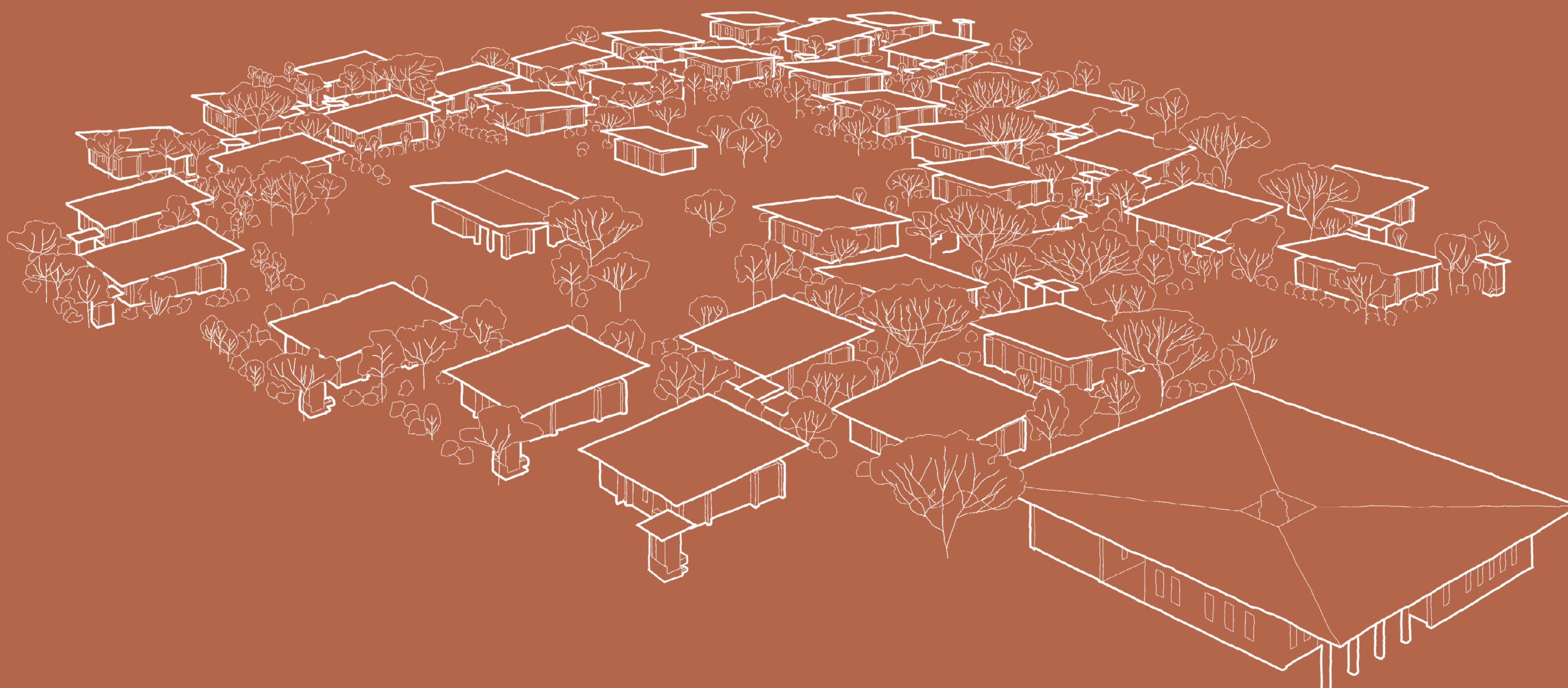

BARINGO SETTLEMENT

MSc04 - Ark7 - June 2021

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Project title: Baringo Settlement

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Supervisor: Zakaria Djebbara

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Abstract

The following paper presents the Master Thesis for MSc04 Group 7. The thesis details the process of designing long term settlement for Internally Displaced Persons, by examining the psychological effects of displacement in conjunction with the phenomenological concept of dwelling. A human centered design position was adopted as the foundation for developing a holistic housing scheme that can be implemented in the context of a Kenyan settlement. The project addresses the role of architecture in promoting a greater sense of belonging and community for a group of people faced with a loss of place.

The project utilizes environmentally sustainable resources and building strategies to create a settlement consisting of multiple clusters, each containing 16 dwellings. Additional amenities such as a Civic Center, Water Post and communal Bath House are also detailed. The scheme is finally presented as a response to the initial problem stemming from a global influx of Internally Displaced Persons.

Reading Guide

The following paper details the development of a thesis project and is divided in 8 chapters.

- *Chapter 1 introduces the premise for the project along with the problem, and the societal- as well as personal motivations for engaging with said problem*

- *Chapter 2 presents the position adopted for the project along with the general approach which collectively forms the methodology*

- *Chapter 3 explores the theoretical background for the project and seeks to obtain knowledge according to the previously defined position and problem*

- *Chapter 4 marks the culmination of studies and investigations conducted, which leads to the identification of Design Criteria and Design Drivers that are presented alongside a spatial program*

- *Chapter 5 presents the architectural proposal and highlights details that have been engaged with.*

- *Chapter 6 detail the Design Process and elaborates on the development of the architectural proposal, illuminating the reasoning behind choices made throughout the project and presented as separate themes*

- *Chapter 7 ties thoughts on the project together in a conclusion and subsequent reflection, with the former seeking to address the initial problem, and the latter considering the project in relation to the defined methodology and scope*

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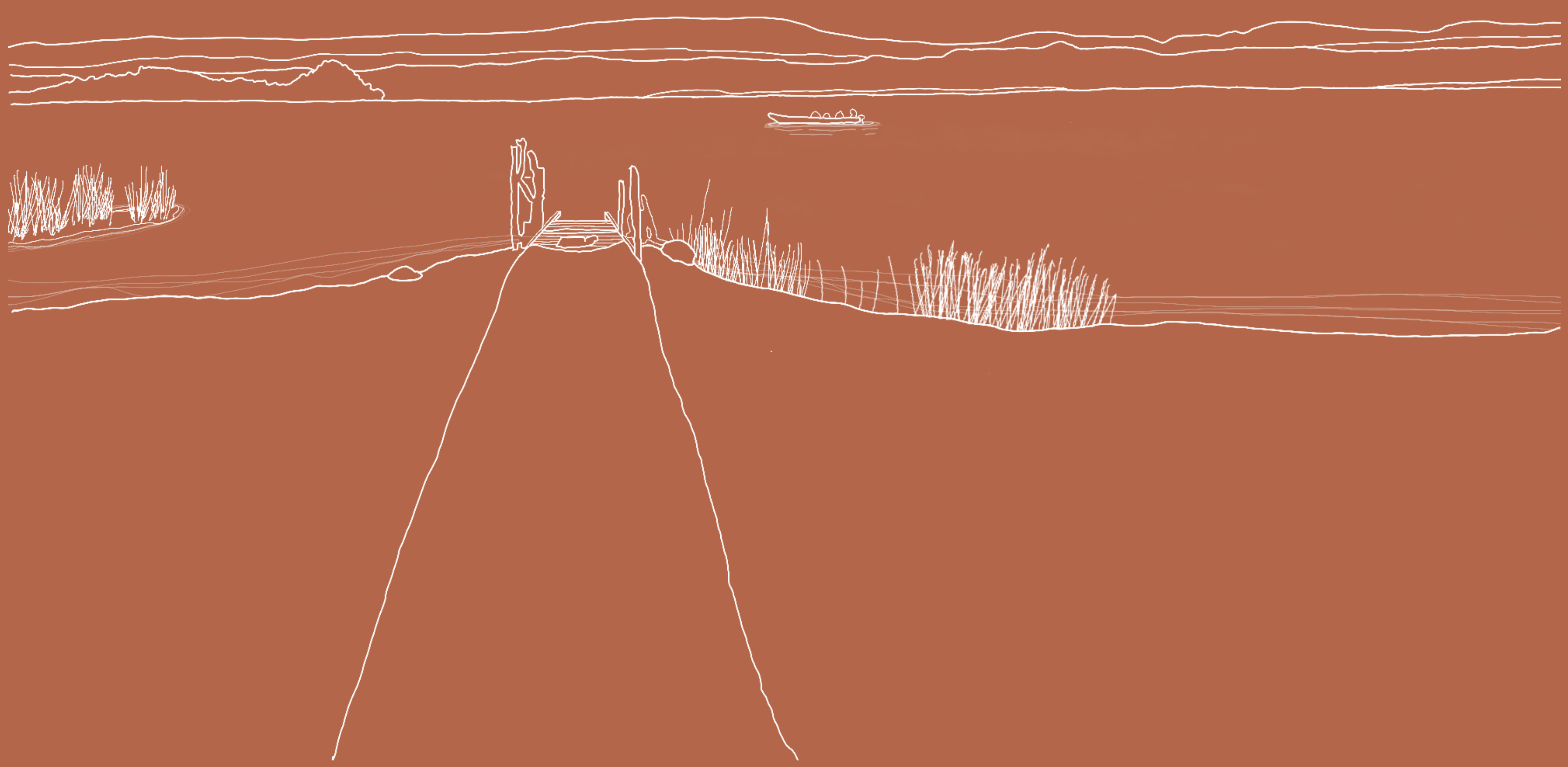


INTRODUCTION

Premise

The late Kofi Annan, former Secretary-General of the United Nations, believed Internal Displacement to be the "greatest tragedy of our time" (Annan, 2004) and through his work and position he sought to bring awareness to this phenomenon. Today it is recognized as an immense challenge in many developing nations. Organizations such as The United Nations Refugee Agency (UNHCR) serve to protect refugees and displaced persons by coordinating relief efforts and providing shelter in affected areas.

In addition, the Internal Displacement Monitoring Centre (IDMC) has been established as a direct response to the need for more comprehensive data acquisition and analysis of situations such as these. A 2019 report on internal displacement has revealed the effects of recent disasters and ongoing conflicts in many African nations. With an estimated 16.8 million Internally Displaced Persons (IDP) spread out across the continent, it is evident that the situation is dire and that actions must be taken to ensure the livelihood and well-being of those affected.

Currently operational camps in Kenya, like the Kakuma Refugee Camp and the Dadaab Refugee Complex, face several challenges, including outgrowing their estimated capacity. Some residents remain for several years due to prolonged conflicts in their country or area of origin (The Guardian, 2016). These problems are recognizable in both formal and informal camps across the globe. Like with refugees, Internally Displaced Persons may find themselves in a position where they are unable to safely return to their homes, emphasizing the importance of creating long-term and sustainable housing solutions. However, the plight of IDPs is not only a question of providing the physiolocial requirements to maintain baseline living conditions. It is also a matter of considering the social and psychological consequences of the initial incident forcing individuals to relocate. There is no single cause for Internal Displacement, and as such, there can be no single solution either. However, it is possible to suggest general measures and indicate how expansion and development of a settlement should be realized. This notion serves as the fundamental idea behind the project itself. It is important to acknowledge, that no two individuals are the same, yet by analyzing relevant qualitative material and combining it with a strong theoretical foundation a more in-depth picture of their experiences is provided.

Architecture affords opportunities to address the physical and the abstract reality of the housing issue for a group of people who, for one reason or another, are unable to return to their place of origin following a disaster. The nature of this problem necessitates a holistic approach to the design process – one in which knowledge of the environmental conditions and tectonic aspect of construction is combined with a human centered focus.

The experienced loss of place is a central topic in more than one sense. It affects all aspects of life and proves that the issue of displacement is more than just a matter of providing simple shelter. The term "settlement" seems more appropriate than just a "camp", as it implies a greater permanence to the built environment. This also means that the settlement must be developed both in an urban and a domestic scale, while being rooted in the present as well as future requirements of its inhabitants. It is also essential to foster a sense of community and belonging by providing the spaces to meet with others in different social situations.

Motivation

This project provides a unique opportunity to engage with architecture in a physical and social context that is significantly different from previous semester projects. Many considerations must be made regarding climate, materiality, and culture, which presents possibilities to explore new concepts and phenomena. Amid an ongoing global construction material shortage, it becomes increasingly relevant to investigate the use of different building techniques, especially in a country such as Kenya where the industrial sector is expanding (CAK, 2017). The nation has established a vision aiming to improve infrastructure and quality of life for its citizens, indicating that proper acquisition and management of construction materials is a vital component in strengthening the building industry (Kenya Vision 2030, 2021). It is therefore essential that the settlement is developed sustainably in both a social and environmental perspective. This project further aims to suggest alternative solutions to issues stemming from unsustainable growth of refugee camps and strives to optimize the use of construction materials.

The motivation for this project is influenced by various factors that can be broadly categorized as either societal or personal. Societal factors stem from issues identified by both governmental and non-governmental organizations as well as those expressed directly by affected individuals. In the context of this project, societal factors relate mostly to the explicit as well as lesser-known ramifications of displacement.

Personal factors reflect interests of the group pertaining to the project. These are the expression of a desire to broaden ones understanding of the subject and gain knowledge that can subsequently be used in the design process. These interests are specific to the group and influence the project throughout, which may enable a more holistic approach to development of the concept and the final architectural proposal.

Societal Factors

- *The number of IDPs is on the rise globally, suggesting that actions must be taken to address the outcome of this issue*
- *Many individuals live in camps years beyond the projected lifespan of the accommodations found here, which indicates that the built environment has to be designed differently*
- *Forced relocation due to natural disasters or local conflicts poses a significant existential crisis following the loss of place and community*
- *Existing refugee camps often exceed their nominal capacity, suggesting that gradual growth must be enabled*

Personal Factors

- *Further expand our understanding of the concept of dwelling – both as a verb and as a noun*
- *Explore the concept of "design for disassembly" while considering opportunities to extend the lifetime of otherwise temporary buildings*
- *Provide a suggestion for how to adapt the architecture to its local environment by analyzing the climatological conditions*
- *Investigate the opportunities presented by sourcing materials locally*
- *Optimise towards the reduction of building materials used and subsequent Global Warming Potential (GWP)*

Problem

The motivations serve as points of departure for the entire project and has helped define the following problem:

> *"How can a sustainable settlement scheme be developed for a group of Internally Displaced Persons that promotes a sense of community and belonging, ultimately enabling the act of dwelling? And how can this scheme be implemented specifically in a Kenyan context?"*

METHODOLOGY

Position

Conceptualizing, designing, and integrating solutions to address a specific problem within a complex physical and thematic context necessitates a strong methodological framework. The methodology is vital to the development of the project and is informed by what is presented here as a "position" and an "approach". These are the embodiments of a "why" and a "how" respectively.

The term "position" is defined as a lens through which different aspects of design is considered. The collective position for this thesis may be described as one of "human centered design" and is motivated by a concern for the individuals physical and psychological needs as well as their experience of the architecture. The resulting design proposal is therefore heavily influenced by personal and societal motivations, but also the various scientific theories and philosophical concepts applied to the analysis and discussion of subjects related to the project.

Decision-making is based on abductive reasoning of evidence and observations. Rather then starting from a pre-defined theory or hypothesis, abductive reasoning considers the given information and seeks one or more theories to contextualize what is found (Peirce, 1998). Possible explanations can be inferred, and some solutions may be suggested, but it must be acknowledged that establishing and proving or disproving specific rules requires additional information. The position is thus reflected in the initial choice of methods and the way they are framed and understood. The loss of place and security that a conflict or disaster inevitably causes has affected the scope of the project, and led to an increased focus on the phenomenological and psychological aspects of displacement. It is partly influenced by a familiarity and interest in these topics. However, it is also important to recognize that other sciences and theories could have been considered, which would have resulted in a different outcome of the initial analysis phase of the design process. Newly acquired knowledge may provide an entirely different or slightly altered outlook, which is often the case in a design process. Rather than situating the project within a rigid, pre-defined theoretical frame, the scope can evolve and encompass other subjects which may inform the design process in new and interesting ways.

In order to formulate our understanding of what human centered design is, many topics must be considered. These topics should each be investigated and engaged with on their own terms, yet always be related to the overall theme and goals of the project. For example, ontological questions are considered through a study of architectural phenomenology, focusing on the concepts of being and dwelling within the built environment. This knowledge is contextualized with the theme of displacement so that it can be applied to the architectural proposal developed in the project. Theories from the field of psychology are likewise used to explain human motivation and behaviours for a group of people, in this case defined as IDPs in Kenya.

Other types of information are analyzed and discussed in order to further bridge the gap between theory and practice. Using qualitative evidence such as case studies of contemporary refugee housing in conjunction with quantitative evidence stemming from the guidelines provided by the UNHCR, a more in-depth perspective is obtained on the premise of settlement-design. Further studies into principles of sustainable development, like integration of passive strategies and use of renewable building materials, are subsequently used to guide the design of the physical environment.

Critical assessment and contextual application of theories and evidence provides the foundation for developing a concept and guides the design throughout the project. The position is however also the subject of re-evaluation during the process.

Approach

A broad interdisciplinary approach is an inherent part of the education in Architecture and Design at Aalborg University, reflecting an idealized union of architecture and engineering. While this approach may seem novel, it is preceded by many examples of holistic design throughout history, all over the world. The notion of an architectural discipline entirely divorced from the science of engineering has nonetheless been prevalent for many years. History has shown that the emergence of the "architekton" or "master builder" as a title is preceded by the original craftsman or "tekton" (Holst, 2017). These share a common etymology with the term "techne" which denotes an applied craft or art. The tekton is a versatile craftsman capable of fully realizing an idea by giving it form. But rather than being an outright return of the tekton, the focus on interdisciplinarity is motivated by the pursuit of a mediator between positions in the field of design and construction.

The notion of an intermediary designer is an acknowledgment of the increasing complexity that characterizes contemporary architecture. This complexity has led to further specialization of the crafts and technical skills that are related to building (Emmitt, 2002). Automation of construction processes, rapid development of new technologies, as well as utilization of software to simulate various conditions are all the result of increased industrialization and the advent of modern computing. These technological advances afford new opportunities in construction, which means that new architecture needs to be conceived as an integrated design.

The Integrated Design Process

The concept of the Integrated Design Process, as defined by Professor Mary-Ann Knudstrup from the department of Architecture, Design, and Media Technology at Aalborg University, can be regarded as a response to the previously established development. In her 2004 publication "Integrated Design Process in Problem Based Learning" she stresses the importance of reaching a synthesis of architecture and engineering disciplines by considering the technical, functional, and aesthetic aspects of design concurrently and throughout the process.

Practical experience and in-depth theoretical knowledge allow the designer to identify and address a concrete *problem* through comprehensive *analysis* of relevant information, which is applied in the *sketching* phase. The design finds its form and expression through a *synthesis* of ideas, which is then *presented* as a solution to the initial problem (Knudstrup, 2004). Despite being presented as five distinct phases, The Integrated Design Process also implies non-linearity, since continuous evaluation of design proposals may prompt further analysis or a re-specification of the initial problem. Emphasis on progression is maintained since the method promotes an iterative workflow where several "loops" are performed throughout and between phases. This process mirrors the hermeneutic discipline of interpretation, in which continuous analysis of a subject may prompt a re-assessment of the initial premise and knowledge acquired (Grondin, 1991). A formulation of the cyclical nature of hermaneutics is offered by German Philosopher Hans-Georg Gadamer:

> *"The fundamental law of all understanding and knowing is to discover the spirit of the whole in the individual and to grasp the individual in terms of the whole." (Gadamer; Boehm, 1976)*

In the context of this thesis paper the Integrated Design Process is recognized as framework for organizing project-based design more so than an all-encompassing and formalized methodology. It encourages a structured approach to design-generation but owing to the often-complex nature of the subject, the Integrated Design Process must be considered in conjunction with the position.

Methods and Tools

Tools

Tools provide the means to gather information, allowing for analysis and discussion of findings. Many of these tools relate specifically or are exclusive to a particular science or philosophical branch. For example, Mazlows Hierarchy of Needs is rooted in psychology, but is adapted and applied to architecture and the physical environment through the groups collective position in human centered design. Other tools are more general, such as literature- and case studies which fit within the analysis-phase of the integrated design process.

- *Analogue sketching is a recurring tool throughout the design process. Individual aspects of the design can be explored on their own terms and easily communicated.*

- *Physical modeling using different materials is a valuable tool for making parts of, or a entire building tangible and investigate elements in a physical and three-dimensional realm.*

- *Digital modeling makes it possible to quickly design objects and buildings that can be altered and adjusted easily. In conjunction with software that can emulate a walkable environment it provides a visual sensation of the created spaces. This tool can on its own not provide a full experience of a space however, as it is limited to a purely digital realm.*

- *Simulations are a vital part of conducting analysis of design parameters, which is helpful in evaluating different iterations of a concept. Simulations include incident radians, temperature and structural element utilization.*

- Literary studies provide the theoretical background for much of the analysis-phase and are performed as a means of gaining relevant information.

Studies and Design Investigations

In the context of this thesis the terms “study” and “design investigation” represent two general methods of structuring evidence based on whether the information they provide is theoretical in nature or represent applied knowledge:

- *Studies represent the theoretical background of the project through analysis and discussion of subjects relevant to the project problem. Depending on the nature and familiarity with the subject, studies provide either general or specific knowledge on key aspects.*

- *Design Investigations serve as tools for applying information obtained through studies more directly in the design development. They take the form of small design exercises with a specified focus related to preceding studies and help bridge the gap between theory and practice.*

Design Drivers and Criteria

Findings from the analysis-phase of the project prompts the formulation of “design drivers” and “design criteria” for use in the ongoing design process.

- *Design Drivers advance the design process. They are identified from the results of studies and investigations performed in the initial analysis-phase. Drivers become guiding principles in the development of the thesis design proposal.*

- *Design Criteria provide the means to formally evaluate iterations of the design proposal. They mirror the drivers thematically, but rather than initiating the development of new solutions the criteria enable decision-making.*

The Phenomenology of Dwelling

The following study is performed in order to provide a better understanding of the basis for dwelling in a given environment. By comparing the works of four prominent thinkers in the fields of phenomenology and architecture, key elements pertaining to dwelling will be identified.

Dwelling is a fundamental concept in architecture because it concerns human experience and the idea of "being-in-the-world". The term refers to both a physical entity in the form of a shelter, but also the sensation of being and belonging in a place. In this regard, dwelling is as much a question of how humans choose to settle as why.

The origins of the dwelling

Throughout history human dwellings have been key to the evolution of architecture as a craft and academic pursuit. In "The Four Elements of Architecture", architect and writer Gottfried Semper argues that the different elements of architecture developed in tandem with the crafts that were utilized to make them. He arrived at a definition of the "primordial dwelling" from recognizing the patterns of construction in various cultures and across different continents. These were:

- *The hearth (ceramics)*
- *The mound (masonry)*
- *The roof (carpentry)*
- *The enclosure (weaving)*

The built environment comes into existence from knowledge and technical skills directed towards the material world in a conscious act of building. But this theory cannot explain the motivation for choosing to build in the first place – otherwise seeking shelter within an existing building or natural structure would suffice.

