned processes have changed during the whole graduation. This final reflection tries to create an accurate insight of those developments and the progress I made in my project, as well as what I've learned from my own work.

Prior Knowledge & First Impressions

Starting my master in 2019, I had just been on holiday to South Africa. There, for the first time on such a big scale, I saw the huge differences between the lower-income and the higher-income population, the different ways people could live and the big contrasts of livelihood that happened even within one city. For me, this story of inequality was a gripping story. The first year of my master I dedicated my history thesis to this story of inequality in South Africa, and how newly implemented housing developments in South Africa seemed to fail over and over again. The inhabitants wouldn't adapt to their newly gained houses and resorted one by one back to building their own informal houses. The graduation studio 'Addis Ababa Living Lab' was for me an obvious choice to further explore this interest in global housing challenges. It was clear to me that the situation in Addis Ababa was in no way comparable to the housing challenge of South Africa. Nevertheless, the knowledge I gained from my history thesis has come in handy in terms of approach and stated goals. The deficits I saw in the South Africa's Housing Developments were very similar to the deficits in Ethiopia's Housing Development (condominium project). Since housing affects the everyday life of virtually everyone, the lack of regionalism, adaptability to its context which I found in the condominium project, caused that people did not fit in their newly gained houses. Their traditional lifestyle did not fit within the framework of the condominium project.

Topic, Research & Design, and Research Methods

Continuing on those first impressions and based on preceding research on the context of Addis Ababa, my problem statement and research question emerged;

"How can Addis Ababa implement a low-rise high-density urban scheme that contributes to densifying the city and at the same time creates social sustainability and fits the cityness of the informal city of Addis Ababa?"

Defining this research question was the starting point of the subsequent design and additional research. The main topic in the research question, 'cityness of the informal city of Addis Ababa', became the guideline of my project. Therefore, the first step in my research was an exploration on this cityness of the informal city of Addis Ababa. For this research I used various research methods, such as watching documentaries, reading interviews with informal squatter settlements dwellers or finding surveys that tell more about those informal settlements. Further, sources such as literature reviews or local websites helped me to create a clear narrative on what the cityness of the informal city implies. As a way to represent this narrative, I made a graphic anatomy that shows the key strengths, weaknesses and threats of the cityness [see 'Chapter 4 - What Once was a Riverlandscape']. Mainly during the first stages of the design process, this narrative and additional research were the greatest input for most of my design choices. For instance the logic behind the low-rise courtyard building block typology is an example of how I have tried to translate my research into the design. As introduced in my design, the typology is an architectural translation of current livelihood patterns in these informal settlements. The shape, amenities and ambitions where based on the research on the cityness of the informal city of Addis Ababa and emphasized the strengths of the cityness and tries to overcome the weaknesses and threats.

However I did this extensive research on the cityness of Addis Ababa, using various methods in which I tried to use as much as possible primary sources, I

sometimes really missed the real experience of visiting such informal settlements. Due to the pandemic, we weren't be able to go to Addis Ababa, and we weren't able to visit the chosen sites. Thence, we were never been able to really study the everyday life and inhabitation patterns that occur in these neighbourhoods. This meant that I had to rely mostly on secondary literature sources. In a project where I mainly tried to focus on the needs of the dwellers, it was sometimes weird to make those assumptions for what would work for them in the design, instead of having a participative process in which you could really reflect your design with the proposed target groups.

As the project proceeded, the narrative around the cityness of the informal city of Addis Ababa and the translation of this cityness into my design of the low-rise courtyard building block was satisfactorily. However, I struggled with embedding these low-rise courtyard building blocks into the context of Addis Ababa. For a certain time in the design process I was not aware of the exact location within the urban context and of the site specific elements such as the topography. Most feedback after the P2 and in later phases of the project pointed this out. I struggled with this problem for a while and started to avoid the problem by focussing on other topics.

Figure 15.1 Sequence of Graphic Anatomy as Exploration of Cityness

What was important to me and what eventually really helped, was to, first, clearly define the problem I was facing and then use research as a tool to solve the challenge. Where in the first phase of the project the research formed the basis for the design, this changed during the entire process to the opposite. The research became the tool to solve challenges occurring in the design. Thereby, I made use of two different research and design methods.

First, I started to look back at the research which we have done as a group. This research focused on gaining a broad understanding of Addis Ababa and Ethiopia as a whole. Thereby, focussing on topics such as ‘facts and figures’, ‘genius loci’ and ‘habitation’. By looking back at this research and looking at certain trends in the context of Addis Ababa, I could make deliberate design decisions. For example, when I focussed on street hierarchy in my masterplan, I struggled with deciding what kind of street-scape was needed in the masterplan. By looking for instance at the modes of transport in Addis Ababa and the current use of the streets in the informal settlements, I could create a clearer vision of how the streets in my masterplan should be designed, which amenities are needed, and what kind of spaces suit the life on the streets of Addis Ababa.