It is therefore necessary to acknowledge the occurrence of a more complex philosophical process:

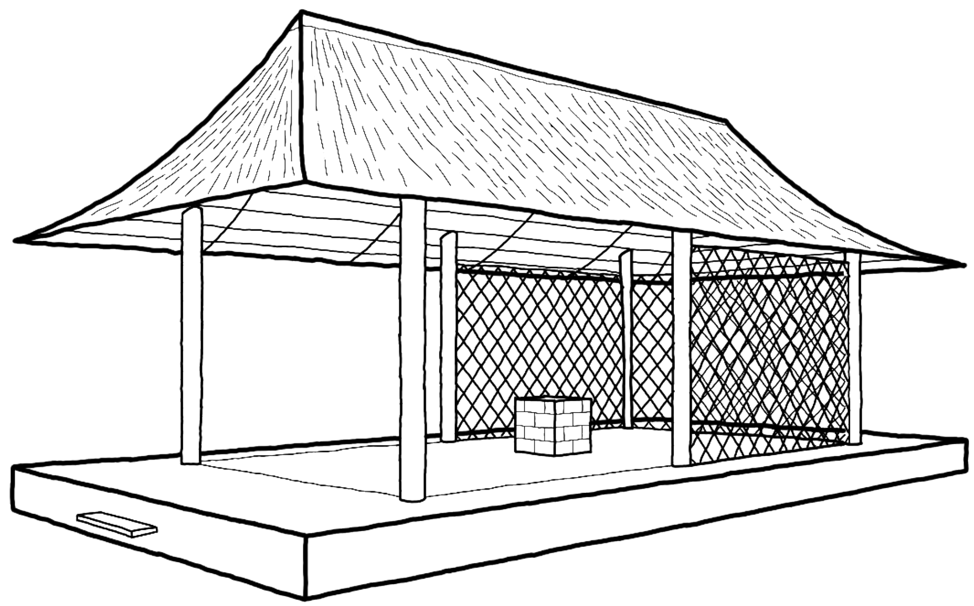
> *"Architecture [...] should choose and apply its material according to the laws conditioned by nature, yet should it not also make the form and character of its creation dependent on the ideas embodied in them, and not on the material?"(Semper, 1989)*

By suggesting that architecture is as much a result of material conditions as it is an expression of abstract ideas, it becomes impossible to separate the object (buildings) from the subject (individuals).

Being and dwelling

Philosopher and writer Martin Heidegger sought to engage with themes such as being and the nature of the world. His influence on phenomenology is evident in the works of many later writers. In the essay "Building, Dwelling, Thinking" he questions how these concepts are connected, and asks why man builds in the first place. Heidegger links the act of building to the acts of creating and maintaining a particular worldview, presented as a fourfold: The *earth*, sitting beneath the *sky*, is inhabited by the *mortals* who stand before and uphold the *divinities*. Heidegger's fourfold presents itself as two sets of opposites where each "realm" of the world is seen in relation to the other. This thinking helps structure and make sense of the world, and is in some ways the very essence of what it means to be human (Heidegger, 1971).

The ability to derive meaning from perceived phenomena characterizes humans, as opposed to the other elements in this fourfold. Indeed, this worldview is the result of creation and it is conceived as a way of explaining not only the surrounding world, but also one's place and purpose in it. It can be argued that Heidegger's thinking is influenced by a westernized view on "being" and the world. The conception



Ill. 1: The Four Elements of architecture

of the world as a fourfold represents one understanding. Yet the human urge and ability to explain and find meaning is ubiquitous across many significantly different societies and cultures. Therefore, emphasis is on the idea that humans dwell and seek to make sense of both the physical and metaphysical reality. By building and contextualizing man's thoughts on the nature of the world through concrete "images", a certain worldview is upheld and reinforced. It is manifested in all that is created and is an inherent human trait:

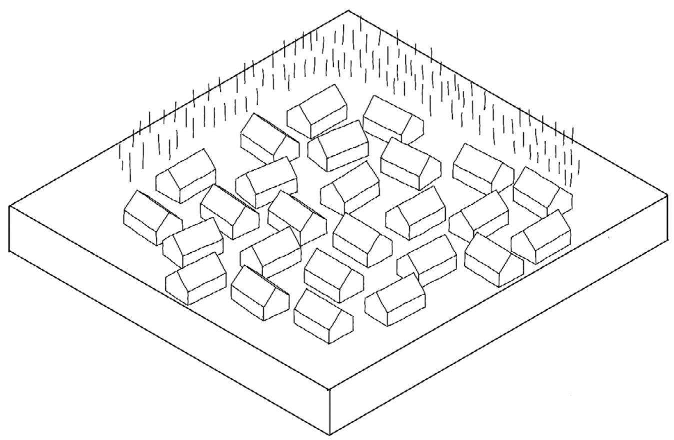
> *"We do not dwell because we have built, but we build and have built because we dwell, that is, because we are dwellers." (Heidegger, 1971)*

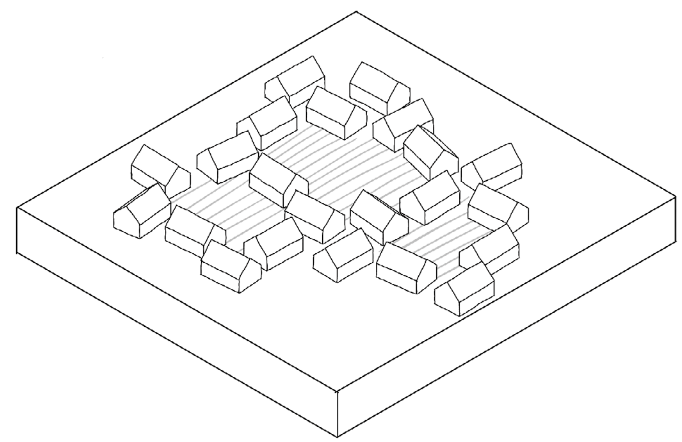
The act of building is itself a means of dwelling which compels the individual to structure or order his surroundings. It is equated with being, and thus can be regarded as an ontological concept. At the same time, it becomes evident that personal agency is an important factor when addressing the central problem of this project. Individuals should be given the opportunity to help develop and influence the built environment to enable dwelling in the first place.

Modes of Dwelling

Architect Christian Norberg-Schulz expands upon the concept of dwelling by recognizing patterns in architecture and society and relating it to Heidegger's theories. The experience and interpretation of places are some of the core themes in "The Concept of Dwelling". Dwelling may be explained through four distinct modes:

- *Natural Dwelling begins with the formation of a settlement, whereby a distinction is made between the man-made space and the surrounding natural location.*





Ill. 2: Above, left: Natural dwelling

Ill. 3: Above, right: Collective dwelling

- *Collective Dwelling occurs in the urban space between buildings, which functions as a space for meeting and exchanging ideas and experiences.*

- *Communal Dwelling is centered around an institution or public building, which can be seen as the embodiment of the values and interests established within a community.*

- *Private Dwelling takes place in the home, providing a space to help define and develop a personal identity.*

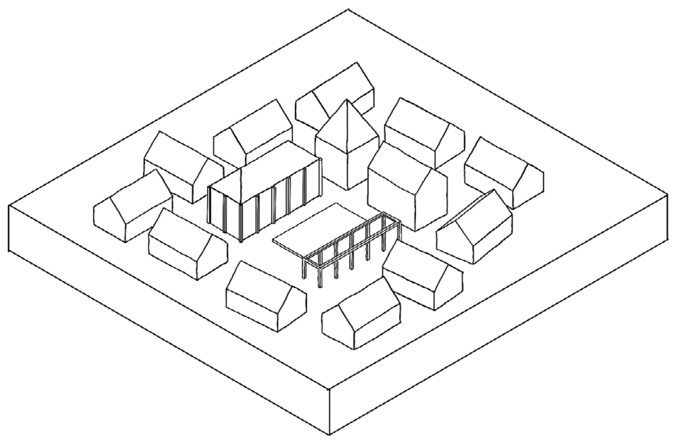
These modes make a clearer distinction of how and where dwelling takes place, which may help bridge the gap between theory and practice in relation to the project. Each of the four modes address basic requirements of living while at the same time representing abstract concepts such as being and identity.

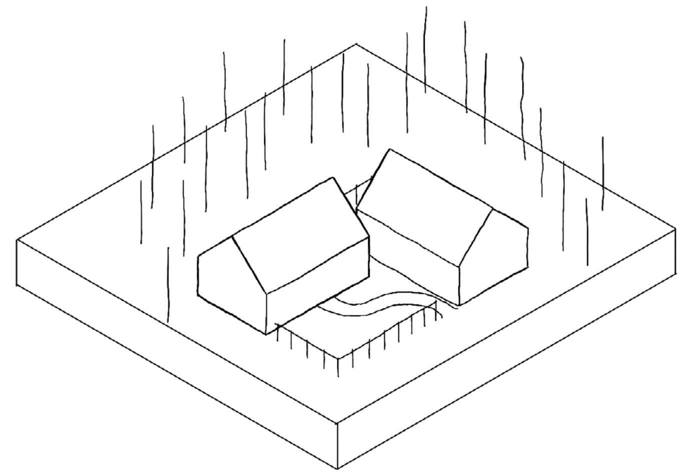
The Verbs of Architecture

Phenomenology in relation to the built environment continues to be subject of fascination among philosophers and architects. Juhani Pallasmaa, author of works on phenomenology and architectural theory, explains that buildings simultaneously prompt and are conditioned by an activity:

> *"Architecture initiates, directs and organizes behavior and movement. A building is not an end in itself; it frames, articulates, structures, gives significance, relates, separates and unites, facilitates and prohibits. Consequently, basic architectural experiences have a verb form rather than being nouns." (Pallasmaa, 2005)*

This statement points to a mutually dependent relationship between man and architecture. One brings the other into existence, yet both provide meaning and purpose to each





Ill. 4: Above, left: Communal dwelling

Ill. 5: Above, right: Private dwelling

other. The house can be regarded as the outcome of an ongoing process of dwelling as Heidegger stated, but it is the acts taking place within that allow man to dwell in the first place. These acts can be seen as the "verbs of architecture". This perspective allows for a slightly different interpretation of Semper's Four Elements of Architecture, based on the needs that motivate their creation in the first place.

The Hearth is the place where individuals gather, and social bonds are formed. The Mound represents the settling of an area and marks the symbolic act of laying claim to a part of the natural environment. But to remain protected and emerge unscathed the Roof must be constructed, which is an act of seeking shelter. Finally, the Enclosure is what prompts people to structure the physical environment, in the process creating spaces and boundaries. The Four Elements are conditioned both by physiological needs and a search for an existential foothold. Architecture can then be regarded as a mediator between man and his surroundings in more than one sense. At the same time, it represents an effort to interpret the physical reality and convey an understanding of it through an act of building.

The concept of dwelling is essential to the discussion of housing in the context of displacement. The Four Elements that make up the primordial dwelling symbolize basic human needs such as gathering, seeking shelter as well as inhabiting and defining a space. Emphasis should be put on the activities facilitated by the built environment, as it is a core part of the experience of architecture. The design proposal should promote a sense of Natural-, Collective-, Communal-, and Private dwelling in the environment. It is therefore necessary to consider the house not only as single entity, but rather as part of a community.

The Psychology of Displacement

The following study seeks to apply concept from psychology to better understand the non-physical reality of Internal Displacement. It is important to consider the mental state of those affected, which may inform of their motivations, wishes and immediate needs.

Definition of Internal Displacement
Any person, regardless of socio-economic background, may become the victim of a crisis forcing them to abandon their home either short-, long-term, or indefinitely. Based on common denominators, Internal Displacement can be defined:

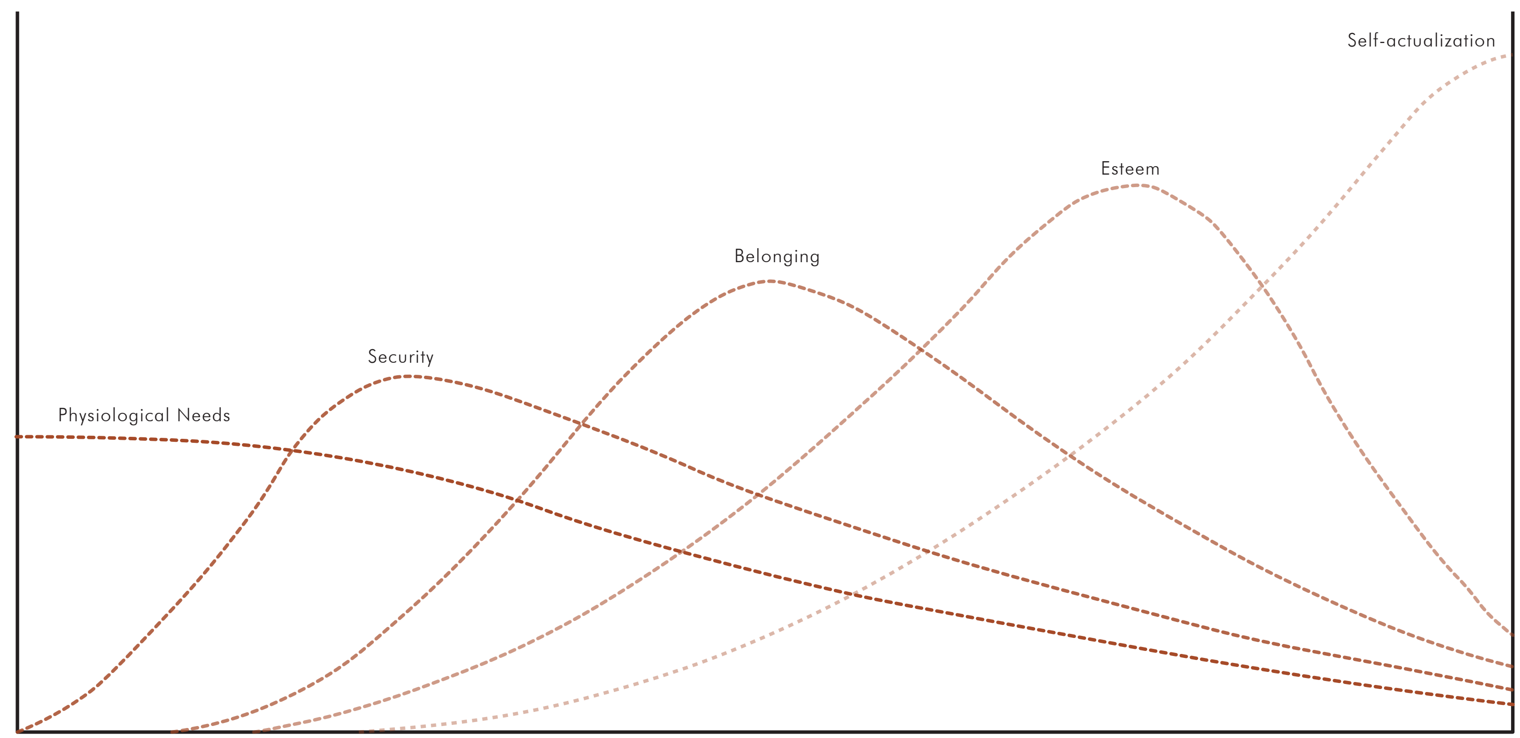
> *"Persons or groups of persons who have been forced or obliged to flee or to leave their homes or places of habitual residence, in particular as a result of or in order to avoid the effects of armed conflict, situations of generalized violence, violations of human rights or natural or human-made disasters, and who have not crossed an internationally recognized State border" (OCHA, 2004)*

The Dynamic Hierarchy of Needs
While this definition of Internally Displaced Persons incapsulates the physical reality of the situation, the psychological aspect is more complex. The mental state of those affected is not accounted for, and thus the motivations of individuals may appear arbitrary. Psychologist Abraham Maslow proposed his theory on human motivation to expand upon existing behavioral theory and help identify what drives a person in a specific situation. Maslow theorized that humans are motivated by needs related to what they are currently lacking. He identified five needs: physiological, security, love, esteem and self-actualization. They are usually depicted in hierarchies determined by their urgency. Any individual must have their prior needs well-satisfied before striving for the fulfillment of others and therefore none of the needs can be isolated from the others. As an example, Maslow stated that the physiological needs are followed by safety needs and that a person deprived of security will seek it, just as a hungry person will crave food (Maslow, 1943). What is important to consider is that the need for food and water is closely followed by the need for security. Together they represent the "basic needs" of any person and are almost on par. By "well-satisfied" Maslow does not imply complete satisfaction of needs, as the relationship between these is more dynamic. Preceding needs in the apparent hierarchy do not have to be fully appeased before the next one emerges. Thus, some are concurrent, but gradually shift in priority (Maslow, 1943).

Loss of Place
The concept of needs can be related to the issue of Internal Displacement. Richard Evans, global shelter and settlements manager at the Norwegian Refugee Center (NRC) shares his observations from working with refugees. Much like IDPs, the loss of place and thus security deeply affects these people, and Evans notes how "*they went straight into a 'sheltering process'*", stating that "*they just wanted some semblance of safety*" (Cromblehome, 2020). These statements reveal how people might act in a crisis situation and how individuals strive to satisfy their immediate needs. In this case it means having a roof over their head, thereby gaining a sense of security. Evans further elaborates on this phenomenon and recounts how people would move their housing units closer to those of other family members or neighbors from their old community. He states that:

> *"When people are forced to flee, they not only lose their homes, but also their communities. That safety net that surrounds them" (Crombleholme, 2020)*

It is impossible to explain the tendency to gather around these communities based solely on the physiological requirement for food and shelter. Using Maslov's terminology it appears as a result of seeking to satisfy psychological



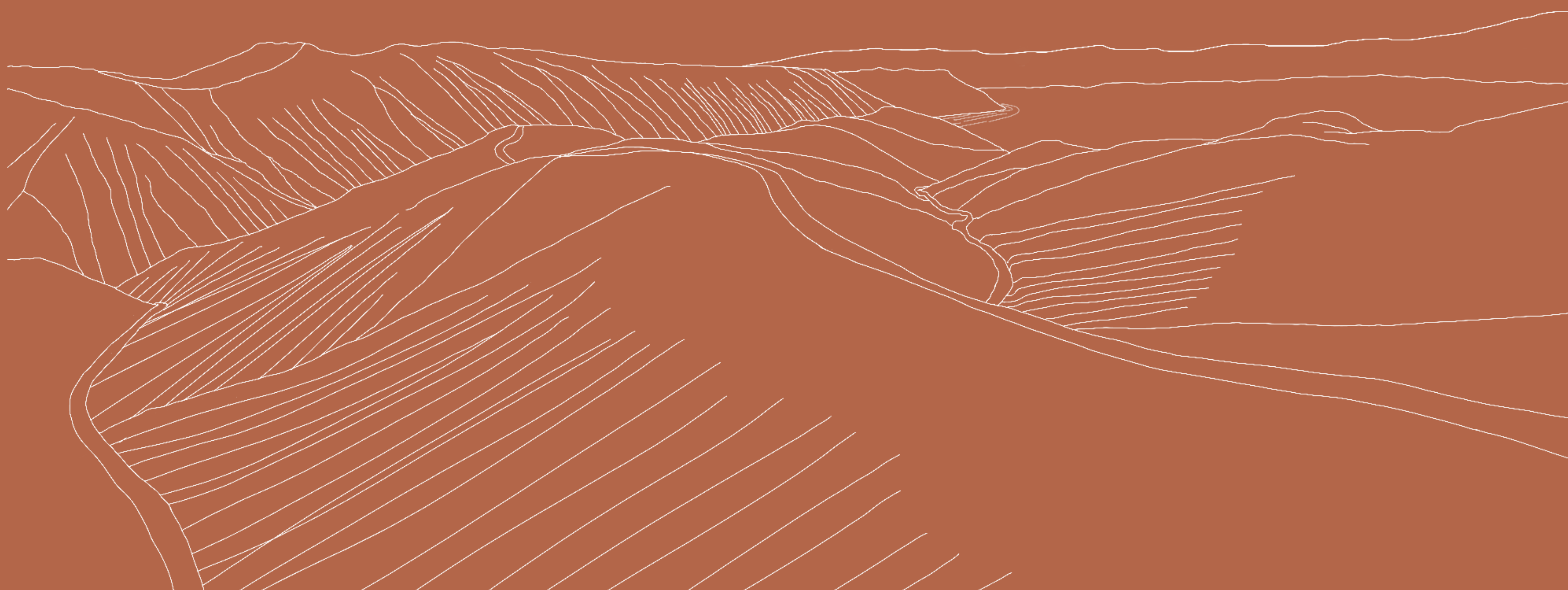
Ill. 6: Mazlow's Hierachy of Dynamic Needs

needs such as belongingness. The NRC also presents a story from the Feristan camp in Afghanistan, where some people had resorted to living under sheets during cold nights and had to wait upwards of 5 months for an insulated tent. An inhabitant of the camp recounts his experiences:

> *"Most of us had more than enough to do when we prepared and cultivated the land, and our children went to school. Here, there is neither work nor school. The city centre is far away, and we are left to ourselves." (Høvring and Azad, 2018)*

While the physiological needs take precedence over most other concerns, the statement above indicates that the initial loss of place also affects the sense of belonging. The concern for sustenance and safety will always remain, however once the former is well-satisfied focus will shift towards creating a community. This development is consistent with the dynamic nature of the Hierarchy of Needs. These stories are often the consequences of informal camps; the informal gathering of refugees not sanctioned or directly controlled by local authorities (Ireland, 2019). They do not come into existence from careful planning but are rather the outcome of an immediate response to an urgent situation, meaning that communal functions and even some basic amenities might be lacking.

By providing the basic amenities, the quality of life for IDPs can be lifted to a level where work, education, and stability can once again become part of their daily lives. Thus the project should emphasize design of functions that relate not only to the physiological but also the psychological needs of IDPs, such as communal spaces for gathering and private spaces for dwelling.



STUDIES

Site Introduction

The purpose of this study is to provide an overview of causes of displacement in Kenya, while relating it to factors such as the country's history. It also serves as an introduction to the chosen site of the project, an area located west of the Baringo Lake in the Rift Valley Province.

Kenya is an East African nation located near the equator. It is bordered by Somalia and Ethiopia to the north, where many individuals have been forced to flee from civil wars and now reside in the Kakuma Refugee Camp or Dadaab Refugee Complex. In addition to refugees, numbers provided by the IDMC estimate a total 163.400 cases of internal displacement between natural disasters and conflicts as of December 2019 (IDMC, 2019). While resettlement of IDPs is considered high-priority by the Kenyan government, there is reason to suspect that apparent difficulties extend beyond a purely economic aspect. Many Kenyans have expressed concerns about returning to their homes, citing fear of persecution and attacks (Mwirichia et al., 2011). A summary of modern Kenya's history provides some of the necessary context for this issue.

Historical Background

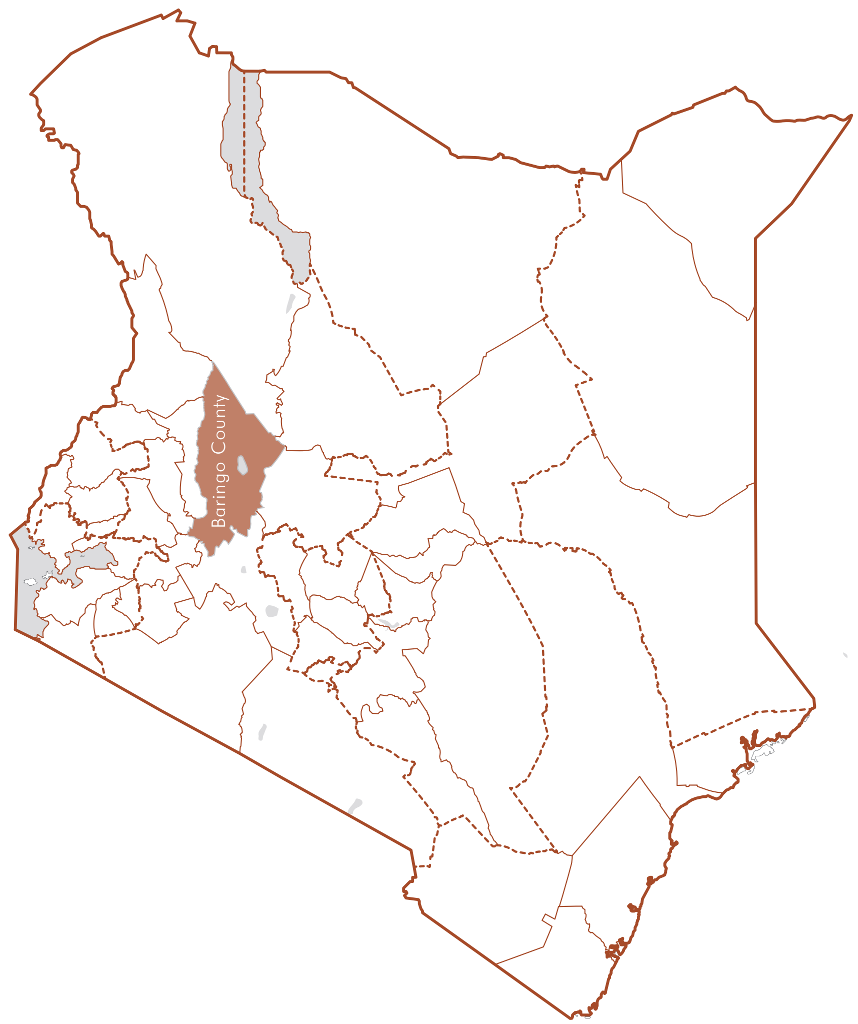
Kenya was previously designated as a British protectorate from 1895 and later as a colony from 1920 until the country was reconstituted as sovereign state following the Independence Act of 1963. Prior to gaining political independence the relations between members of the native population and the colonial authority country were fraught with conflicts, culminating in the Mau Mau Uprising. Colonialism also contributed to escalation of inter-ethnic strife. Imposed administrative boundaries lead to fierce competition for resources in some regions, which negatively reinforced social and ethnic seggregation of communities (Ndege, 2009). Post-colonial era Kenya was also characterized by political turmoil. The Kenya African National Union (KANU) led by the first president Jomo Kenyatta, was at the center of political power for many years following the dissolution of the Kenya African Democratic Union (KADU) in 1964 and the banning of the Kenya Peoples Union (KPU) in 1969. At the time they were the only opposition parties (Ogot, 1981). Conflicts between communities based on political affiliation remains an important subject in contemporary Kenya.

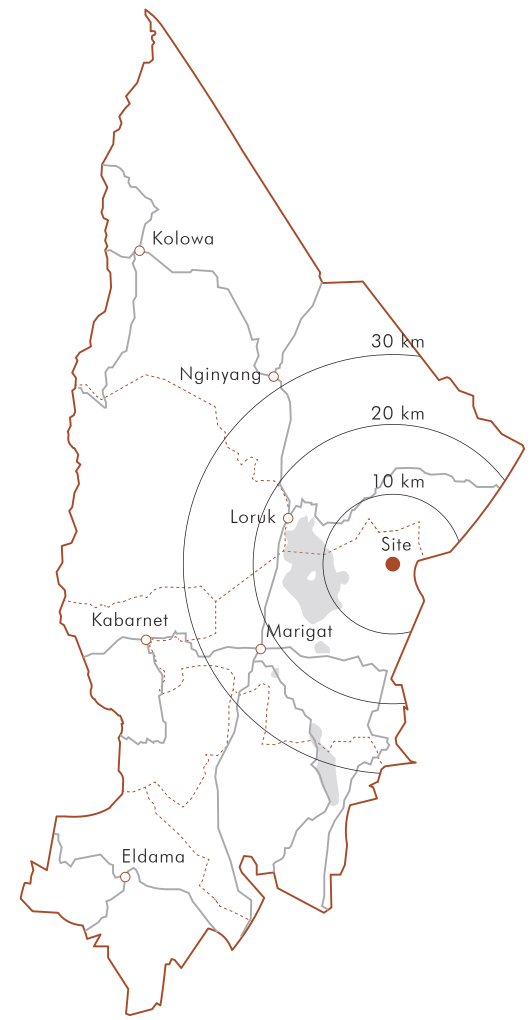
Causes of Internal Displacement

Conflicts in the Rift Valley province have been further exacerbated by historical grievances owing to land disputes. Jomo Kenyatta, himself a Kikuyo, has been accused of favoring Kikuyu interests in the years after the Independence act, which to this day still affects the reputation of the community (Kahuru, 2019). Following the heavily-disputed 2007 presidential election, upwards of 500.000 people were forced to flee their homes as a result of the ensuing unrest (OCHA, 2008). Among others the Kikuyu were targeted, who represent the thirds largest community in Baringo County (KNBS, 2016).

In addition to conflicts stemming from politically motivated violence and ethnic clashes, natural disasters in the area is a major factor of internal displacement. A statistic presented by the IDMC, shows that Rift Valley of Kenya has seen a recent influx of new IDPs as a direct result of flooding of lakeside towns. The site has been chosen as it is situated east and upland from the nearby Baringo lake yet is accessible and has seen few cases of local conflicts recently (IDMC, 2021).

Historically, Kenya has seen many cases of both natural disasters and conflicts between individuals leading to internal displacement. While recent floodings account for the majority of new cases, deep seated political and socio-economical differences is a contributing factor in the IDP Stock number. Counties in the region have been affected by these events, making the area near Baringo suitable as a site.





Ill. 7: Left: Map of Kenya (no scale)

Ill. 8: Right: Map of Baringo (no scale)

Microclimate

The purpose of this study is to obtain a better understanding of the climate of Kenya and determine which parameter might affect the design of buildings. The purpose is also to study the opportunities provided by microclimatic conditions on the chosen site near Lake Baringo.

This study puts forward a series of climatical conditions for the site, which need to be addressed when considering both house design, as well as passive solutions implementation.

Geography and Macroclimate of Kenya

As Kenya is located near the equator, the length of a day varies little, the shortest day being 12 hours and 6 minutes and the longest 12 hours and 9 minutes (Weathers Park, 2021).

Kenya is bordered by the Indian Ocean to east, but also shares a stretch of the Lake Victoria shore with neighboring countries. The Rift Valley province takes it name from a series of prominent faults and trenches that originate in Ethiopia and continues south to Malawi. Many rivers and lakes can be found throughout the valley-system, among these the Baringo Lake.

There is reason to believe incidents of flooding will become increasingly frequent as the effects of climate change grow in severity, leading to new cases of internal displacement. This development calls for a more contextual design of buildings that can respond to the climatic conditions.

As a response, the site chosen for the project is located 180 meters above the surface of the Baringo Lake, yet still with access to water in the form of rivers from the surrounding mountains and the nearby Mukutan Gorge. The terrain is relatively flat, making the plateau ideal for a settlement with minimal site-preparation and alterations to the natural landscape required.

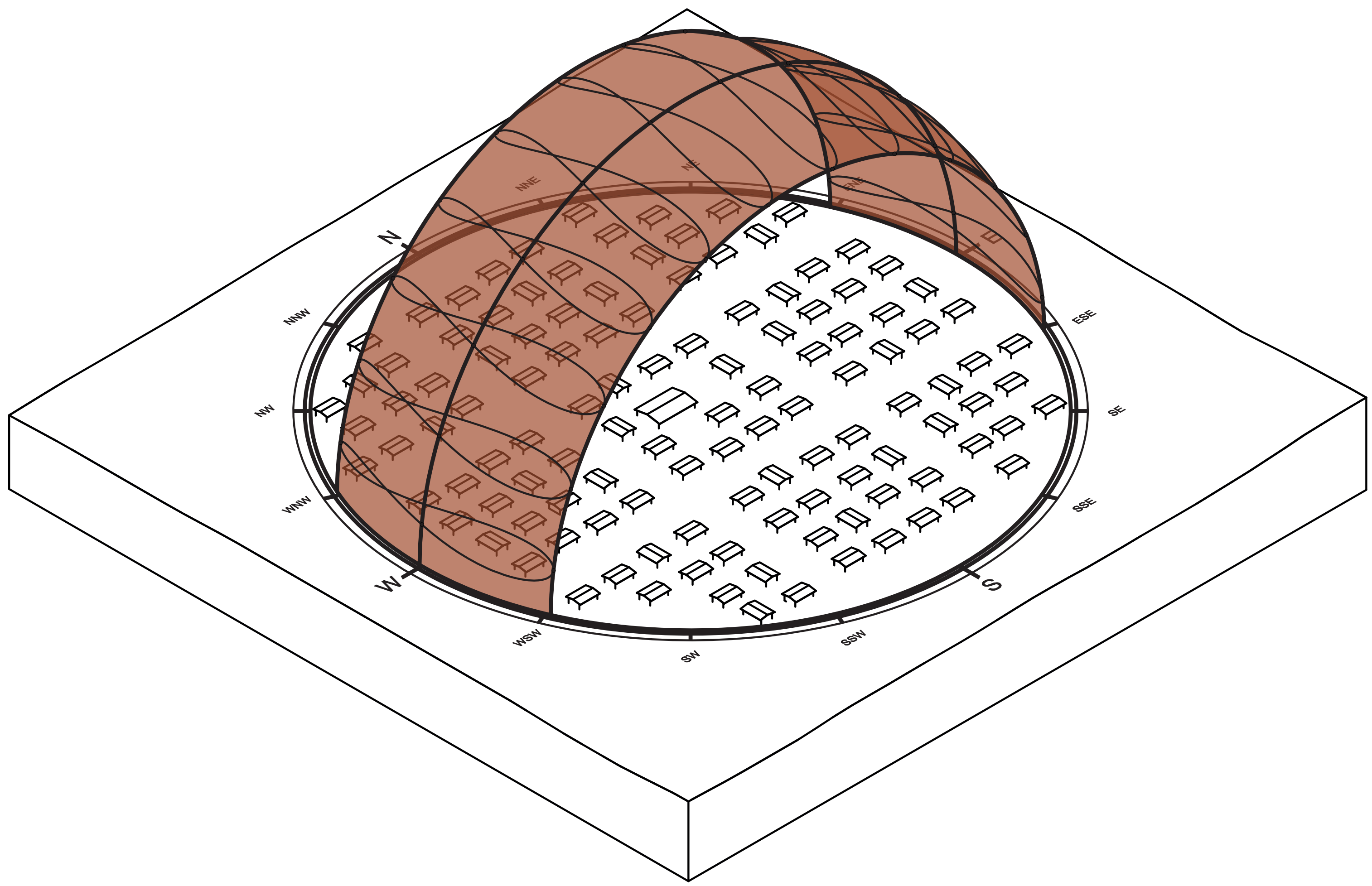
The country is split into three climate zones: a hot and humid zone near the coastline, a temperate zone in the west and south-west around the mountains and plateaus, and a hot and arid zone in the north and east. The climate of these zones is controlled by the wind originating in the large-scale pressure systems of the Indian Ocean and the adjacent landmasses. The origin of these winds determines the dry and wet seasons, with dry and low precipitation seasonal winds coming from the north and south, and wet seasonal winds coming from the Indian Ocean in the east.

The site chosen for the project is situated in the hot-arid zone, meaning that the temperature variation throughout the day is high, and the maximum temperature is above that of other types of zones. The air humidity is low however, meaning that the sensation of heat is not as pervasive as in hot-humid zones. It also means that passive strategies relying on an evaporative cooling effect can be utilized in the design of buildings.

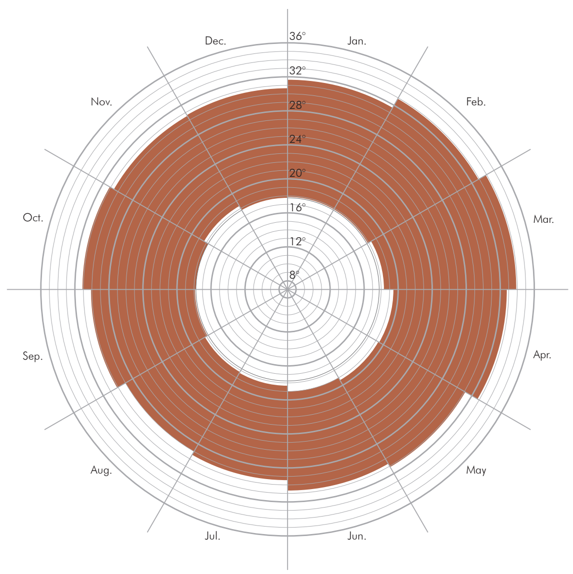
Sun Path

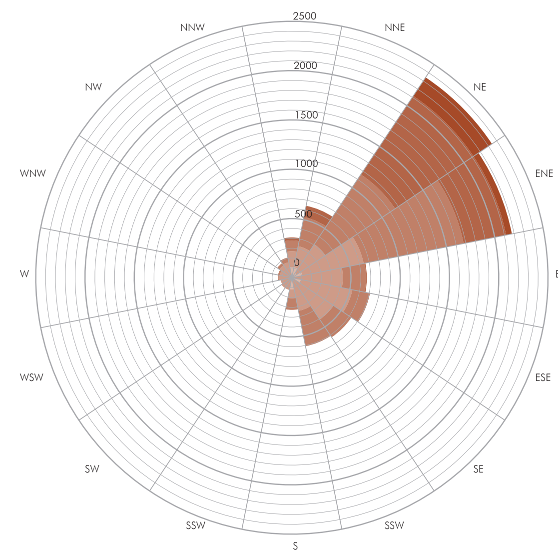
Because of its location near the equator, the sun path in Kenya is very different from countries such as Denmark. During equinox, the sun altitude is almost 90°, moving directly from east to west. As the sun approaches solstice, the sun angle will tilt towards the northern hemisphere during the summer solstice, and towards the southern hemisphere during the winter solstice. At each solstice the suns altitude is around 65°. The shadows cast by the high sun are few and far between, which would impact thermal comfort.

These conditions pose restrictions on many outdoor activities, and people are often resigned to staying indoors during midday, where the sun altitude and temperatures are highest. This indicates that ample shading of exterior spaces should be provided, which could improve the conditions for occupants during days when it is not overcast.



Ill. 9: Sun Path Diagram on site





Average temperature

There is relatively little variation in average high- and low temperatures throughout the year for this region of Kenya. At its highest, the average high temperature near Lake Baringo sits at 34°C in the month of March, whereas the average high temperature in August sits at 29°C, making it the "coldest" month of the year.. Average low temperatures also vary little, with 19°C and 17°C for April and October respectively. While these temperatures vary little over the course of a year, day-time conditions differ by almost 14 °C compared to night-time.

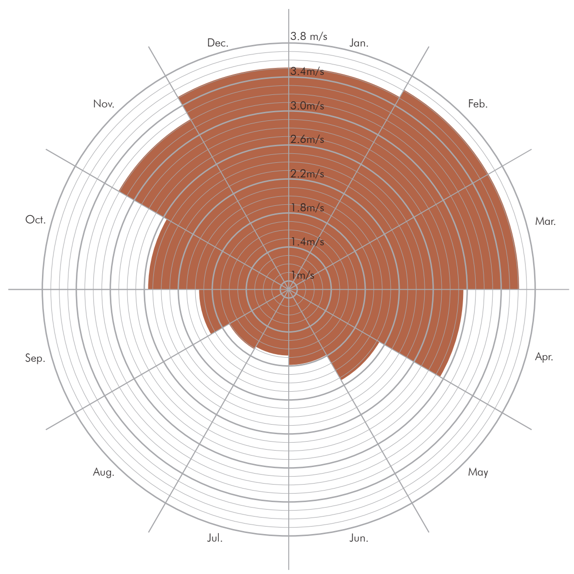
The low seasonal temperature variation suggests that dwellings should be designed for year-round conditions of day temperatures around 30°C and nightly temperatures around 18°C, and that the ventilation strategy should reflect the mean temperature difference throughout the day.

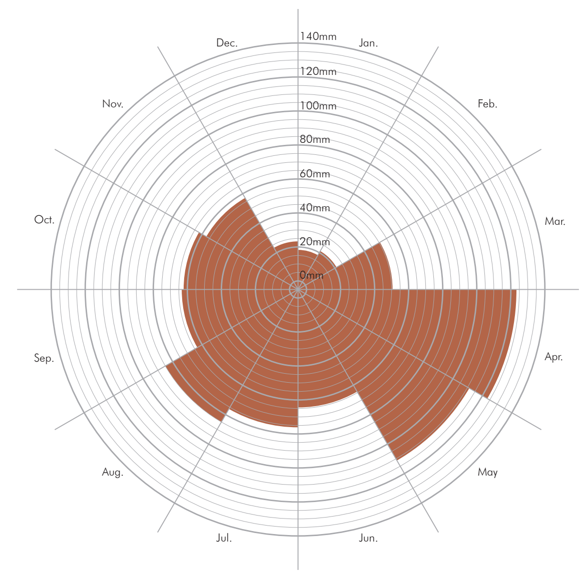
Windrose

A wind rose plot of Baringo shows the hourly distribution of winds at different velocity-intervals in each cardinal, intercardinal and secondary intercardinal direction. The plot indicates that the strongest winds originate in the North-East direction. They also come from North-East and East-North-East for majority of the time throughout year, with an average of 2350 and 2200 hours, respectively. This amounts to around half the number of total hours a year. The winds affect many different aspects of the climate in this part of the Rift Valley, which also impacts the design of the buildings. The imposed load necessitates further structural analysis, but the wind must also be accounted for in terms of sheltering. Additional vegetation could help shield from the stronger winds and provide extra shading of the outdoor areas. Lastly, the wind may be used to facilitate natural ventilation under the right conditions.

Ill. 10: Left: Average Temperature Diagram

Ill. 11: Right: Windrose Diagram





Rainfall

The average rainfall near Lake Baringo varies from month to month. The region experiences months of little rainfall like January with less than 20 mm on average, and others with significant amounts of rain, such as April with an average of 124 mm. This can be explained as result of eastern winds from the Indian Ocean colliding with the seasonal southern and northern winds from inland Africa leading to large amounts of rainfall.

Similar rainfall records from the nearby lake Nakuru show an annual average of 965mm, with more rainfall in the rainy season and less in the dry season, but a relatively even distribution throughout the rest of the year. This, coupled with the relatively even temperatures, should yield long growing seasons which is excellent for agriculte and planting trees that could sustain the water in the ground.

Average windspeeds

The months in which the highest windspeeds are measured, correspond to a degree with the months experiencing the least amount of rain. These months the wind primarily comes from North-East and East-North-East, meaning that there a few instances of winds from other directions colliding which is the primary source of rain.

Strong winds means that structures should be able to withstand and provide necessary shelter, which could be accomplished by arranging building volumes in specific ways or with the provision of extra vegetation. The constant and relatively high temperatures likewise affect the design of spaces and indicates a ventilation strategy should be defined and detailed. The amount of rain may prove beneficial for agriculture and suggests that water could be stored and used later.

Ill. 12: Left: Rainfull Diagram

Ill. 13: Right: Average Windspeeds Diagram

Climate Responsive Design

The following study seeks to identify and determine specific design strategies to be used in the development of the architectural proposal. Results of the previously conducted Climate Conditions Study informs the initial choice of strategies.

The study considers mostly passive strategies, since installation of photovoltaic panels and generators may prove expensive. The power budget of those installed may also be needed for common facilities such as clinics and distribution centers, as well as other functions, making mechanical cooling less economical.

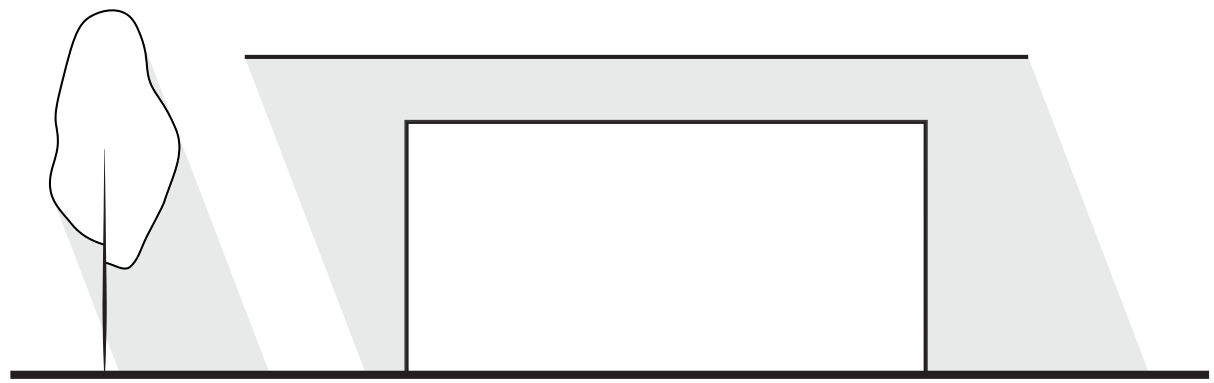
Solar shading
The use of shading to provide cool exterior spaces and reduce the interior temperature is an intuitive solution, which has been used throughout the world and in many different climates. There are multiple ways to shade, such as using curtains, moveable screen walls, having a fixed overhang, and planting vegetation. Each have different strengths and weaknesses, such as overhangs being permanent fixtures and requiring extra space. They require no user interaction, but will only serve one purpose, unlike move-able walls and curtains which can be adapted to fit a situation, which requires a specific user behavior to functions ideally.

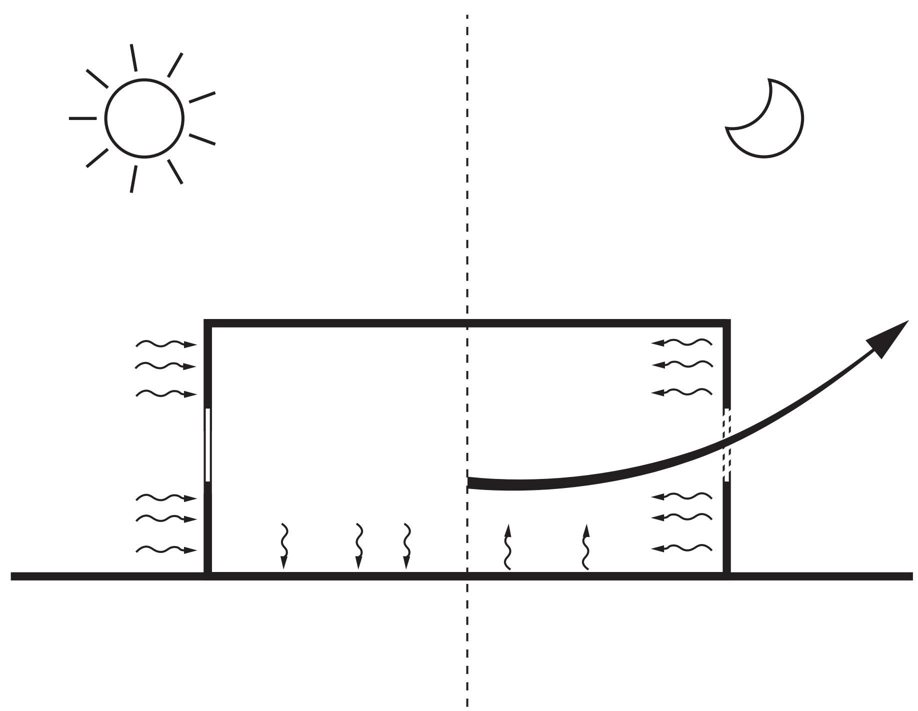
The Climate Conditions Study shows the area used for the settlement is characterized by a high sun altitude with little annual variation, meaning that South- and North facing walls can be shaded entirely which would provide cooler exterior areas throughout the entire year. While the temperatures are generally higher during midday, East- and West facing walls should also be adequately shaded to avoid excess radiation heat from the rising and setting of the sun. Shaded spaces should be placed close to the house, so that they can be utilized for various household activities. The evening meal is often enjoyed in these outside spaces, meaning they should be big enough to accommodate such activities (UN-Habitat, 2014).