The second method I used, was a process of site analysis and adaptation. By really going into detail on the site’s specific elements (the ridge, the meandering river, connecting urban fabric, etc.) I could create a clearer image for myself of how the neighbourhood was located, which challenges the neighbourhood had to face and how I could relate to those challenges. In this case, the design of the river and riverbank can be used as a fitting example. I was familiar with the problems Addis Ababa has to face relating to flooding of the river and the aggravating effect the deteriorated riverbank has on those floods. A research on meandering rivers gave me the possibility to point out various critical spots within the riverbank in relation to flood-risks. Those critical spots became the first focus points in the strategy which I developed for the riverbanks. The

research that followed, focussed on passive / natural ways of dealing with such flood risks and integrated the solution, i.a. the implementation of urban wetlands, into my design. In this way I was able to narrow down my focus on specific problems in the design and conduct targeted research to come up with design steps fitting to the narrative of my project.

Relevance

What I stated in the first topic of this reflection paper describes the relevance of this studio and this design task; housing affects the everyday life of virtually everyone. In the context of this studio, Addis Ababa Living Lab, my goal was to create a sustainable housing development that cater the cityness of the informal city of Addis Ababa, but also comes up with solutions for ongoing problems for those informal settlers. In my research I talked about rapid urbanization and how this process influences developing cities and the life of many within these cities. It has not only impact on the housing demand, but also social or ecological drawbacks of the rapid urbanization can be seen. In my design, the most important ecological drawback I describe is the degradation of the rivers and riverbanks. In my design I have tried to come up with solutions on how a sustainable housing development can not only improve the life of many, but also can accommodate an environment in which high-density housing goes hand in hand with sustainable ecological development.

Ethical Issues and Dilemmas

The most obvious ethical dilemma I have encountered is, again, the realisation that housing affects the everyday life of virtually everyone. And so will my design. Just as previous Ethiopian Housing Developments, such as the condominium project, I propose a project in which current informal settlements will be demolished and will be replaced with new buildings. In my research I talked about how the previous housing development projects resulted in existing communities that were being torn apart. The socio-economic climate on which peoples livelihood depended was neglected or didn't fully work in those new housing projects. In my design I tried to address this socio-economic climate and tried to cater for the needs of those informal dwellers to keep this climate intact. This is done by looking at the research to which spatial and social characteristics seemed to be a virtue for this climate. However, even if the project is developed with all those good intentions, the actual use of and adaptation to the development is hard to estimate. It is undeniable that the socio-economic climate will change slightly, since the whole neighbourhood will get a different dynamic. And even those little changes can have bigger consequences for the already vulnerable informal dwellers. Therefore, in potential application of the project it is more than important than to do this in a participative way in which the community is involved and in which they can, even more, adapt the design to their needs.

CHAPTER 16

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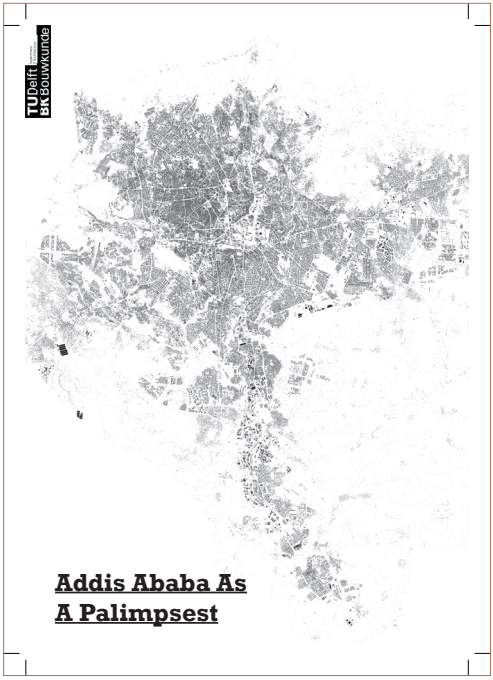
Group Research; Addis Ababa as a Palimpsest

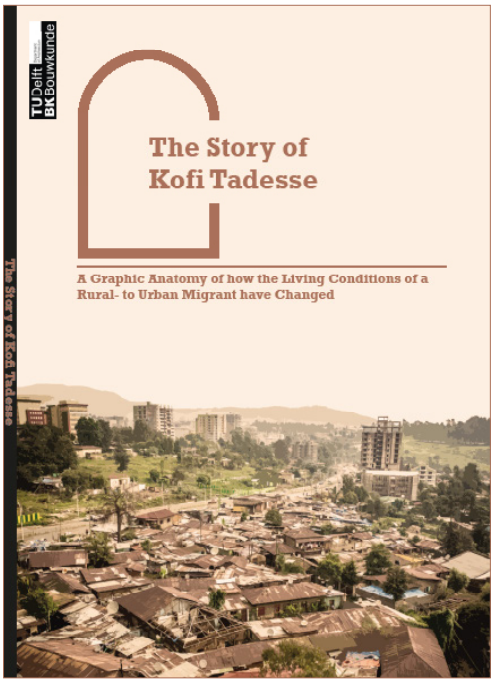
At the start of this course, we as a group have elaborated on our group research. A research on the context of Ethiopia with a specific focus on Addis Ababa. In this group research we have researched various topics, divided in four themes; ‘Facts & Figures’, ‘Genius Loci’, ‘Thematic Mapping’ and ‘Habitation’.

This group research have been an input for many design decisions and has functioned as a handhold for my research.



Graphic Anatomy; The Story of Kofi Tadesse

This graphic anatomy is a translation of my research on the habitation patterns and traditional way of life of the current informal riverbank setters. 'The Story of Kofi Tadesse' is about the main character Kofi, who takes the reader "on a tour" through his life. How his dwelling have changed from the rural place he came from to the newly developed revitalized informal riverbank where he lives now. The story is fully fictional and any resemblance to real persons, living or dead, or events is purely coincidental.



Structural Calculations

There are made various calculations for the 'Compressed Earth Block' structure. I have determined the loads on the load-bearing Compressed Earth Block Walls. After that, several verification calculations have been conducted to see if the structure is strong enough or will kink / bend.

Determination of Loads on Load-bearing Structure

Determination of Loads on Loadbearing Compressed Earth Block Wall

	Length [m]		*Width [m]*		*Load per m2*		*Permanent Load [kN]*	***Total [kN]***	*Live Load [kN]*		*Safety Factor*		*Attributable Live Load [kN]*
Roof													
Imposed load	6	x	1,5	x	1	=	→		9	x	0	=	**0**
Roof structure load													
- CEB Barrel Vault	*20 blocks*	x	*34 blocks*	x	0,074	=	50,03						
- Sand Infill	0,9	x	6	x	14,715	=	79,46	+ / 2					
calculation of load distribution of roofs & floors on sheet 'forces roof / floor structure'								**64,75**					
Wall Load	1,3	x	6	x	6,475	=	50,50						
								115,25					
2th Floor													
Imposed load	6	x	1,5	x	3	=	→		27	x	1	=	**27**
Roof structure load													
- CEB Barrel Vault	*20 blocks*	x	*34 blocks*	x	0,074	=	50,03						
- Sand Infill	0,9	x	6	x	14,715	=	79,46	+ / 2					
calculation of load distribution of roofs & floors on sheet 'forces roof / floor structure'								**64,75**					
Wall Load	3,5	x	6	x	6,475	=	135,97	+					
								265,46					
1th Floor													
Imposed load	6	x	1,5	x	3	=	→		27	x	1	=	**27**
Roof structure load													
- CEB Barrel Vault	*20 blocks*	x	*34 blocks*	x	0,074	=	50,03						
- Sand Infill	0,9	x	6	x	14,715	=	79,46	+ / 2					
calculation of load distribution of roofs & floors on sheet 'forces roof / floor structure'								**64,75**					
Wall Load	3,5	x	6	x	6,475	=	135,97	+					
								265,46					
								+					+
	Totals in kN =				permanent load = G:			**646,17**			live load = Q:		**54**
					partiële factor γ voor G:			**1,2**			partiële factor γ voor Q		**1,5**
	Total Load:		Fc;d = γG * G + γQ * Q =				**856,41 kN**						

Verification Calculation; Compressive Strength

Controle calculation 'Compressive Strength'

$$\sigma_{c;d} = \frac{F_{c;d}}{A} \leq f_{c;d} \qquad \text{U.C.} \rightarrow \frac{\sigma_{c;d}}{f_{c;d}} \leq 1$$

Fc;d =	856,41 kN	=	856408 N		
A =	1,8 m2	=	1.800.000 mm2		
$f_{c;d}$ =	8,5 - 16 N/mm2				
$\sigma_{c;d}$ =	= 856408 / 1.800.000	=	0,48 N/mm2	< $f_{c;d}$	
U.C. =	= 0,48 / 8,5	=	0,06	< 1	suffice

Verification Calculation; Kink Strength

Controle calculation 'Kink Strength'

$$F_{cr} = \frac{\pi^2 \cdot E \cdot I}{\ell_{cr}^2} \qquad n = \frac{F_{cr}}{F_{c;d}} \geq 5 \qquad \text{U.C.} \rightarrow \frac{5 \times F_{c;d}}{F_{cr}} \leq 1$$

E =	3750,00 N/mm2				
I =	13500 * 10^6 mm4				
l_{cr} =	2500 mm				
F_{cr} =	= (π^2 * 3750 * 13500 * 10^6) / 2500^2	=	7,99E+07 N		
n =	= 37,99 * 10^7 / 856408 > 5	=	93	> 5	suffice

As calculated above, the verification calculation on both the 'compressive strength' as well as the 'kink strength' are suffice. The structure is (more than) strong enough to withstand the actual forces.