Thermal mass
Thermal mass is a material property, tied to the materials density as well as ability to store heat as a function of its specific heat capacity (kJ/kg.K) – the amount of heat energy required to increase 1 kg of material by 1°K. The thermal mass can be measured by its volumetric heat capacity (kJ/m^3 K) (Baggs and Mortensen, 2006). Materials with a high thermal mass are usually dense and can store heat to be released at a later point. A building with a great amount of thermal mass can minimize the effect of heat flow fluctuations. This is referred to as the thermal inertia of a building (Baggs and Mortensen, 2006).

Structures with a high thermal mass are well-suited in the local climate, as they can store a great amount of heat energy from the air around the exterior spaces. Dwellings should however also be compact to reduce the overall solar exposure.

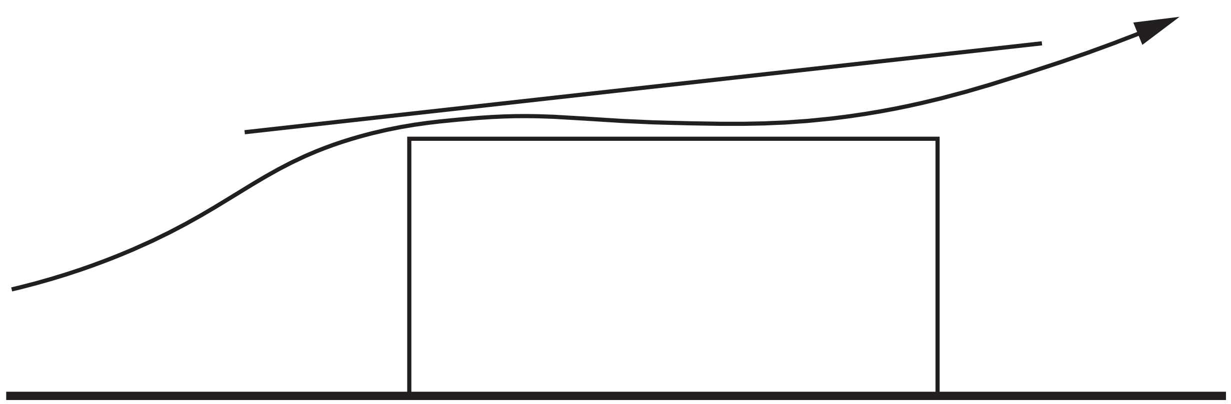
High thermal mass and night ventilation
Building in this climate will put a large emphasis on cooling rather than heating, and in the case of a refugee settlement, access to modern electric cooling systems may not be possible. Natural ventilation is a viable alternative to mechanical ventilation in the context of this project. It can be achieved by having different thermal zones on opposite sides of a building. Shading in one area and high incident solar radiation in another results in a temperature difference which can be used to create drafts through the house. This can also be achieved through the stack effect by having openings in the building envelope at different heights. Warm air will pass through the highest opening, while cool air will enter through the lower, creating a continuous flow using thermal buoyancy.





Ill. 16: Above: Shading Strategy

Ill. 17: Below: Thermal Mass and Ventilation Strategy



Ill. 18: Above: Evaporative Cooling Strategy

Ill. 19: Below: Double Roof Strategy

The local climate has a high impact on the ventilation strategy, when implementing natural ventilation. In the hot-arid climate of Rift Valley, daytime temperatures average between 29°C and 34°C, discouraging the use of ventilation during the hottest days, as this would increase the indoor temperature. Instead, natural ventilation should be utilized during nighttime, where temperatures drop to about 20°C. The interior spaces are ventilated to offset the effect of heat accumulated throughout the day. By implementing thermal mass in shaded areas of the building that are ventilated during the night, the effects will complement each other and reduce the indoor temperature during the day.

Evaporative cooling

Evaporative cooling functions by changing the sensible energy to latent energy, reducing the temperature of a space by increasing the humidity. Evaporative cooling is therefore more effective in areas with low humidity since the air is less saturated (UN-Habitat, 2014). If evaporative cooling is used to cool an indoor space, a good ventilation rate is needed to counter an accumulation of water vapor, which may work against the strategy of night ventilation. This method can instead be utilized in outdoor spaces, reducing the temperature of the air around the houses (UN-Habitat, 2014).

The hot-arid climate of the Rift Valley makes the evaporative cooling effect suitable as a passive strategy to be implemented in the settlement, either in the form of water basins or vegetation. Water should however be prioritized for consumption and sanitary purposes, but excess water spilled or water collected during rainy seasons can be utilized.

Double leaf roof

According to a UN-Habitat report on sustainable buildings in east Africa, the most effective roof type is a ventilated double skin (UN-Habitat, 2014). An outer roof shields the ceiling of the house from solar radiation and can be used to shade the building in areas where excess solar heat gain should be avoided. This roof should consist of a reflective material to reduce the amount of heat energy absorbed. The space between should be ventilated, utilizing the stack effect as well as the Venturi effect. A slanted roof with a smaller opening towards the inlet and a larger towards the outlet can achieve this effect. In the case of this project, an inlet towards the north or east would accommodate the more prominent north-eastern wind, as indicated in the previous study.

Months with higher degrees of precipitation may provide significant amounts of rain. Depending on the nearby vegetations ability to retain it, the water might pass directly through the ground. Large roof surfaces shielding the structure beneath can also function as a rain collection system, allowing for storage and slower release into the environment, giving nearby plants a more stable supply of water.

Dwellings should generally be compact and use materials with a high thermal mass to reduce thermal fluctuations and absorb heat from the surrounding atmosphere during daytime. Since evaporative cooling as a passive strategy is most effective in a hot-arid climate, such as the one the site is located in, it can be implemented in the building design. Likewise sufficient shading of exterior areas and structures should be provided to ensure thermal comfort of these spaces during the day. Buildings can be arranged relatively close and/or vegetation could be used for shading.

Settlement Organization

The purpose of this study is to gain a better understanding of how a refugee camp is organized as opposed to an informally developed urban environment, by comparing the plans for Kakuma Refugee Camp and the nearby original Kakuma town.

The Kakuma Refugee Camp was established in 1992 as a response to the increasing number of refugees from Ethiopia, Sudan, and Somalia. Little information is available on the planning strategy of the camp and the town from which it takes its name. Using the few resources available, such as satellite imagery, the placement of buildings and roads can be depicted, which provide an overview of how the two areas are organized. The sites chosen for the comparison are located 7 kilometers apart.

Kakuma town appears to follow no apparent pattern of organization, whereas the camp is structured in a semi-rigid grid. In the grid structure the hierarchy of pathways and spaces is determined by their width, which makes the roads suitable for different forms of traffic. The many intersecting roads provide a large degree of freedom when traversing the camp. However, it is also difficult to suggest a specific behavior from a planning perspective, and some roads may become more heavily trafficked while new ones emerge independently of the original plan.

In the informal town the winding pathways sometimes terminate near a destination, often a specific house. The indication of a destination and endpoint means that traffic is less sporadic, even though the network of paths and roads would make it seem so. An additional effect is the variation in width of these paths. The closer one gets to the city center, the larger they get corresponding with the expected flow of traffic. This creates a more fluid transition between spaces, rather than creating clearly defined boundaries. Another trait of Kakuma town is the apparent shared ownership of the public spaces. When members of a community share the streets knowing that it is mostly only used by people within said community, the effect of defined boundaries dissipates to an extent.

Another noticeable difference between the two urban landscapes is the density. The refugee camp is significantly denser than the town. Average area at the disposal of inhabitants is the primary factor. Refugees are typically allotted less space per person than people not affected by displacement. This is a result of how the available space is distributed and prioritized when planning a camp. Planners will often seek to accommodate as many people as possible within the thresholds defined by humanitarian organizations such as the UNHCR. Within the designated area the camps tend to become increasingly dense as time progresses until expansion is required. In Kakuma town most of the land is owned by the inhabitants, with many options for expansion depending on the resources' and available land at their disposal.

Having a dense cityscape with small private plots creates a demand for public spaces and amenities. In the lower density urban environments residents often have more private space to perform some of the same activities. These public spaces create a diversity in the urban fabric through different typologies and functions, which may not be present in purely residential areas.

The static grid structure may result in less open spaces and a lack of destination points in the urban environment, which should be avoided. A less defined organization may create a more diverse settlement and spaces with different functions and atmospheres. However, it is still important to avoid long stretches of road leading to and from each destination and remain easily navigable. The design proposal for a settlement should also be semi-dense with different neighborhoods and access to public amenities.

Ill. 20: Left: Kakuma Town (no scale)

Ill. 21: Right: Kakuma City (no scale)

Urban Typologies

The purpose of this study is to identify some of the widely used urban typology through a literature study and catalogue these. The pre-established typologies will serve as inspiration for the subsequent Urban Structure Investigation, meaning that the conclusion is suggestive rather than affirmative.

Typology as a framework

In Rafael Moneo's essay "On Typology", the Pritzker winning Spanish architect touches upon the subject of a building "as an entity in itself" (Moneo, 1978). Yet it cannot be denied that patterns have and will continue to emerge in architecture. Individuals tend associate parts or the whole of a building with other architectural entities:

> *"The identification of an architectural element like 'column,' or of a whole building -'courthouse'-implies an entire class of similar objects with common characteristics" (Moneo, 1978)*

Throughout the 18th century the study of building typologies has changed, with classification of individual buildings and building organizations often being redefined. Parameters used to differentiate typologies have also changed, but typically include form, detailing, function, and composition. While the study of typologies is a form of classification it cannot be seen as an exact science, but rather "as the frame within which change operates" (Moneo, 1978).

The typologies

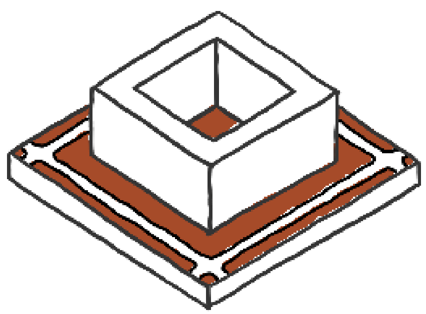
Since there are many ways in which a typology may be classified, it is helpful to consider some of the pre-established or widely used definitions.

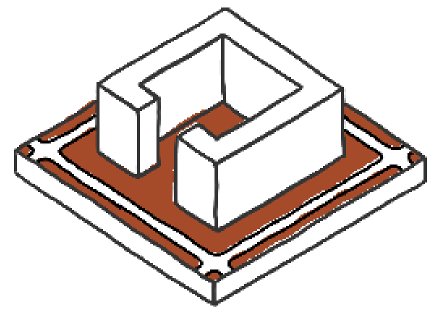
Architects Bernard Leupen and Harald Mooij present nine urban ensembles but also acknowledge that there exist others, which "do not fit into any of the categories above and perhaps cannot be identified according to one particular morphology" (Leupen & Mooji, 2012). The presented typologies should be viewed as primitive methods of arranging building volumes, which can be used either separately or as elements within a larger and more elaborate composition. They provide different approaches to urban development from low to high density and must be considered in terms of access to sunlight and a right to privacy. These are:

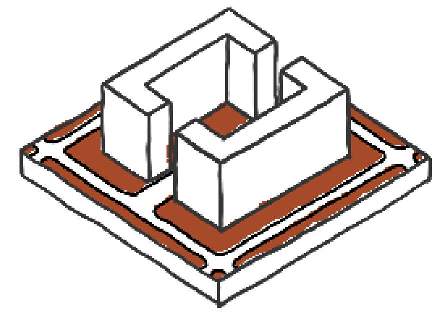
- *Perimeter block*
- *Semi-open block*
- *Super block*
- *Open block*
- *Sun oriented parallel rows*
- *Ribbon development*
- *Free-standing objects*
- *Free composition*
- *Villa park*

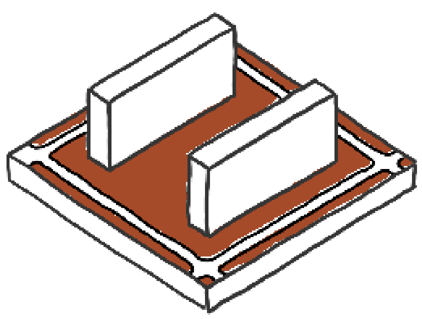
The Open-, Semi-open-, and Super block are evolutions of the perimeter block, each trying to correct some of the faults inherent in the original. The pattern of sub-dividing the original volumes culminate in the Free Composition and by extension the Villa Park, which affords the architect a greater degree of freedom in the arrangement of volumes.

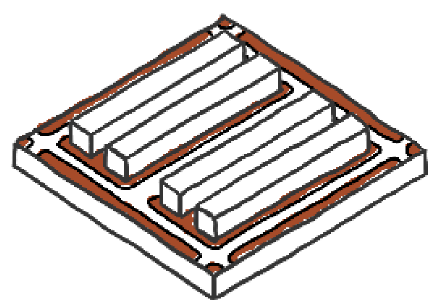
The nine typologies presented serve as inspiration for the development of different compositions in the Urban Structures Design Investigation.

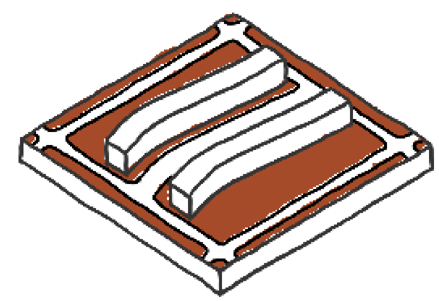


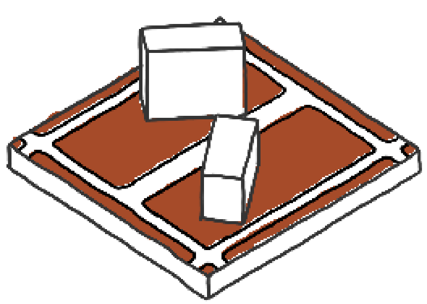


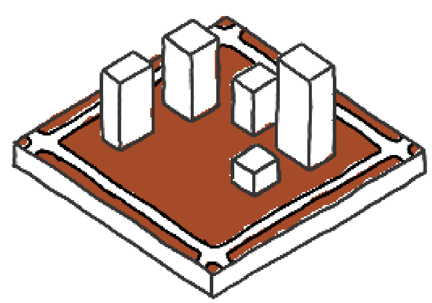


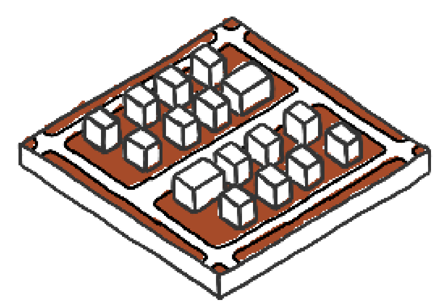












Ill. 22: Above, Left: Perimeter Block

Ill. 23: Above, Center: Semi-open Block

Ill. 24: Above, Right: Super Block

Ill. 25: Middle, Left: Open Block

Ill. 26: Middle, Center: Sun Oriented Parrallel Rows

Ill. 27: Middle, Right: Ribbon Development

Ill. 28: Below, Left: Free-standing Objects

Ill. 29: Below, Center: Free Composition

Ill. 30: Below, Right: Villa Park

Urban Structures

The purpose of the following design investigation is to explore different types of urban structures with a point of departure in the previously conducted urban typology study. The compositions presented in this investigation each consist of 33 land plots; 32 for residential use and one communal. The space between the plots will be viewd as unbuilt area with pathways. For the purposes of this investigation the size of plots has not been fixed, yet still provide a principal understanding of the patterns that emerge in the urban environment.

The Urban Typology Study was characterized by a high-density urban landscape which cannot be directly translated in the context of the following investigation. An exploration of different compositions with varying degrees of density of land plots may provide a more nuanced result in the form of emerging patterns. Knowledge obtained through both the Urban Typology Study and the Kakuma City Case Study will inform the conclusions of this investigation.

Method

Using sketching as a tool to produce various preliminary urban structures, patterns have been identified which has helped define six compositions that are distinct. Realizing that some of these newly established typologies share a number of features, parameters have been identified to better distinguish each of them. Digital modelling was used to produce three dimensional environments and measure distances and compare the area occupied. The types were then defined based on three parameters:

- *Distance: The average distance between the residential plots and the communal plot is measured. The residential plots should be within reasonable distance of the communal centre to ensure equal access and avoid unsafe areas in the settlement that are a long way from the nearest public amenity.*

- *Density: All the variants contain the same number and sizes of plots, meaning that the area they take up collectively reflects the urban density. This parameter is a major contributing factor in the character and experience of the settlement.*

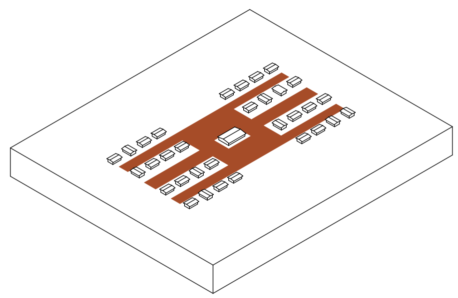
- *Exposure: A measurement of how many sides of the individual resident plots are exposed to the surrounding unbuilt area and public pathways. The exposure affects the sense of privacy, but also whether some areas become to hidden from public areas and thus are potentially unsafe.*

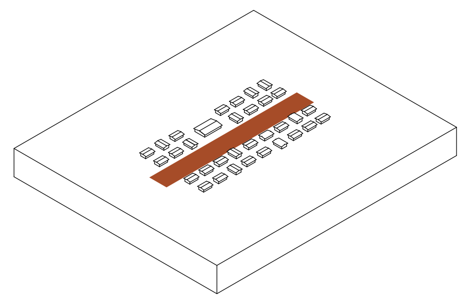
Distance and area are quantitative measurements, whereas exposure is a qualitative parameter. While two compositions can have the same average number of exposed and closed off sides, the experience of the environments may be significantly different owing to multiple other factors that influence the atmosphere. Neighbouring residential plots may have a different character and feel to them, depending on whether they are opposite each other or joined at the corners. The specific values for this study can be found in appendix 01.

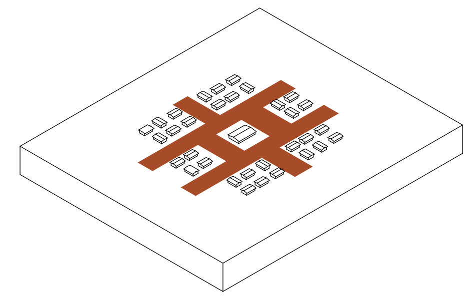
Results

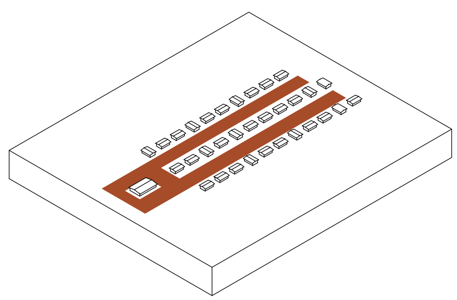
The first composition has individual plots aligned to straight lines with similar solar exposure conditions. All the plots are oriented the same way; one plot facing the back of another. Public pathways can be located on one side of a row and shared by the opposite. This creates a longer distance on the back side of the plots to some of the other neighbours. As there is possible access on two side of any given residential plot it may create unintended traffic and affect the sense of privacy. Depending on the location of the Civic Center, inhabitant may have to traverse long distances.

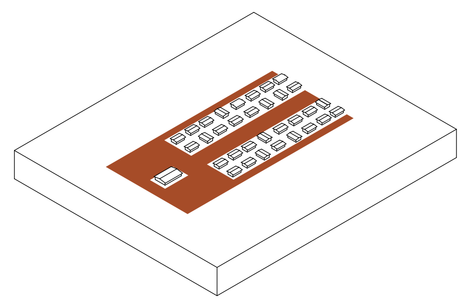
The second composition is inspired by the open block presented in the typology study in the way that two parallel rows face each other. In this composition the backs of the plots

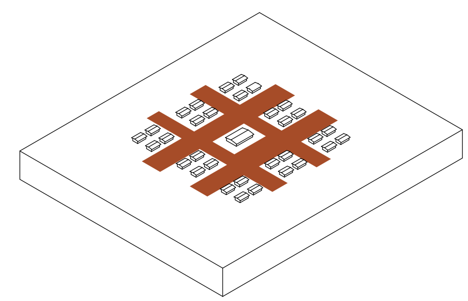












are placed against the back of the next row of plots, meaning individual residences will only be exposed to the fully public area from one side. Like the previous composition, this one is characterized by potentially long distances to and from the community centre. There is however an average higher density as neighbours live relatively closer to each other.

In the third composition the plots are placed in clusters of four residential plots arranged around the communal plot, creating a network of roads between the clusters. The plots are placed adjacent and thus limits the exposure to the road. The average distance to the community centre is minimised compared to previous compositions.

The fourth composition is inspired by the block and super block typology, but unlike the third composition smaller pathways are created within the clusters of residential plots. This of course increases the exposure of the plots to some extent, although the pathways may be considered less formal and primarily used by the inhabitants of the clusters in question, which lends itself to a semi-private atmosphere. Like the third composition the plots are arranged around the communal plot making for smaller distances and higher density.

The fifth composition is inspired by the villa park typology. Though these are variants of the same typology, they create different conditions for exposure of the plots. One has an even spread of residential plot while the other has strings. Because of the spacing between the plots, the overall density is significantly lower than the other compositions. This is a consequence of the typology serving as inspiration having the largest overall area required of those compared in the

Ill. 31: Above, Left: First Compostion (var. 1)

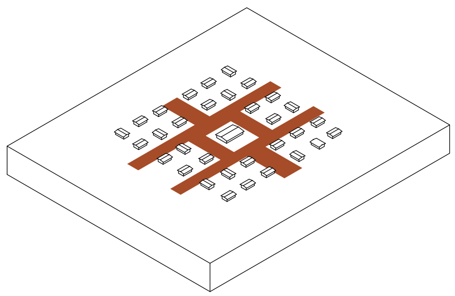
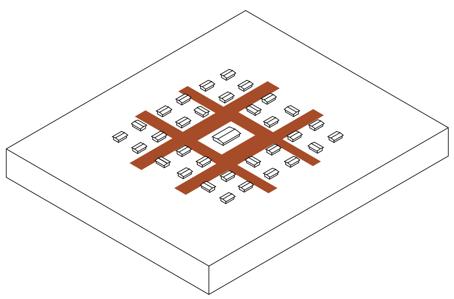
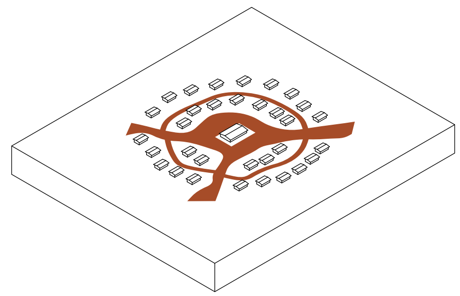
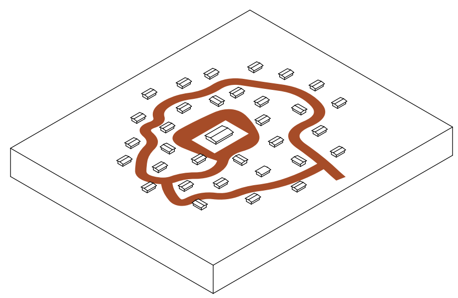
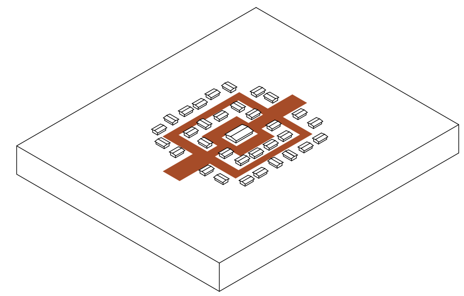
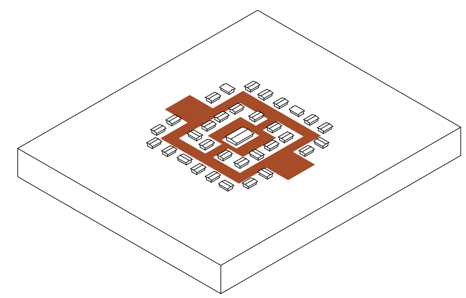
Ill. 32: Below, Left: First Composition (var. 2)

Ill. 33: Above, Center: Second Composition (var. 1)

Ill. 34: Below, Center: Second Composition (var. 2)

Ill. 35: Above, Right: Third Composition (var. 1)

Ill. 36: Below, Right: Third Composition (var. 2)

Ill. 37: Above, Left: Fourth Compostion (var. 1)

Ill. 38: Below, Left: Fourth Composition (var. 2)

Ill. 39: Above, Center: Fifth Composition (var. 1)

Ill. 40: Below, Center: Fifth Composition (var. 2)

Ill. 41: Above, Right: Sixth Composition (var. 1)

Ill. 42: Below, Right: Sixth Composition (var. 2)

Urban Typology Study. The average distance is similar to that of the third and fourth composition presented in this design investigation.

Using the fifth composition as inspiration, the sixth composition considered seeks to increase the average density by aligning many of the individual plots and reducing size of pathways. It has many of the same properties as the other compositions yet may prove difficult to access and navigate. The overall bounding area is very small compared to the other compositions, and it can therefore be concluded that this will create a dense environment.
Criteria were developed based on the findings of this preliminary design investigation. These include:

- *Minimise the distance to public amenities to the degree it is possible.*
- *Create clusters of lower density with a different degree of privateness compared to the surrounding built environment.*
- *Minimise the exposure of individual plots to enhance the sense of community*

While this investigation does not indicate that one composition is significantly more suited in the context of a settlement than any of the others, it has yielded patterns that can be used in continued design process. The results indicate that individual plots can be grouped and arranged around public amenities, creating clusters where buildings are less exposed yet still share a common area that is easily accessible.

Current Sheltering Solutions

The purpose of this study is to get an overview of some of the modern emergency refugee houses on the marked, and to create an understanding of what is needed from these houses. A case study of "Better Shelter" refugee houses by Ikea, and the "MCPE" home kit by Marwa Dabaieh will be performed, listing pros and cons of each solution and which aspects may be brought forward in the design phase.

Emergency housing is not only a question of providing the necessary amount of space per person and following a set of minimum requirements indiscriminately. A human centered design approach also means that individuals should be able to dwell within the settlement:

> *"In the Middle East, we were building camps: storage facilities for people. But the refugees were building a city" (Kleinschmidt, 2015)*

While refugee camps are established as temporary solutions, many such camps often end up as long-term housing for refugees. On average, a refugee spends 17 years of his or her life in exile (UNHCR 2014), with some refugee houses becoming quasi permanent settlements, such as the Dadaab settlement in Kenya and Cooper's Camp in India. Even though the statistics and history of these camps show a tendency towards refugees staying in these camps for extended periods of time, often lasting across generations, many camps are still composed of tents and other temporary structures.

This policy of short-term accommodation for what may become long term housing is not only environmentally unsustainable, but also less dignified for the people living in these camps. Tents used in such camps have an average lifespan of six months and does not offer much in terms of protection from the elements, safety, or adequate living conditions (The Guardian 2017).

In recent years, these issues have been addressed by multiple companies, such as Better Shelter and Suricatta Systems, who seek to create durable, safer, and more dignified living conditions for refugees. These shelters address some of the issues of cheap low-cost refugee housing by creating more robust solutions with a greater degree of longevity.

While these companies are designing shelters that can last a few years, others such as Marwa Dabaieh, a professor of sustainable architecture and environmental design, seek to create homes in a different way. Using vernacular architecture and design for disassembly, Dabaiehs "Minus carbon & plus energy design home kit" is a more permanent solution, utilizing passive and off-grid solutions.

Better Shelter

The Better Shelter is a 17.5 m2 shelter developed by the IKEA Foundation alongside UNHCR which won the Beazley Design Museum "Design of the Year" in 2016. Built from a skeleton frame, the Better Shelter is shipped in two flatpacks, much like any other IKEA furniture set, and can be assembled by 4 people. While the framework is reminiscent of a tent frame, the sturdiness and size of the structure provides the occupants a greater sense of safety and better living conditions. The frame can also be reused in case the cladding fails, and multiple frames can be put together as makeshift clinics and schools. The shelter is supplied with a lockable door, solar panels and ventilated panel and windows equipped with mosquito nets. The cladding used is also stab-proof, an important feature in high tension zones.

While these shelters were initially met with great enthusiasm from the UNHCR, with 15.000 units being bought, concerns were raised about vulnerability to fire. This led to two thirds of the units being put into storage while an investigation was conducted, resulting in a potential loss of $12.5 million (Dezeen 2017). This may have been unwarranted however,

Ill. 43: Outside Better Shelter

seeing as the shelter was never designed to meet Swiss fire regulations.

Along with this investigation, a series of design flaws were discovered, among which were the lack of wheelchair access caused by the door frame. Reports of the frame not being as study as intended were also found, showing the refugees performing improvised repairs to maintain the stability of the shelter.

Despite its flaws, the Better Shelter is a noteworthy improvement, even in short-term refugee camps, compared to the standard tent often used. Unlike tents, it is highly reusable, less degrading to the people using it, provides privacy and safety and supplies the occupants with electricity. But with an expected lifespan of 3 years, these shelters will have to be replaced many times if a camp becomes semi-permanent.

MCPE

The Home Design Kit MCPE is a 37 m2 off-grid house designed to help alleviate the situation of a growing number of refugees awaiting permanent residence in Sweden. The house is made from lightweight construction materials, which are sourced from the local environment. Using wood for framing and plant-based fibers for insulation, the embodied carbon is kept to a minimum in both material extraction and transportation. As it is built for disassembly, the house can be assembled by the inhabitants in just 11 workings days, with the help of 4-7 persons daily, by using "pre-built" blocks of wood and insulation material, which are then cladded. After use, these blocks can either be repurposed or composted. If built using the same methods as in the prototype, the house should be fire resistant for 90 minutes, or 120 minutes if plastered with 2 cm of clay, and completely water resistant.

Ill. 44: MCPE

The house is supplied with a working toilet and kitchen, along with various off-grid and passive energy solutions. These strategies assist in regulating indoor temperatures using trombe walls and earth pipes, and produce electricity through photovoltaic panels and wind turbines. Since the houses are built off-grid, each is fitted with a water and waste management system to optimize water usage.

However, many of these passive systems are only functional if the users know how to operate them. The trombe wall and green wall both require manual operation to function, and the photovoltaic panels would need cleaning regularly if the shelter is built in a dusty area. Unlike the Better Shelter, these houses are not modular, with most walls either used for passive solutions or kitchen space, making it harder to expand the house. The house also requires more work than the Better Shelter, as space needs to be dug up for the septic tank, earth pipes and earth fridge, as well as more extensive foundation to support the house. While this leads to a short period of time where the refugees do not have a proper home, the time spent building versus the time spend living in the house makes up for it.

The study indicates that a long-term housing strategy benefits from having more permanent and sturdy buildings, which additionally helps to create a sense of security and privacy. An increased area pr. person to accommodate the future needs of the inhabitants is also advisable. Passive strategies can be implemented, provided the occupants are properly informed about operation.

Camp Guidelines

The purpose of this study is to examine the standards that UNHCR, the UN refugee agency, has laid out for planning refugee camps. The most essential guidelines will be highlighted and the list is therefore not exhaustive.

Location is a key factor when planning a settlement. The chosen site has a significant impact on the situation for displaced persons in terms of protection, well-being, and further development.

According to UNHCR, camps should ideally be located sufficiently far from conflict or other causes of displacement, but still close enough for the IDPs to reach it safely and in good health. It should be within manageable distance of food and water supplies, easily accessible by aid organizations, which indicates that it should be located close to a reliably functioning road that can be traversed even during rainy seasons. Access to national grids and services are valued highly and would negates the requirement to develop these facilities within the camp.

Alternatively, the camp should be partly or entirely self-sustaining for electricity and water. It is also advised to select a location with sufficient ground cover, such as grass or bushes, that can protect the area from severe weather conditions, such as flooding and heavy winds, especially in areas where dust clouds are common as these can cause respiratory disease. This is especially relevant in a hot-arid climate such as the one in Rift Valley. A location with vegetation may also provide opportunities for cultivation of the area in the form of private vegetable gardens or small-scale agriculture.

Average area pr. person

Crowded conditions have often been linked to increased morbidity and levels of psychological stress, and so the area per person is a critical factor when planning a camp, both in terms of covered living area and general settlement size. UNHCR provides a guideline concerning the average camp are per person [m^2], which is a general figure including both interior and exterior spaces:

- *Standard:* *45 m^2*
- *Acceptable range:* *>35 m^2*
- *Unacceptable range:* *35-30 m^2*
- *Critical range:* *>30 m^2*

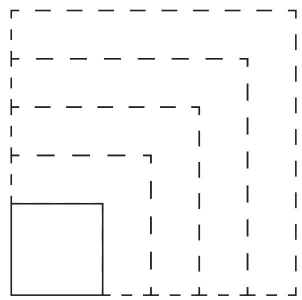
A minimum of 3.5 m2 covered living area per person is advised. However, to avoid congestion, additional space is advised.

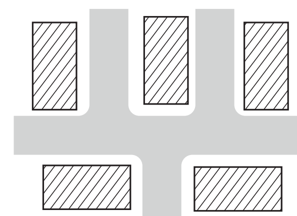
Distribution of area

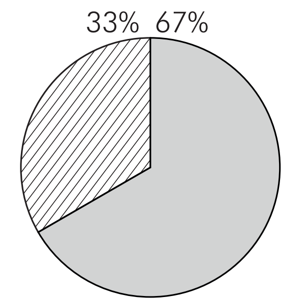
Using the guidelines provided, approximately two thirds of the area per person should be allocated for shelter units, roads, distribution points and common amenities. The last third should be preserved for household gardens attached to family plots (UNHCR, 2021). A minimum of 2 m between structures is required, with the addition of a 30m firebreak every 300 m. The distribution of area affects the overall density of the settlement, and these guidelines ensure that it can be developed without some of the adverse effects of overcrowding The terrain should generally be gently sloping with a gradient for the camp site at 1-5%, ideally 2-4% to ensure drainage while remaining accessible and traversable.

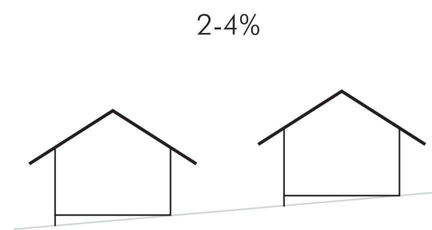
Site planning

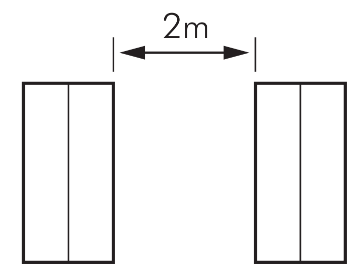
The planning of the site should begin on the scale of the individual shelter, by addressing the needs of the family such as distance to the nearest water post and access to communal functions, showers and latrines.











The UNHCR provides a definition of the different modules typically used when establishing a camp:

- *Family* 4-6 persons
- *Community* 80 persons (16 families)
- *Block* 1.250 persons (16 communities)
- *Sector* 5.000 persons (4 blocks)
- *Settlement* 20.000 persons (4 sectors)

The social structure and relations between clusters should also be considered. As previously established, people tend to group together with relatives or neighbors from their original community. Since the population of Kenya comprises many different ethnic groups and peoples, there may be a large degree of diversity between clusters, and a tight-knit community within. This would possibly help increase the sense of belonging. Areas between clusters may then become spaces for gathering of many different individuals.

The standards put forth by the UNHCR are intended for emergency-situations, meaning length of operation should be considered. Short term housing using simple shelters may be deemed adequate in some situations, but an extended displacement situation necessitates a different approach. The settlement should be organized as a series of clusters to create communities. The study influences the development of a spatial program on a domestic and urban level, and indicates that the standard 40 m2 area per person may be exceeded, and that the public spaces can likewise be larger to accommodate a variety of functions and amenities.

Ill. 45: Above, Left: Area pr. Person

Ill. 46: Above, Center and Right: Distribution of area

Ill. 47: Below, Left: Minimum area pr. Person

Ill. 48: Below, Center: Site Grading

Ill. 49: Below, Right: Minimum Distance between buildings.

Domestic structure

The purpose of the following design investigation is to identify principles for arranging building volumes in a domestic scale. Each composition is presented, compared, and discussed according to their individual strengths and weaknesses.

Four types of compositions using simple geometries to create a housing unit are considered in the following investigation. Variations of each with the same floor area as the original are also shown to indicate alternative developments. While there are many other possible variations, this investigation is primarily concerned with the governing morphological principles. This investigation involves a comparative analysis where each type of composition is considered according to the following parameters:

- *Material used: The total surface area of all volumes compared to the total floor area provides an indication of the expected amount of material used to construct additional walls. Other factors influence building mass, such as the layout of interior spaces, but for the purposes of this investigation have been simplified.*

- *Exterior spaces: The potential for using one or more building volumes to create exterior spaces and unique areas, for example courtyards. The investigation only accounts for the primary volumes and not additional elements present on a residential plot that could be used to create these spaces such as fences and vegetation.*

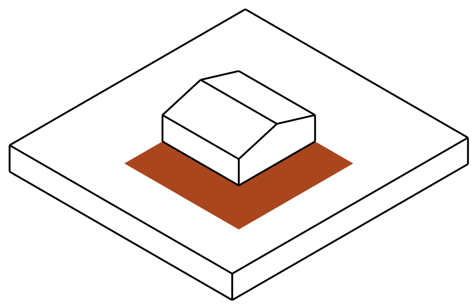
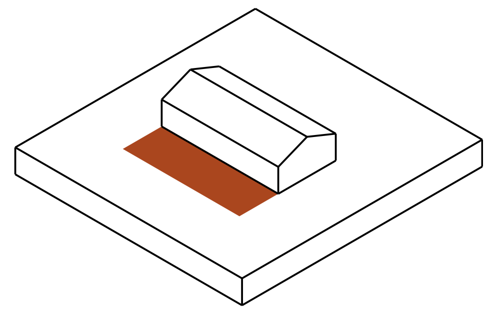
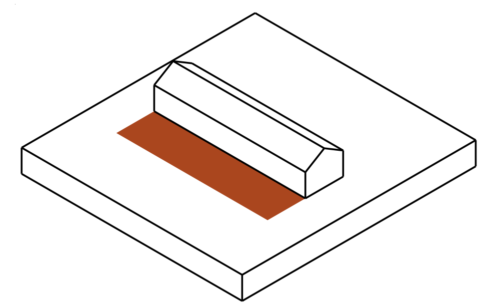
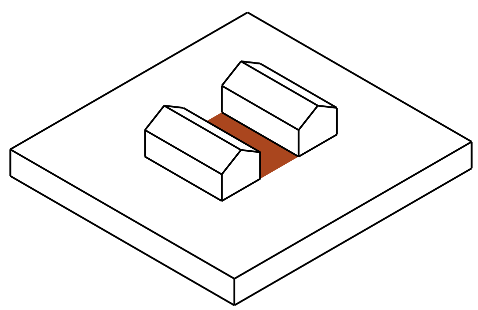
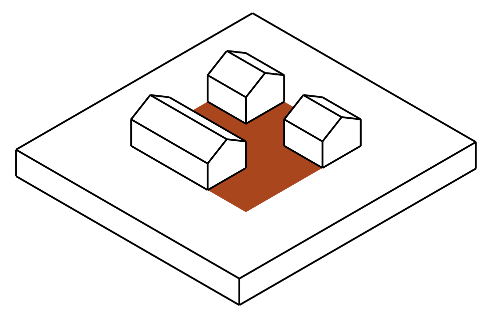
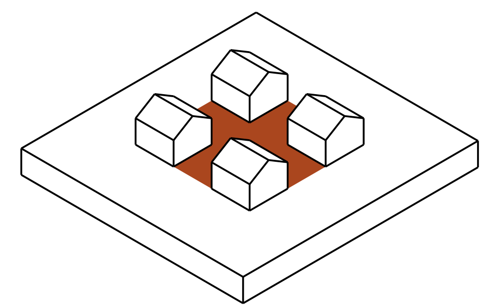
- *Simplicity of structures: The predicted ease of construction in terms of joining elements like walls and roofs is considered on a principle level. The efficiency of the construction is not considered directly, as that is influenced by other factors not accounted for in this investigation. Simpler geometries would reduce the amount of alterations made to justify certain rooftypes.*

The Types

In the first type of composition, the dwelling appears as a unified volume with a rectangular form. Each variation of its form affects its apparent "slenderness". The total surface area is kept to a minimum, since the buildings are simple in form and organization. This makes it difficult to define unique outdoor spaces without the use of additional structures to create either hard or soft boundaries. Roof and load-bearing structures can be relatively simple, meaning that they are easier to construct and do not facilitate many unique solutions. The building takes the appearance of a "long-house", and the potential for variation is minimal within the parameters set up here.

The second type consists of multiple individual volumes. Each new variation is found by dividing the preceding variation in smaller parts. By subdividing the volumes of its predecessor, the individual building masses become increasingly smaller, to the point where they can only contain a few rooms each. This could be used to arrange specific functions within the dwelling, such as sleeping areas or the kitchen independently on the assigned plot. At the cost of an increased total surface area the volumes can be arranged to indicate outdoor spaces between the buildings with multiple pathways. The predicted complexity is relatively low, since structures like roofs and load bearing systems can be created as individual elements spanning short distances.

For the third type of composition, the original form is split into smaller segments which are then "reattached" in a different way. The dwelling appears as a single "assembled volume" where the individual segments are shifted, but always parallel. Repeating this process produces buildings that are increasingly complex in geometry and may indicate exterior spaces such as a courtyard in this case. The smaller the segments are the larger the surface area becomes, which indicates that additional wall material may be re-

Ill. 50: Above, Left: First Type (var. 1)

Ill. 51: Above, Center: First Type (var. 2)

Ill. 52: Above, Right: First Type (var. 3)

Ill. 53: Below, Left: Second Type (var. 1)

Ill. 54: Below, Center: Second Type (var. 2)

Ill. 55: Below, Right: Second Type (var. 3)

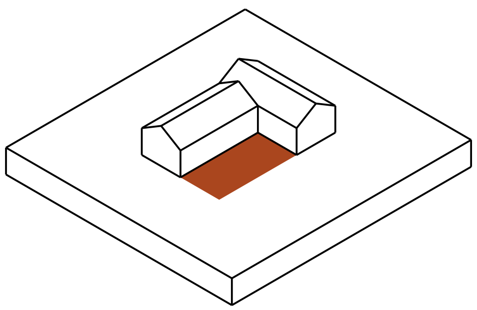
quired, compared to the first and second composition. The predicted complexity of the structure also increases, seeing as the conditions for joining individual roofs potentially requires many modifications to the system used.

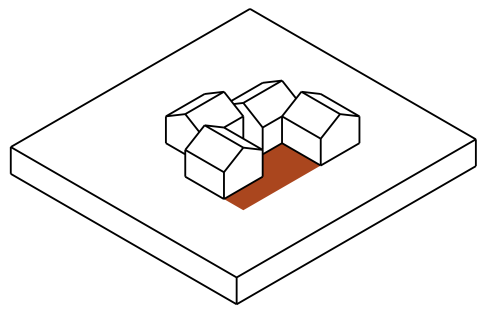
The fourth type of composition is a collection of multiple assembled volumes, inspired by the principle guiding the previous two. The dwelling is split into individual buildings, forming a compound with potentially complex spatial dynamics. This configuration enables the creation of diverse outdoor spaces where both courtyards and pathways leading to and from the dwelling can be indicated using only the building masses. Like with the previous type of composition, the complexity of the structure might be greater than that of the first and second one. Likewise, dwellings would require more building material overall, owing to its relatively large surface area.

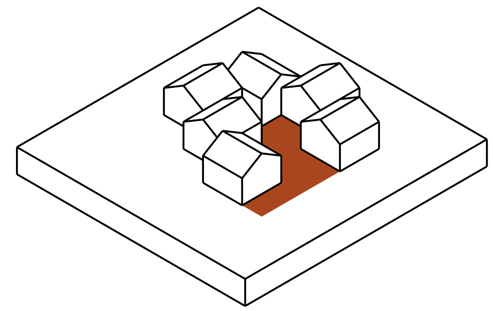
Evaluation

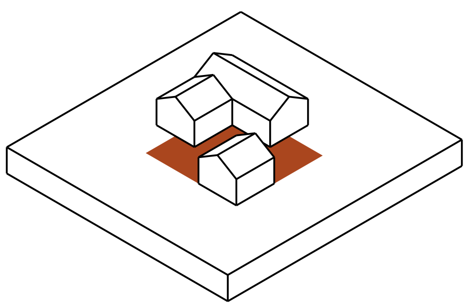
While the third and fourth types have the potential to create many different types of spaces within a dwelling, the first and second may also be developed further. The apparent simplicity of the geometries should not be equated with a less interesting environment. A premise of this investigation is the use of universal morphological principles for every dwelling, however, not all buildings need follow the same system. Other buildings such as those containing the communal functions could deviate from the principles that dictate house-design, to stand out in the local environment.

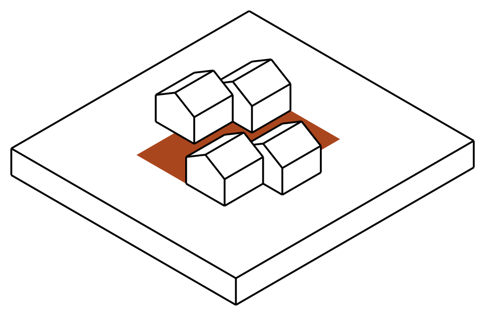
What is not immediately evident from this investigation is that uniformity in the appearance of the volumes does not exclude the possibility to create a dynamic and interesting environment around the dwelling or inside of it. This can be achieved by introducing additional variables such as chang-

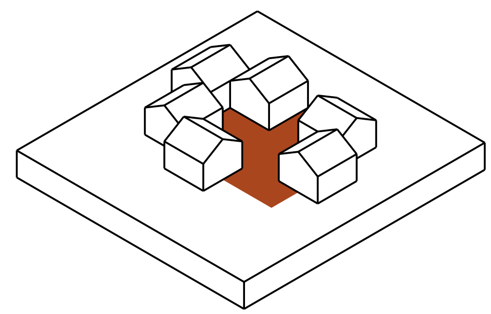












es to orientation and heigh of the individual buildings, or by providing additional elements such as trees, fences etc. on the plots. The space between separate dwellings likewise has the potential to create different types of areas, which is not reflected in the design investigation.

Lastly, the analysis conducted as part of this investigation relies primarily on a qualitative assessment, often referring to an anticipated outcome such as complicated structures, which might require specific modifications to a preestablished system. It is evident that additional investigations will have to be conducted to further quantify the information and enable a more in-depth evaluation at a later point in the process. However, as a simple design investigation these findings provide a suitable basis for further development.

This investigation indicates that multiple volumes can be used to define semi-open courtyards, but the resulting dwelling would require more building material, and depending on their configuration increase the complexity of construction. The results suggest the dwelling should consist of no more than three individual buildings on a lot. By simplifying the geometry many of the problems associated with overly complex structural systems are avoided.