Solar Chimney Calculations

Determination of Ventilation Capacity

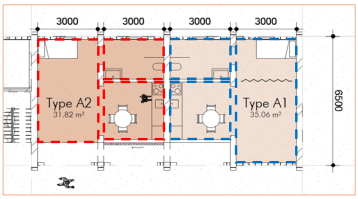
Calculations based on Dutch Standards (bouwbesluit)

Required Ventilation / Airflow:		[dm3/s]		[m3/h]	
Living Spaces	=	0,9	=	3,2	*(per m2) (min. Value of 25 m3/h)*
Toilet Room	=	7,0	=	25,2	
Bath Room	=	14,0	=	50,4	
Kitchen	=	21,0	=	75,6	

Maximum airspeed:		[m/s]
Main channel	=	5,0
Branch channel	=	3,0
Inside dwelling	=	0,2

Ventilation Capacity Type A1		area (m2)		[dm3/s]		[m3/h]
Living Space	=	*19,5*	=	*17,6*	=	*63,2*
Bath room		-	=	*14,0*	=	*50,4*
Kitchen		-	=	*21,0*	=	*75,6*
Total Ventilation Capacity			=	***52,6***	=	***189,2***

Ventilation Capacity Type A2		area (m2)		[dm3/s]		[m3/h]
Living Space	=	*16,5*	=	*14,9*	=	*48,1*
Bath room		-	=	*14,0*	=	*50,4*
Kitchen		-	=	*21,0*	=	*75,6*
Total Ventilation Capacity			=	***49,9***	=	***174,1***

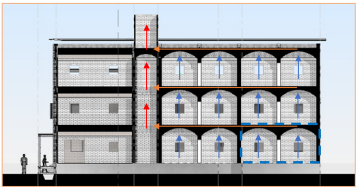


Typical Floor Plan Low-rise

Calculation of Solar Chimney (Summer Situation) [Dwelling Type A1 - ground floor level]

** constant values / non-variables*

Gravitational constant (g)	* *9,8*	-	
Height difference (h)	9	m	
Atmospheric pressure at g.l. (Po)	* *100000*	Pa	
Gas constant of air (R)	* *287*	J/kgK	
Outside temperature (To)	24	°C	
Temperature in solar chimney (T1)	25	°C	
Pressure difference (dP)	**0,35**	**Pa**	$\Delta P(h) = \frac{ghP_0}{R}\left(\frac{1}{T_0} - \frac{1}{T_1}\right)$
Discharge coefficient (Cd)	* *0,8*	-	
Inlet opening size (A)	0,062	m^2	
Density of air (ρ)	* *1,2*	kg/m^3	
Airflow rate (Q)	**192,1**	**m^3/h**	$Q = C_d A_{eff}\sqrt{\frac{2\Delta P}{\rho}}$
Room volume (V)	120,9	m^3	
Air change rate per hour	**1,6**	**x / h**	



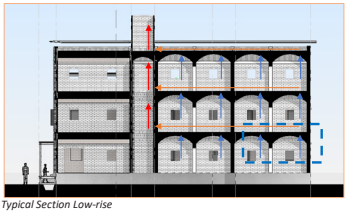
Typical Section Low-rise

→ **189,2** m^3/h needed
* dependend on Inlet Opening Size
- try to optimize, thus as small [A] as possible

Calculation of Solar Chimney (Winter Situation) [Dwelling Type A1 - ground floor level]

** constant values / non-variables*

Gravitational constant (g)	* *9,8*	-	
Height difference (h)	9	m	
Atmospheric pressure at g.l. (Po)	* *100000*	Pa	
Gas constant of air (R)	* *287*	J/kgK	
Outside temperature (To)	20	°C	
Temperature in solar chimney (T1)	21	°C	
Pressure difference (dP)	**0,36**	**Pa**	$\Delta P(h) = \frac{ghP_0}{R}\left(\frac{1}{T_0} - \frac{1}{T_1}\right)$
Discharge coefficient (Cd)	* *0,8*	-	
Inlet opening size (A)	0,062	m^2	
Density of air (ρ)	* *1,2*	kg/m^3	
Airflow rate (Q)	**194,7**	**m^3/h**	$Q = C_d A_{eff}\sqrt{\frac{2\Delta P}{\rho}}$
Room volume (V)	120,9	m^3	
Air change rate per hour	**1,6**	**x / h**	



Typical Section Low-rise

→ **189,2** m^3/h needed
* dependend on Inlet Opening Size
- try to optimize, thus as small [A] as possible