Ill. 56: Above, Left: Third Type (var. 1)

Ill. 57: Above, Center: Third Type (var. 2)

Ill. 58: Above, Right: Third Type (var. 3)

Ill. 59: Below, Left: Fourth Type (var. 1)

Ill. 60: Below, Center: Fourth Type (var. 2)

Ill. 61: Below, Right: Fourth Type (var. 3)

PROGRAM

Summarization

This project seeks to address the initial problem outlined in Chapter 1 by presenting a scheme for developing accommodations within a settlement for Internally Displaced Person in Kenya. The scheme is manifested in an architectural proposition located on a site east of the Baringo Lake in the Rift Valley Province. The settlement will comprise multiple clusters forming smaller communities, each made up from 16 dwelling with nearby access to common amenities. Between clusters, publicly accessible functions shared by multiple individuals are placed.

As part of the project, the community is envisioned in the context of a continually developing settlement. This means that the organisation- and building strategies that are developed throughout are as important as the architectural proposal designed and presented. These strategies require thorough analysis and simulation to situate the design in the physical environment. Therefore, the project benefits from a holistic philosophy where different aspects are approached either from a "ground/up" or a "top/down" perspective.

Design Drivers and Criteria

As outlined in the Approach-section of Chapter 2, Design Drivers and Design Criteria are valuable tools in the design process. Drivers may instigate new design investigations and prompt further research of specific subjects, whereas the criteria are tangible objectives for the final architectural proposal, enabling evaluation. They also serve as points of departure for the sketching phase of the integrated design process and help operationalize the information obtained through the conducted studies and investigations.

Drivers and Criteria are not static, as they are re-assessed and re-specified throughout all phases of the design process. Prioritization may also change as new iterations are created, which is implied in the model of an integrated design process.

Spatial Programme

The spatial programme provides a quick overview of the functions contained within each of the units detailed and used to populate the settlement. The house is designed to accommodate up to 7 individuals, which is an increase from the 5 persons outlined in the UNHCR's definition of an average family size. A Civic Center is also presented with spaces intended for functions like classrooms, library, health clinic and activities. A Water Post is located inside each cluster, providing access to water for consumption and household needs while also offering a space to wash clothes and gather outside. Communal Bath Houses are also planned inside each cluster, with gendered showers and toilets.

Floor area and expected number of occupants pr. room is highlighted in the programme, along with additional factors such as ventilation strategy, orientation, and perceived degree of "openness" that inform the design of buildings.

Vision

What is unique to this project is its scope. Rather than seeking to address the immediate challenge of short-term disaster relief, a proposal for a sustainably developed semi-permanent settlement is designed. This is reflected in the built environment, with different types of units being built using materials that have a greater capacity to withstand the test of time. Inspiration is drawn from guidelines presented by UNHCR for emergency housing, but the different time frame means that the individual dwellings must also accommodate other needs. It has led to the following definition:

> *"The vision is to develop a long-term settlement for Internally Displaced Persons in Kenya wherein a sense of belonging and dwelling is emphasized, and climate responsive strategies are implemented"*

Drivers

- *Promote a sense Natural-, Collective-, Communal-, and Private Dwelling in the built environment*
- *Express the notion of a hearth, mound, roof and enclosure in the Dwelling*
- *Promote a sense of belonging and feeling of ownership for the inhabitants*
- *Design buildings according to the microclimate near Lake Baringo*
- *Organize the urban environment in a dynamic pattern creating spaces with different functions and atmospheres using transitions*
- *Lower the overall density of the settlement compared to examples of currently operating camps in Kenya*
- *Satisfy and possible exceed the minimum area requirements provided by the UNHCR to account for the longer time frame of the settlement designed*
- *Communicate a greater permanence of the dwelling through the architecture*
- *Lower the anticipated complexity of construction by simplifying the geometry of buildings and using surrounding structures and elements to indicate unique exterior spaces*
- *Integrate sustainable energy- and material solution*

Criteria

- *Create a settlement comprising clusters of 16 dwelling with shared water facilities*
- *Design a civic center with public amenities such as classrooms, a library, medical clinic and market space*
- *Use climate responsive building strategies, including a high thermal mass, night ventilation, shaded outdoor spaces and evaporative cooling*
- *Organize clusters of dwellings around specific amenities such as a water post and a communal bathhouse*
- *Enable inhabitants to build and expand the physical boundaries of their homes*
- *Reach a minimum lifespan of 7 years for buildings*
- *Design buildings for possible future disassembly*

Spatial Program

Single Family Dwelling

1 Family

Space	Size [m²]	Capacity	No. of spaces	Openness	Orientation	Lighting	Ventilation	Note
Kitchen	5	1	1	Open	North/South	Daylight	Natural	
Living room	25	1	1	Open	North/South	Daylight	Natural	
Storage	4	1	1	Closed	West	Artificial	Natural	Tank for homestead water supply
Large bedroom	6	2	2	Closed	East	Artificial	Natural	
Small bedroom	4	3	3	Closed	East	Artificial	Natural	

Bath House

Per 16 families

Space	Size [m²]	Capacity	No. of spaces	Openness	Orientation	Lighting	Ventilation	Note
Restroom	8	1	2	Closed	-	Hybrid	Mechanical	2 stalls per restroom
Bath units	2	1	4	Closed	-	Hybrid	Mechanical	
Waste disposal	8	-	1	Open	-	Hybrid	Natural	Sheltered space for waste
Service room	10	1	1	Closed	-	Hybrid	Natural	Storage etc.

Water Post

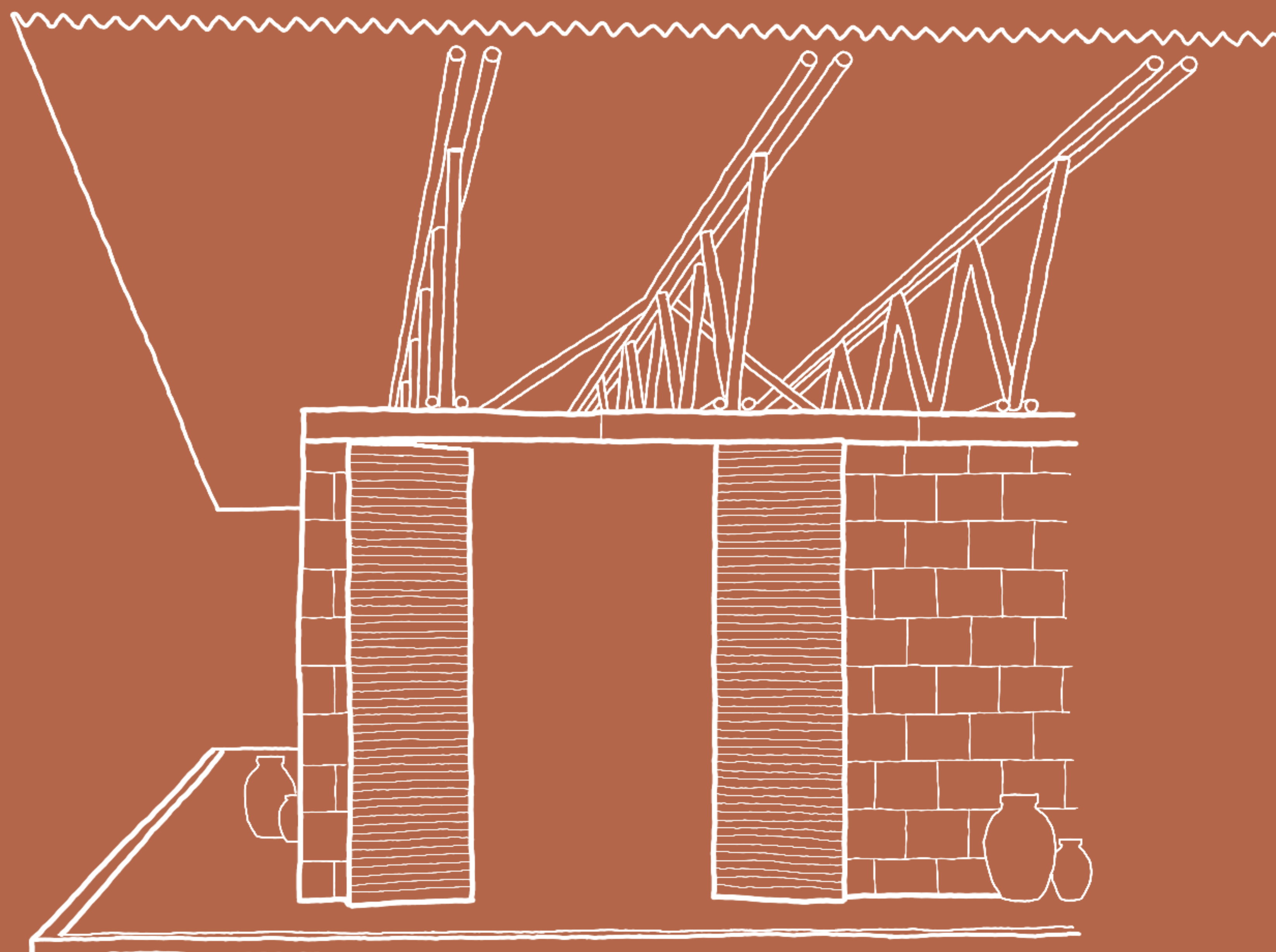
Per 16 families

Space	Size [m²]	Capacity	No. of spaces	Openness	Orientation	Lighting	Ventilation	Note
Washing room	40	8	1	Open	-	Hybrid	Natural	Primitive washing facilities
Water post	60	-	1	Open	-	Hybrid	Natural	Water collection area

Civic Center

Per 8 Community

Space	Size [m²]	Capacity	No. of spaces	Openness	Orientation	Lighting	Ventilation	Note
Small room	60	20	2	Open	East/west	Daylight	Natural	Flexible and transient usage
Large room	80	30	2	Open	North/South	Daylight	Natural	Flexible and transient usage

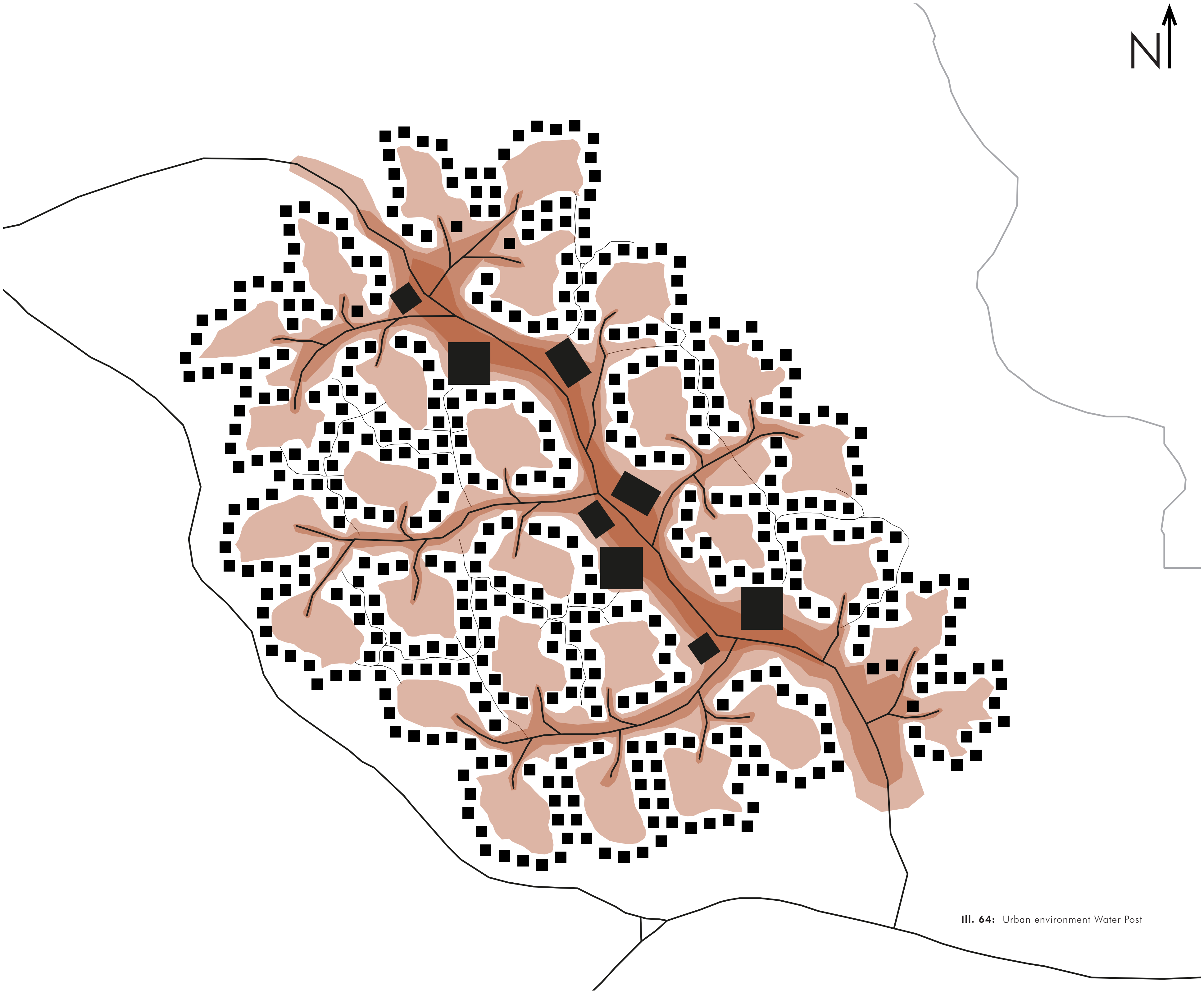


PRESENTATION

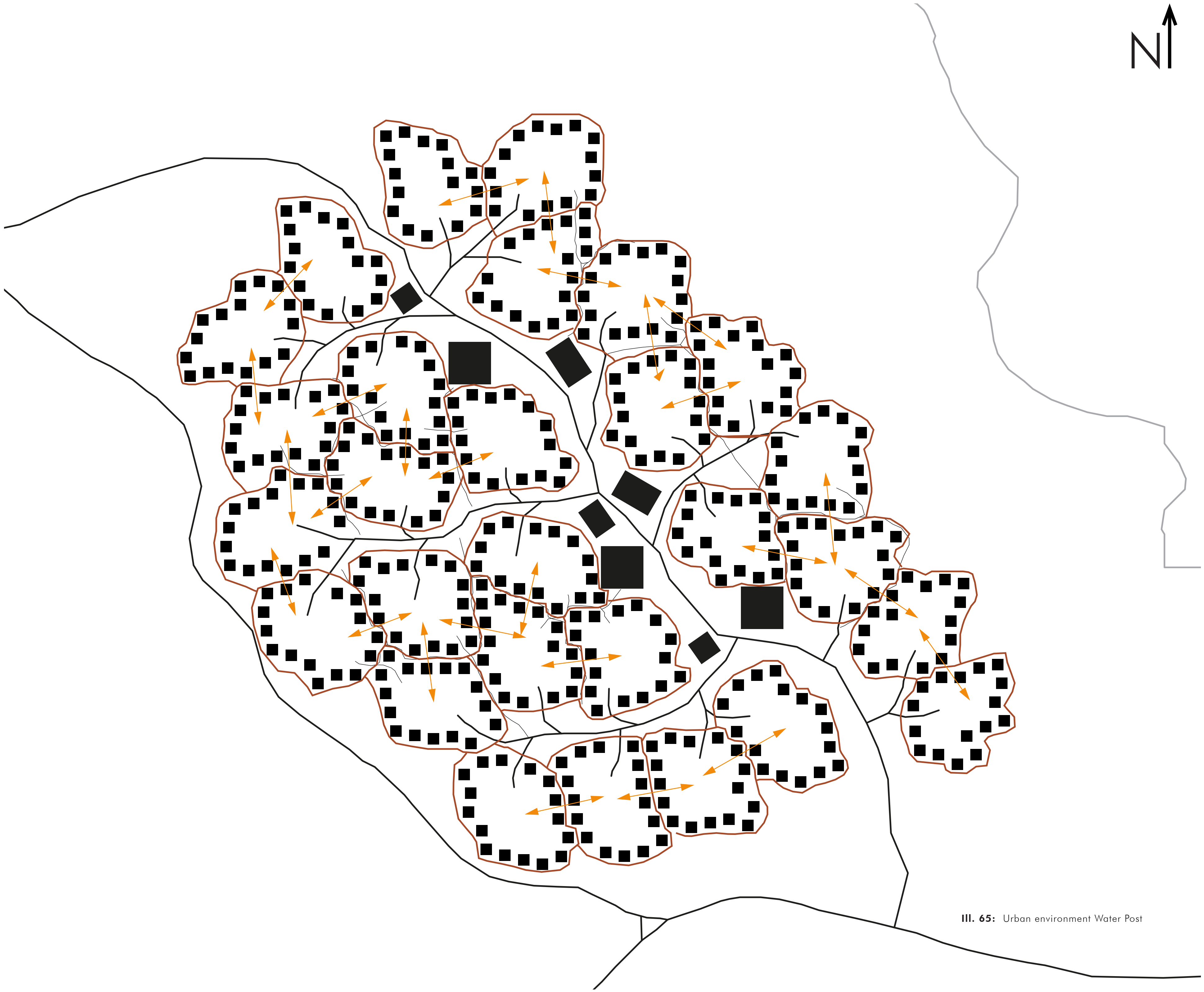
The Settlement

Ill. 62: Urban environment Water Post

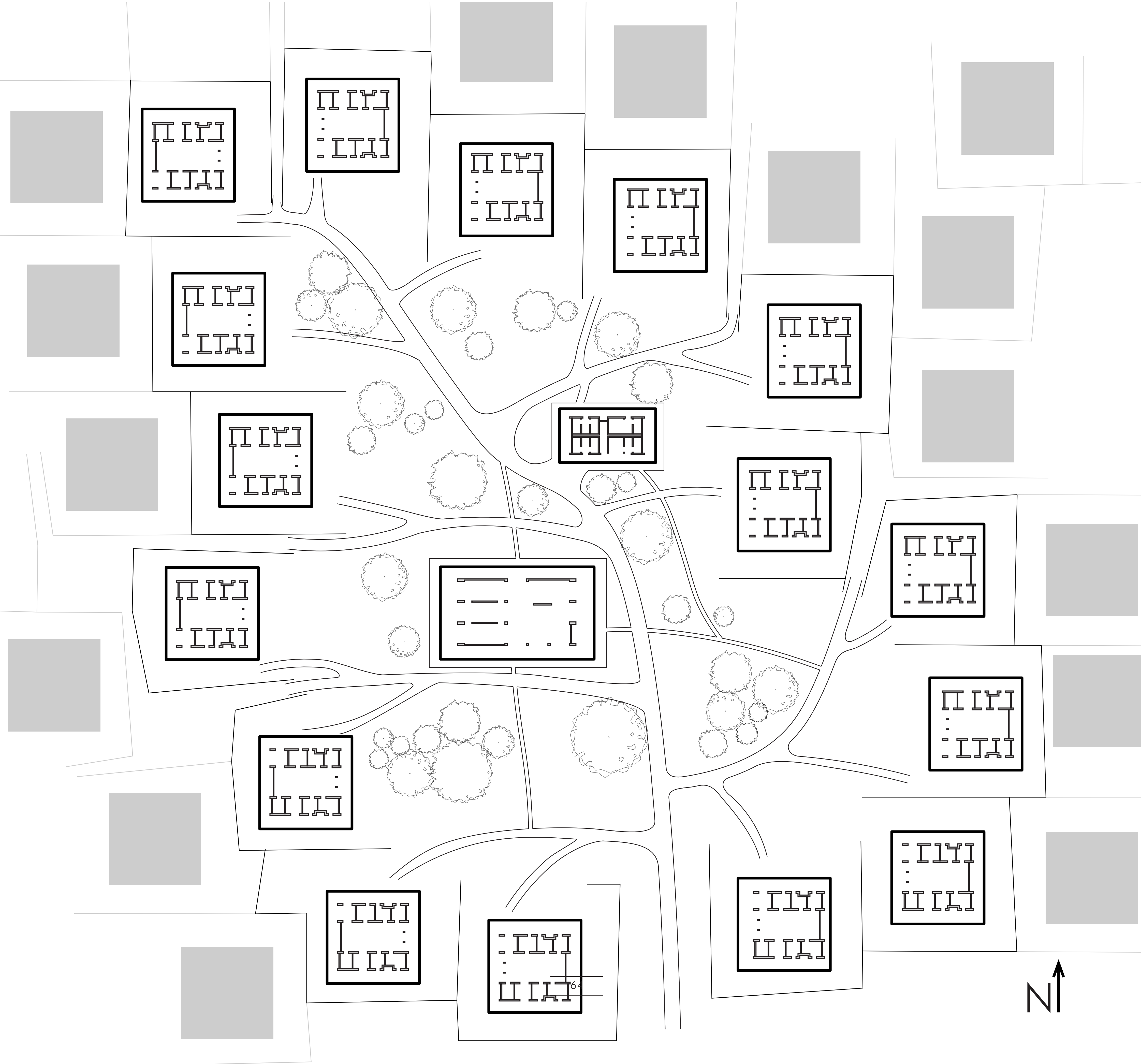
Ill. 63: Urban environment Bath House



Ill. 64: Urban environment Water Post



Ill. 65: Urban environment Water Post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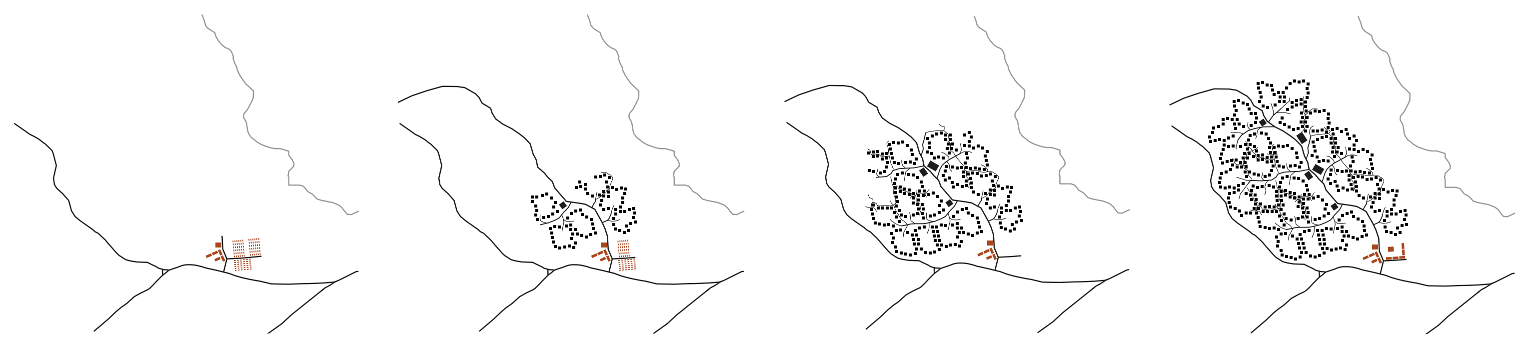


The Settlement is located on a plateau overlooking Lake Baringo, connecting to the western main road leading to the nearby town of Mukutan. The south junction acts as the primary entrance to the settlement. Roads leading to and from individual clusters branch out from a a main nerve that connects every part of the settlement. A network of small pathways provides access to neighboring clusters.

Public functions, such as Civic Centers and recreational areas, are placed along the main nerve. This layout helps blur out the boundaries of each clusters, while maintaining a sense of belonging to a specific community within the settlement. The variation between wide open public spaces and the more intimate privatized area near individual dwellings creates different experiences. Opportunities to gather in both formal and informal settings are provided, which underlines the communal aspect of the settlement.

Located inside every cluster are a communal Bath House and a Water Post. These become the hubs of individual communities, with all the houses oriented towards them to heighten this sensation. Lampposts provide lighting during nighttime, which helps establish the clusters as spaces that are safe to traverse at all times.

Clusters are envisioned in the context of a settlement that can be expanded to accommodate new inhabitants. This ties in with an ambition to address the long-term prospect of internal displacement. In the emergency phase, temporary shelters may be placed in a designated area in close vicinity to an administration office. From here the settlement can be built using the proposed scheme. It will gradually come into its own as time progresses and additional clusters are added.

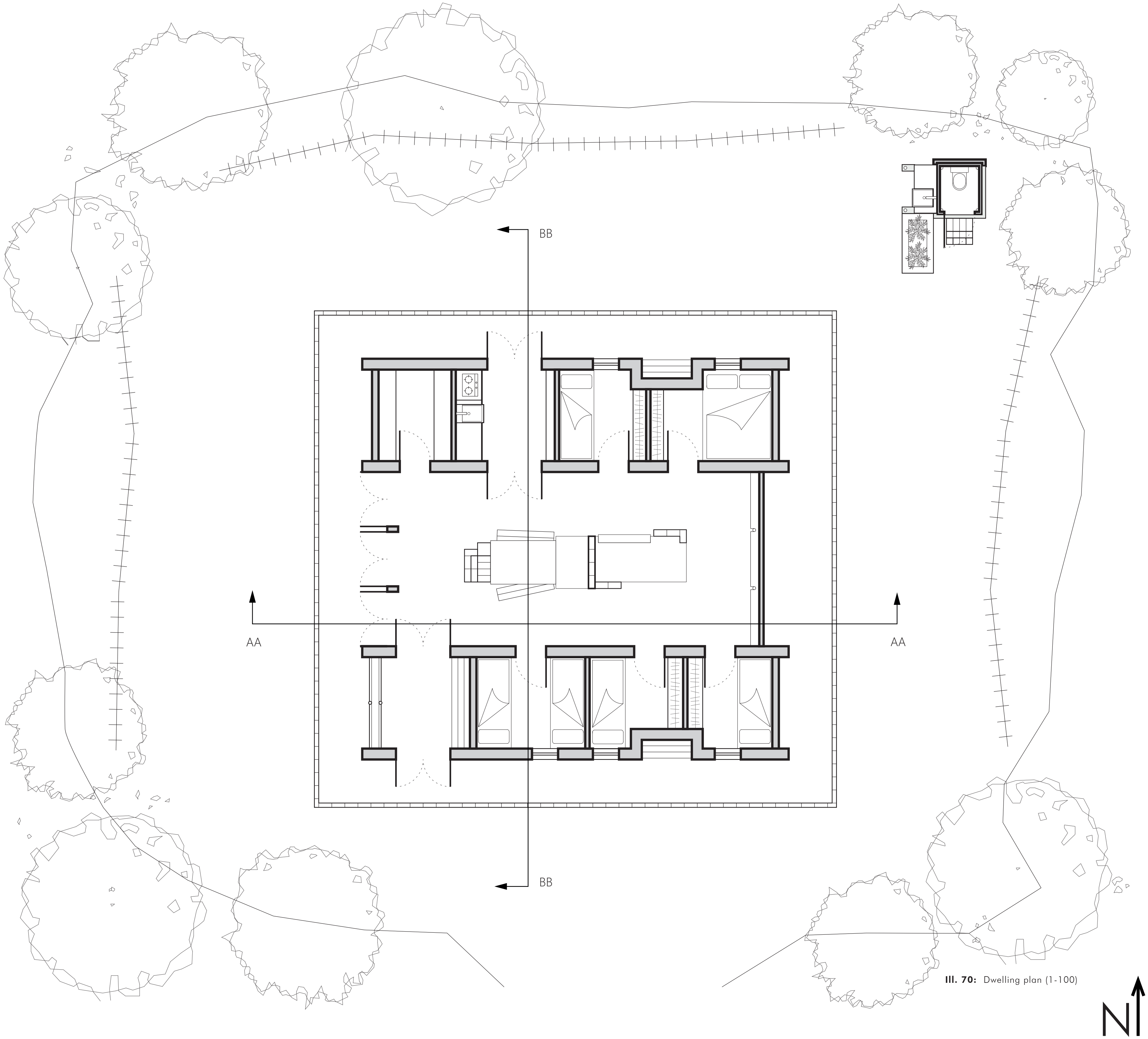
Ill. 66: Opposite page - Cluster plan 1:500

Ill. 67: Development of settlement (no scale)

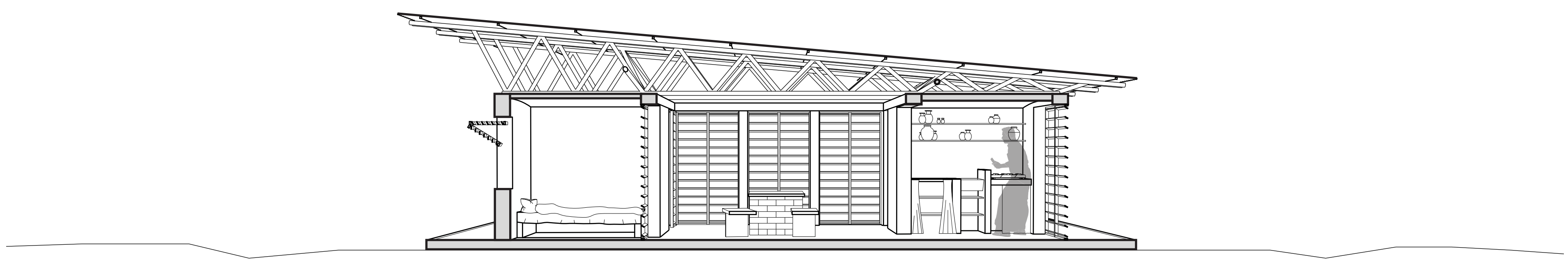
The Dwelling

Ill. 68: Dwelling

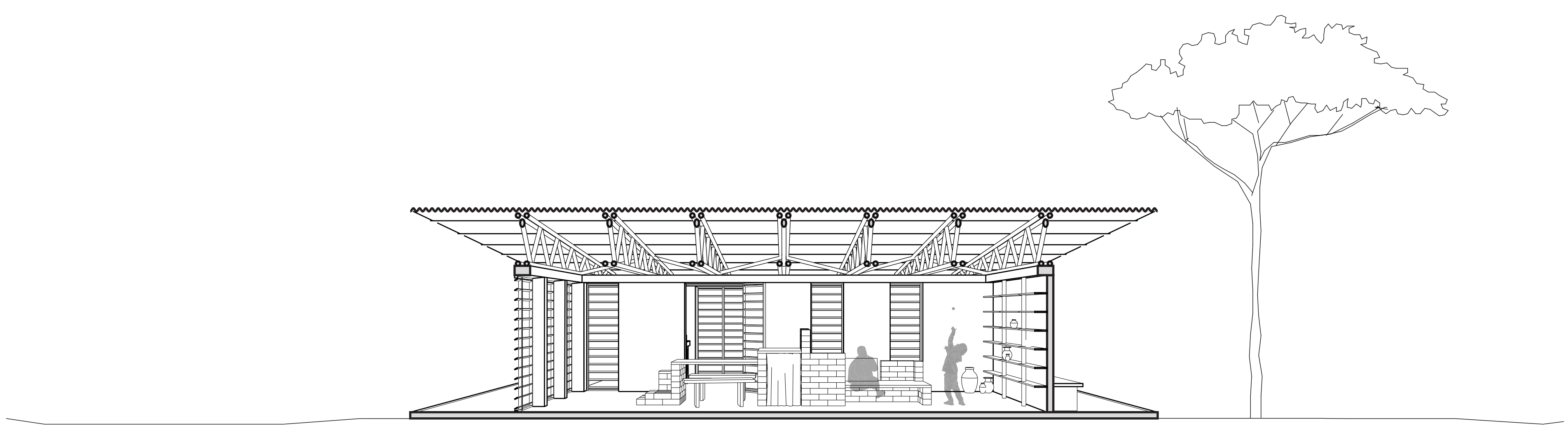
Ill. 69: Living area - Dwelling



Ill. 70: Dwelling plan (1-100)



Ill. 72: Dwelling Section BB (1-100)



Ill. 71: Dwelling Section AA (1-100)

Ill. 73: Kitchen - Dwelling

The sixteen individual dwellings within each cluster are designed to accommodate upwards of 7 people. A mix of single and shared bedrooms is provided, in addition to a kitchen and storage space. Fully enclosed rooms are arranged along two parallel strings.

The space between these creates a shaded area, that can be characterized as somewhere between an enclosed courtyard or veranda, and a general-purpose living room. This room can be characterized as the "hearth" of the building and becomes the place where members of the household can gather and share their experiences, ultimately enabling the private aspect of dwelling. It becomes a space where the users contribute value through their use of it, and the activities prompted by them.

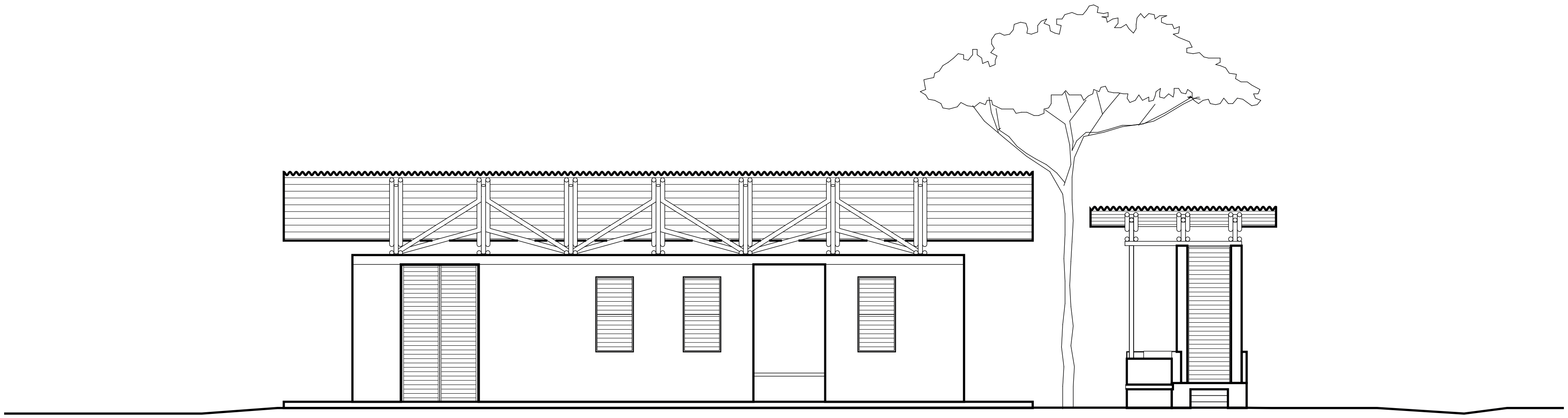
The layout reflects considerations made on the climatological conditions on the site of the settlement. The high sun altitude during midday has indicated that extensive shading is required. However thermal comfort must be maintained throughout the day, making evening and morning situations equally important to consider. To avoid accumulation of heat energy in bedrooms, rooms with fewer occupants on average, such as the storage space are arranged to create a buffer-zone. Openings in the façade are adjustable to address changing conditions throughout the day. The choice of materials also reflects a climate responsive design strategy by harnessing the physical properties, while creating building that communicates a kinship with vernacular architecture in the region.

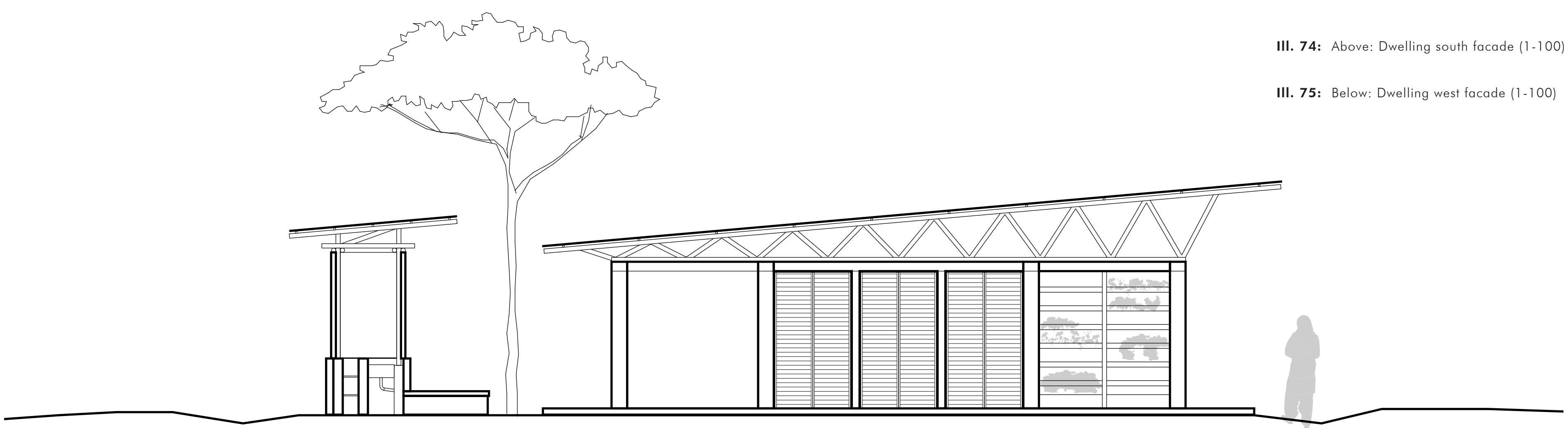
A large roof structure binds the two volumes together. This emphasizes the experience of a singular building rather than two separate ones, thus making it appear more as a proper home than a temporary shelter. Shaded spaces are created all around the exterior of the dwelling, thanks to the large overhang.

This extends the space suitable for activities and stay to also include some of the surrounding area on the assigned plot. In hot-arid climates such as this, people tend to remain indoors all throughout the day, only venturing outside when it is needed. This is not the case for the house typology presented as part of this project. By making the outdoor spaces more useable during midday, the building is transformed, which could influence the behavior of residents in a positive way, but also provide an entirely different atmosphere. When activities can take place outside, it seems reasonable to assume that the communal space around individual dwellings begins to take on a different character as well. It helps to establish a stronger connection between the individual and their community. Both the collective and private modes of dwelling can thus be manifested trough the architecture.

A vertical garden is integrated in the southwestern corner of the building. The space includes multiple shelves and a planter which can be used to grow produce for consumption. Part of this area is shaded by the roof above, but the shelves still receive ample sunlight when oriented west. Here residents can tend to their own personal garden and utilize the grey water produced by other household activities.

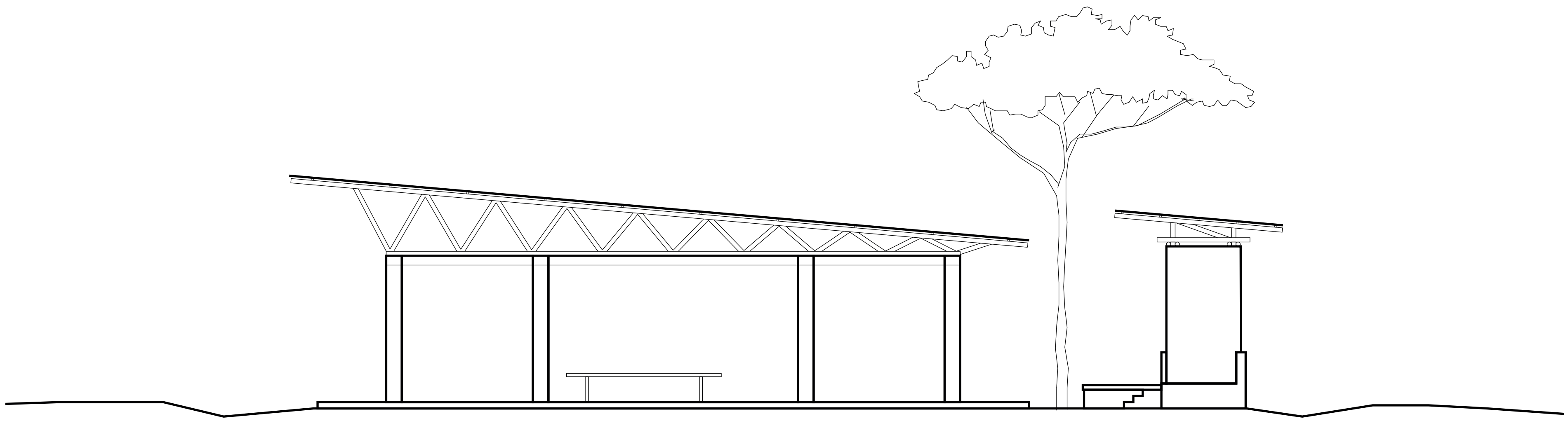
A green toilet is to each household and made accessible on the plot itself, offering a greater degree of privacy and security when required during nighttime for example. The toilet is a better alternative to pit latrines, as liquid and solid waste can be separated and collected easily which will improve camp sanitation overall.

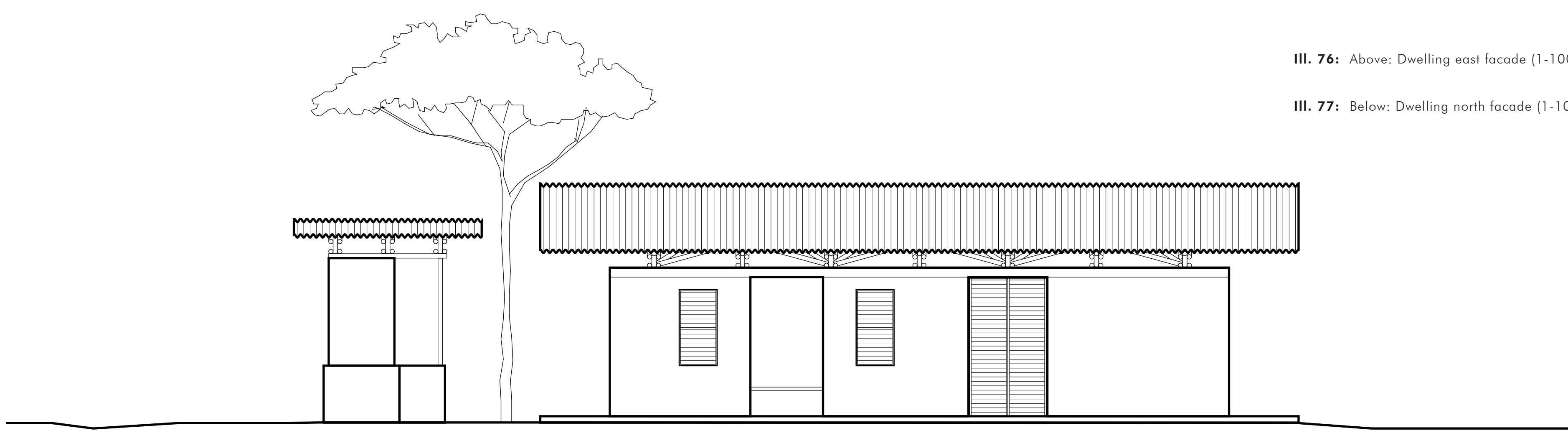




Ill. 74: Above: Dwelling south facade (1-100)

Ill. 75: Below: Dwelling west facade (1-100)

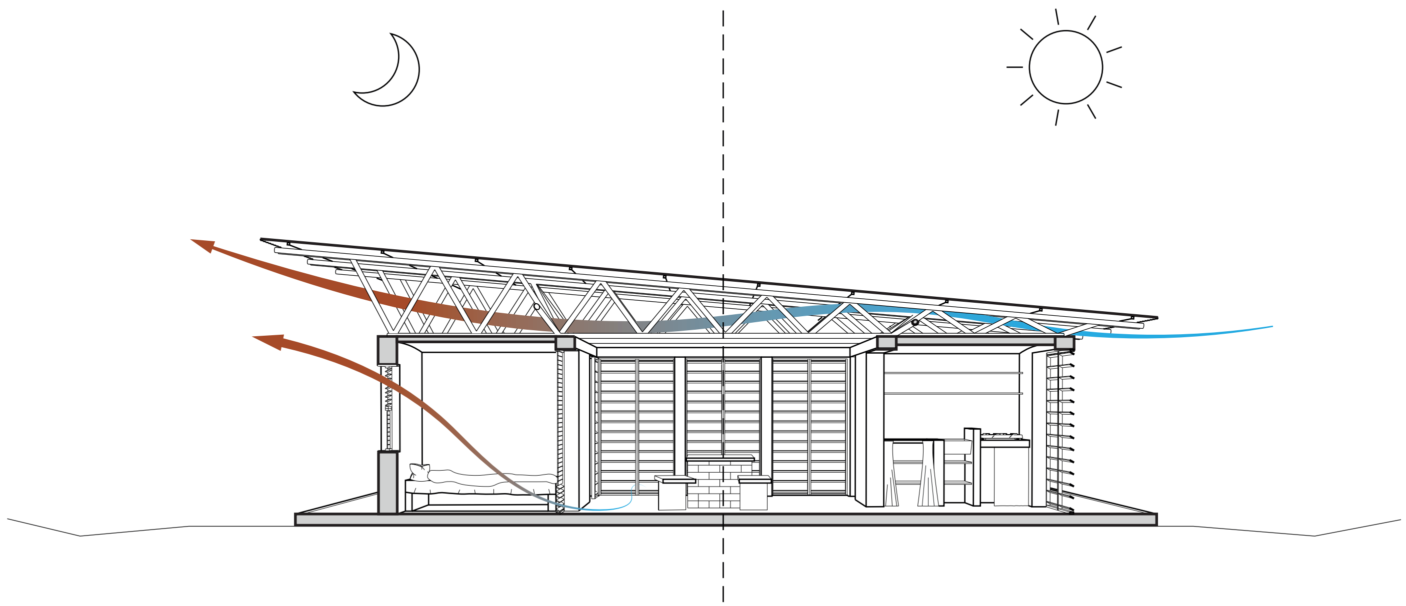




Ill. 76: Above: Dwelling east facade (1-100)

Ill. 77: Below: Dwelling north facade (1-100)

Ventilation Strategy



Ill. 78: Ventilation Principle (No scale)

The ventilation principle used across buildings in the settlement endeavor to keep a comfortable temperature and create spaces for people to dwell, in an otherwise unforgiving environment. This is achieved by employing night ventilation in conjunction with high thermal mass, which will be placed towards the living space. During the day, the CEB walls will feel cold to the touch, while absorbing and storing the heat from the room. This heat will then be release as temperatures drop, increasing the temperature during the night and reducing the temperature fluctuation between night and day. The heat released during the night must be ventilated out, to release the energy from the house, allowing the walls to absorb more heat the following day.

To increase the effectiveness of this principle, the use of thermal buoyance is implemented. The windows and doors are fitted with lamella that can be opened and closed in segments, which will increase the height difference between the inlet and the outlet of the dwelling. The rooms of the house have a door oriented towards the central veranda and windows on the façade, creating cross ventilation which will pull cool air past the thermal mass, thus increasing the effect.

The space between the roof and ceiling must be ventilated during the day, since the air will be heated by the sun hitting the roof. The single pitched roof is shaped to work with this phenomenon, allowing the heated air to flow upwards and escape along one façade. The pitch is oriented from north to south, with a smaller inlet on the north façade which is one of the dominant wind directions. As such, the roof will make use of both the venturi effect as well as thermal buoyancy to ventilate the hot air created.

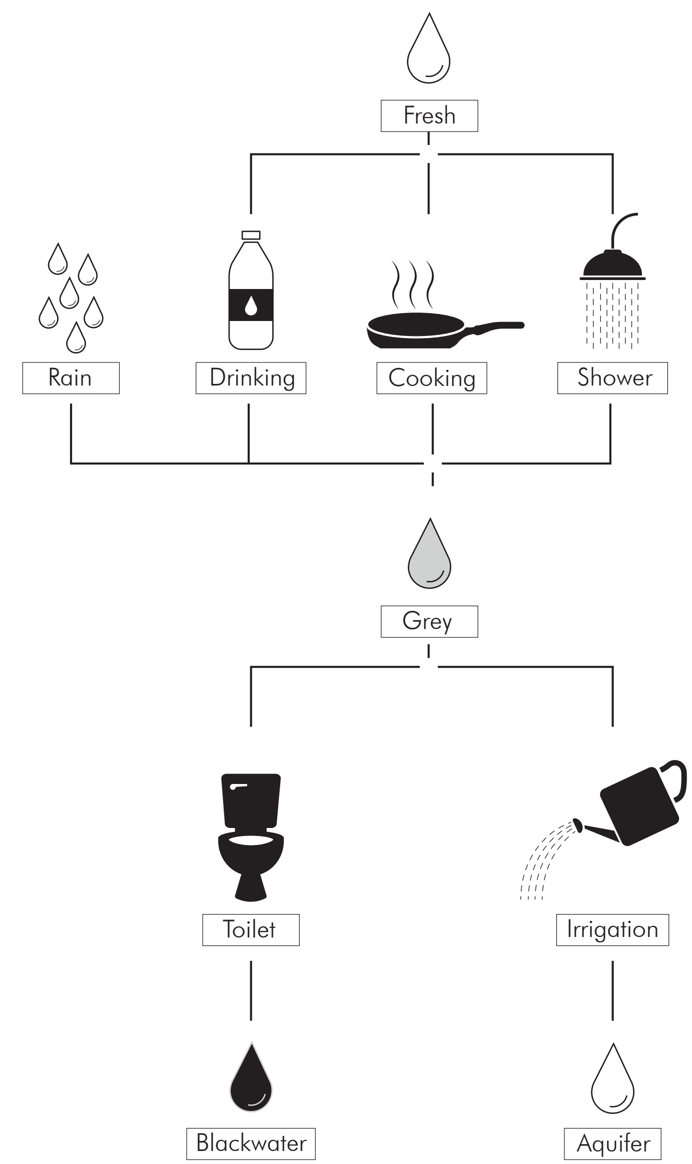
Water Management

Through the use of a closed water management system, the water supplied to the settlement can be used not only as drinking water but be reused for toilets and irrigation. By splitting water reservoirs into fresh, grey, and black water, a large amount of the water that would otherwise go to waste can be given new uses.

Fresh water for each household will be collected at the Water Post and brought to a water container in the house. Excess water from cooking, washing hands, etc. as well as rainwater is collected and stored in a grey water tank. From there it is slowly released back into the ground, giving vegetation around the house a stable supply of water. This tank can also be accessed by the inhabitants and be used for specific irrigation in the form of plant boxes and green walls, giving the users the opportunity to grow their own vegetables.

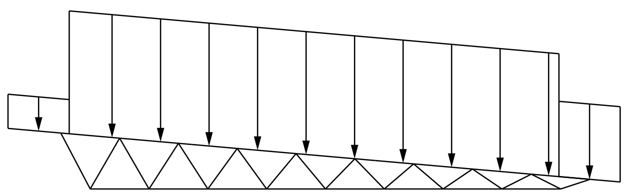
At the Bath House, fresh water is supplied for showers and sinks while the grey water collected is used to flush the toilets. The black water created from toilets is stored in septic tanks, while the same principle from the house is used for grey water.

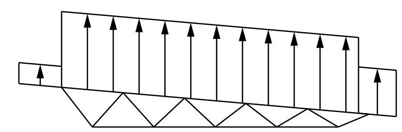
By slowly feeding water into the ground in a region primarily used to seasonal rains, the ground will become more saturated, creating a more stable environment for vegetation to grow. This will create a more intricate root network, allowing for more water to be retained in the ground, which will lead to a more lush environment around the camp.

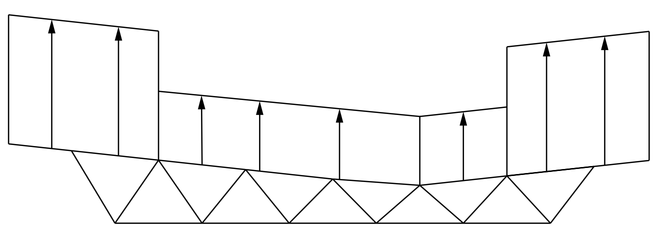


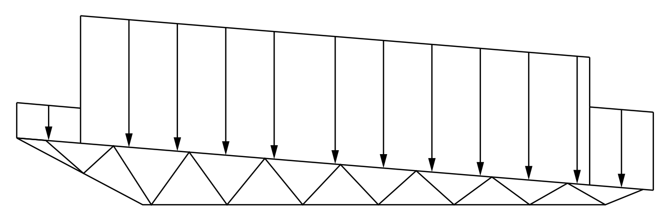
Ill. 79: Water Management

Structure









The structure used in the buildings all derive from the principle of repetition of a planar truss placed upon a heavy load bearing wall. As the load bearing wall is assembled without mortar, a bamboo element is placed in the cavity of the CEB which connect the top and bottom SEB, keeping the wall in place. The bottom SEB is anchored to the ground by a pile foundation, ensuring the double leaf roof is grounded to withstand wind drag. The construction elements are exposed to anybody passing by the building, making it easier to read while providing an intuitive sense of understanding of the building. But the nature of the building is truly expressed through its materiality. The walls create a heavy enclosure with a physical and visual connection to the ground, expressing an inherent stereotomic quality, seeing as the walls are composed of the same material as that which they sit on. The walls support the light bamboo structure connecting with the metal roof that covers the entire dwelling.

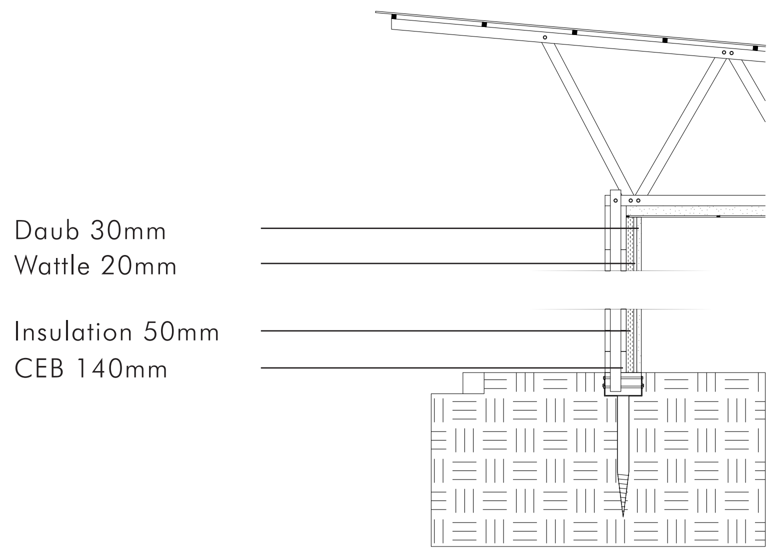
This structure appears very light, but also very intricate by comparison, being constructed of many individual elements that together express a tectonic quality. Besides visual and tactile aspects of the materials used, the elements inherent physical properties contribute to the dwelling's quality. The heavy CEB walls offer sturdy protection from the surroundings, while being applied as thermal mass to increase the comfort of the space. The perforated bamboo trusses allowing wind to enter, seemingly being caught by the metal sheet that almost seems to mimic a sail. The trusses and the metal roof have an ambiguous sense originating from the matter of them being planar objects. This gives contrasting views of the elements depending on the angle of approach. From some angles they will seem to fill up the entire view, while at others they will almost shrink to a single line in the air. Since roofs are inclined in one direction in multiple buildings, this sensation of different views is afforded the observer.

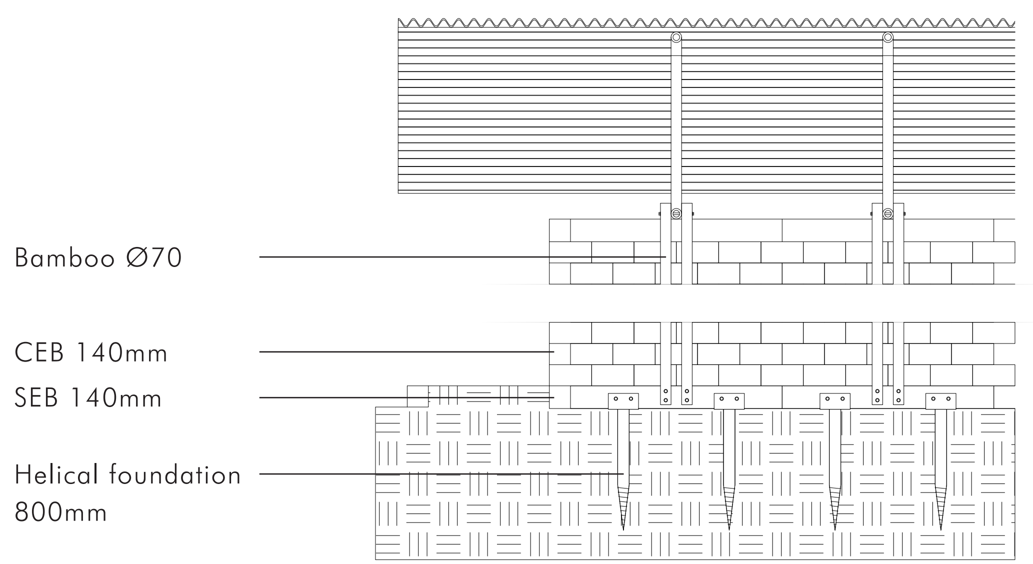
Ill. 80: Above left: Dwelling

Ill. 81: Above right: Wash House

Ill. 82: Below left: Water Post

Ill. 83: Below right: Civic Center





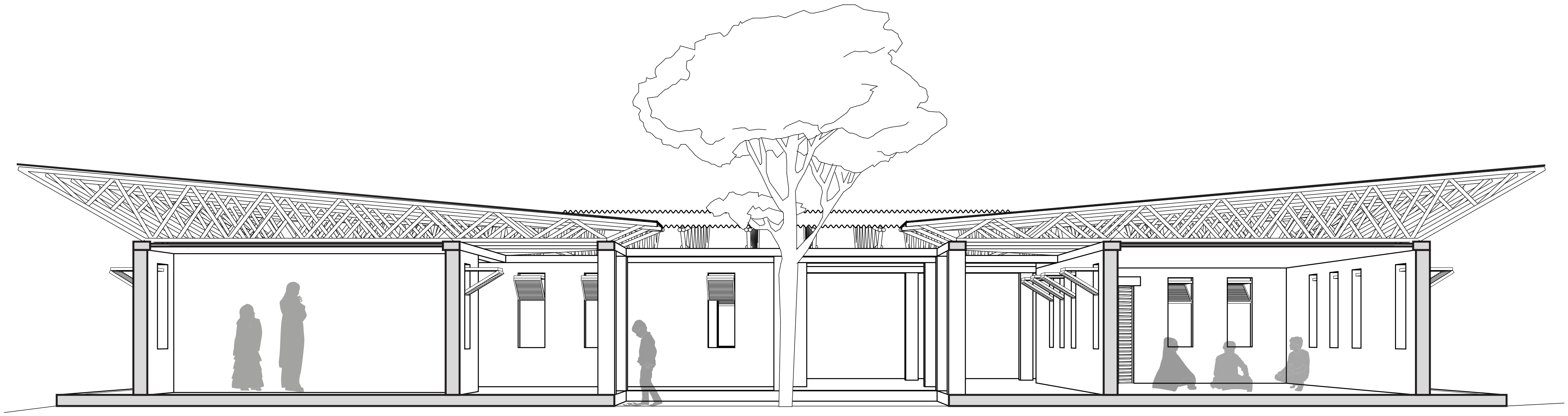
Ill. 84: Above: Wall section detail (1-50)

Ill. 85: Below: Wall section detail (1-50)

The Civic Center

Ill. 86: Civic Center

Ill. 87: Courtyard - Civic Center



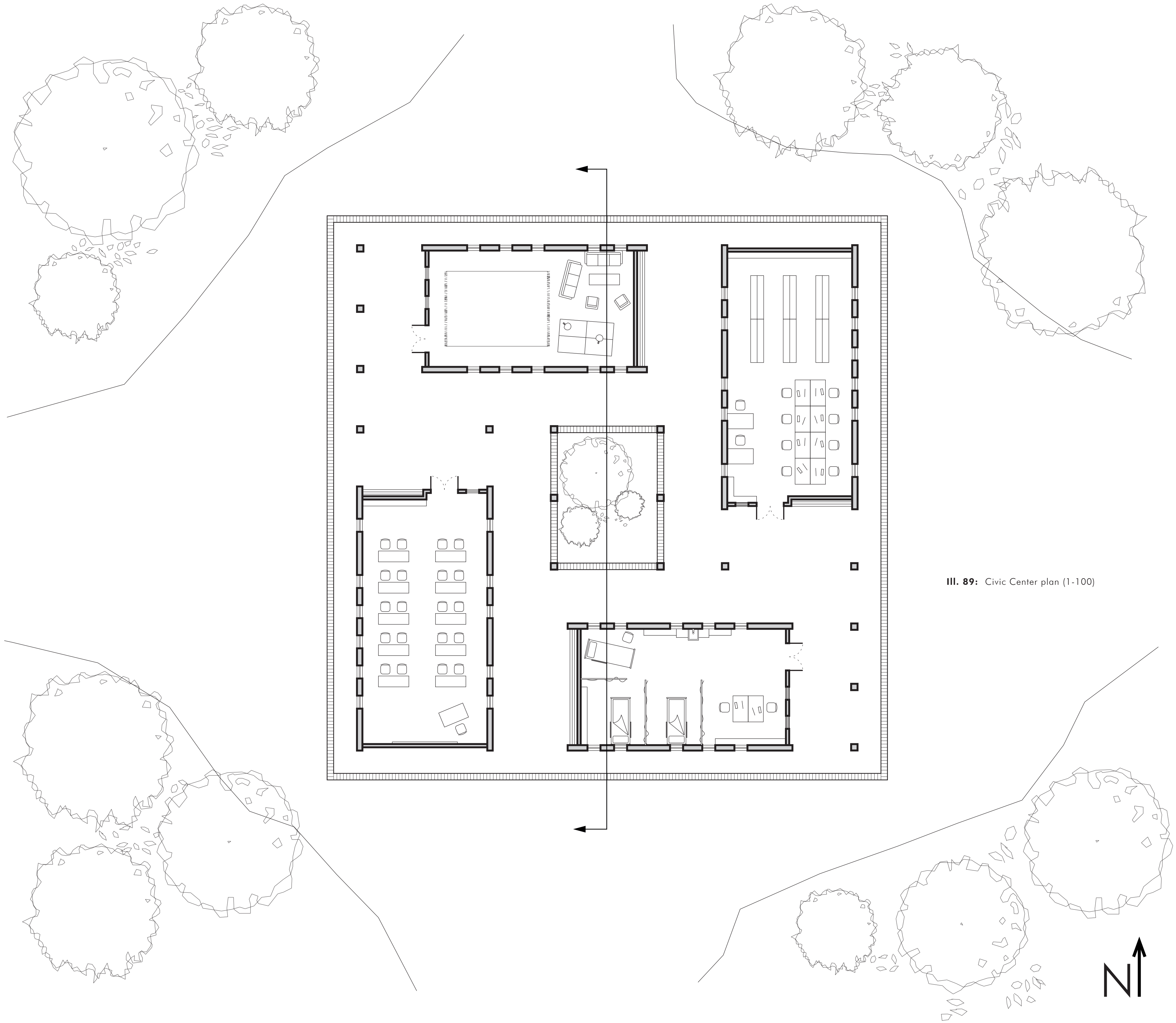
Ill. 88: Civic Center Section (1-100)

The Civic Center is used as a larger gathering point within the settlement. It serves public functions that transcend individual clusters. It includes amenities such as classrooms, a library, a medical clinic, and a space made available for school related activities or other purposes.

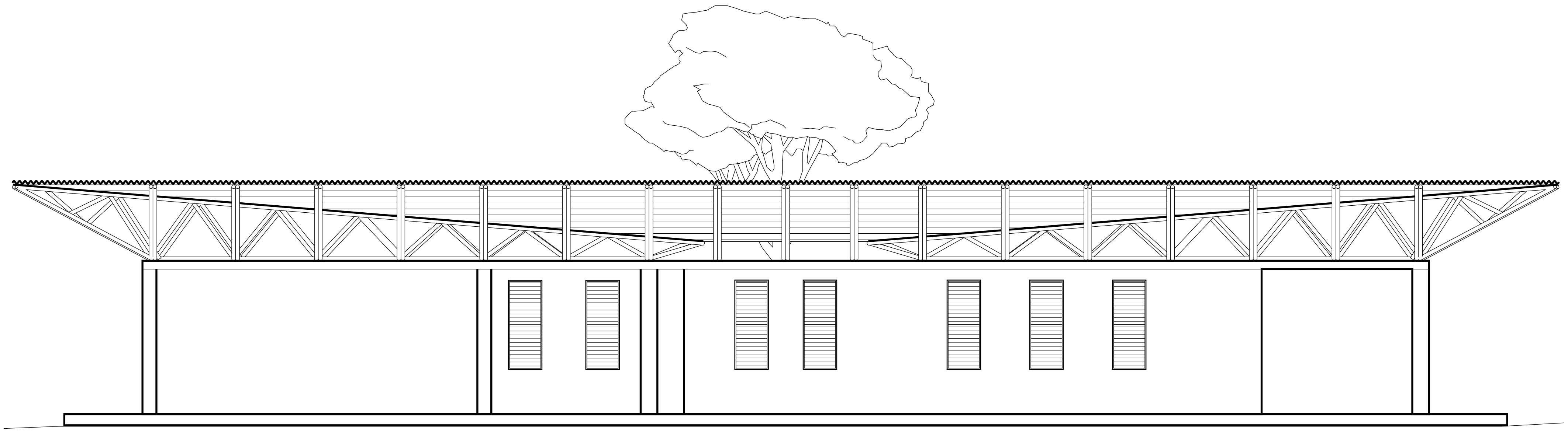
The Civic Center comprises four separate buildings, connected by a singular roof-structure. Since rooms are disconnected from one another, openings in the complex are created in all directions leading to and from it. Buildings envelop and create a courtyard within the complex. This offers a shaded area not located within the more formally specified zones. Users are provided seating which is integrated in the gables of the individual buildings, but also along the edges of the deck which gives way to a small piece of ground in the atrium. This creates different atmospheres all around the complex, influenced by shading, weather conditions, and the activities that are performed at different points in time. The Civic Centers becomes a place where people from different communities can meet and exchange experiences, emphasizing the communal and collective aspects of dwelling.

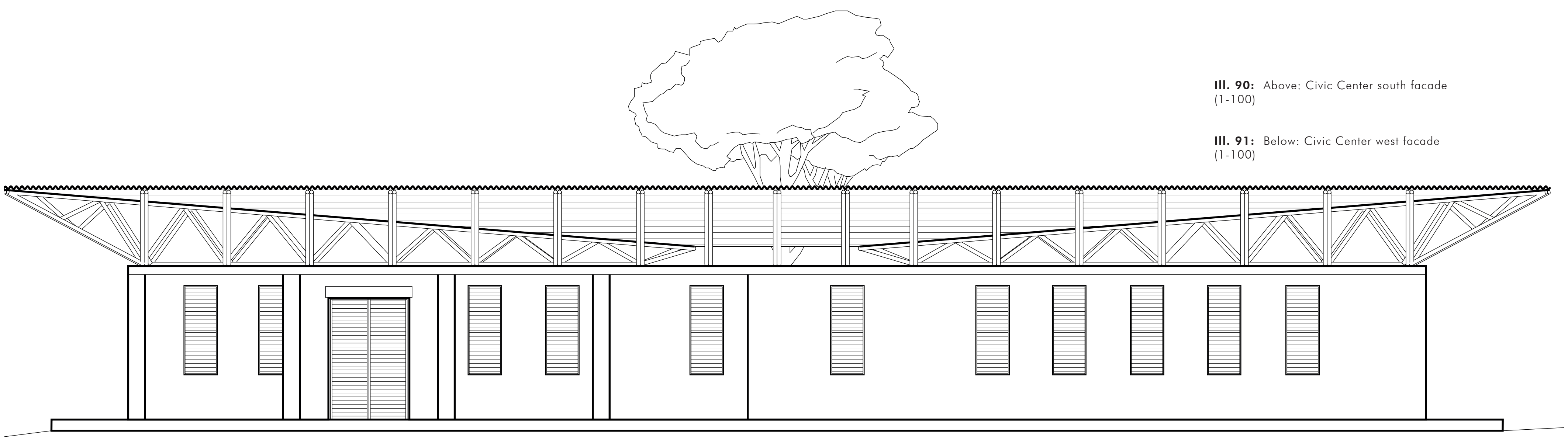
These aspects of dwelling are reinforced by architectural gestures. The roof contour has an upwards motion from the atrium to the facades, opening the building and its entrances up to the surroundings, welcoming people in the neighboring outdoor spaces.

Gradual expansion of the settlement necessitates construction of additional civic centers. Since individual buildings within the complex can serve multiple functions, new civic centers may contain additional amenities or be used as a dedicated space for schools etc.



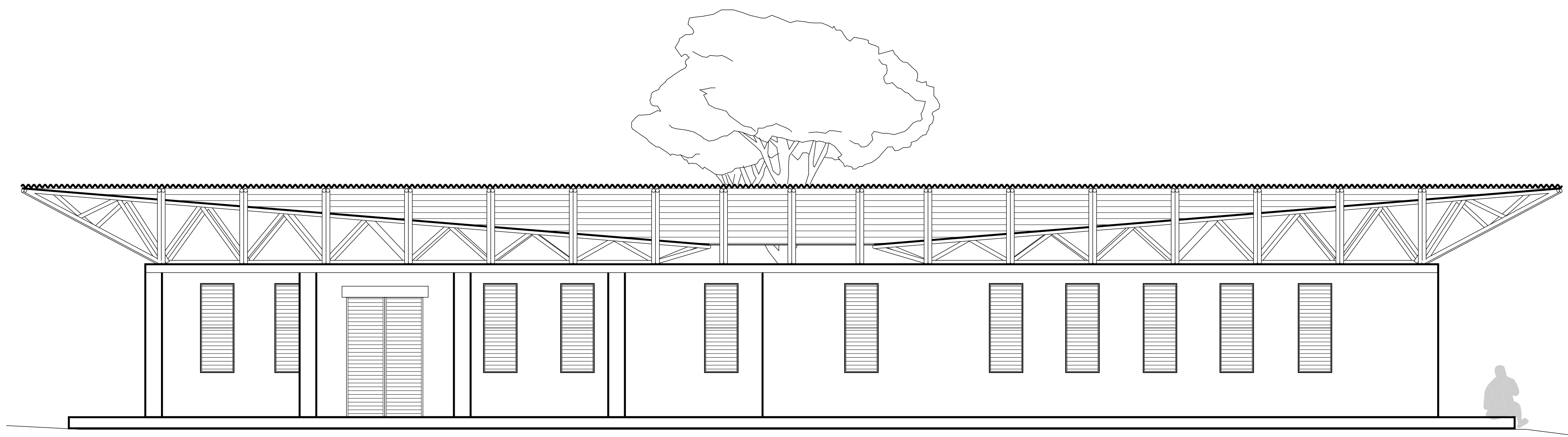
Ill. 89: Civic Center plan (1-100)

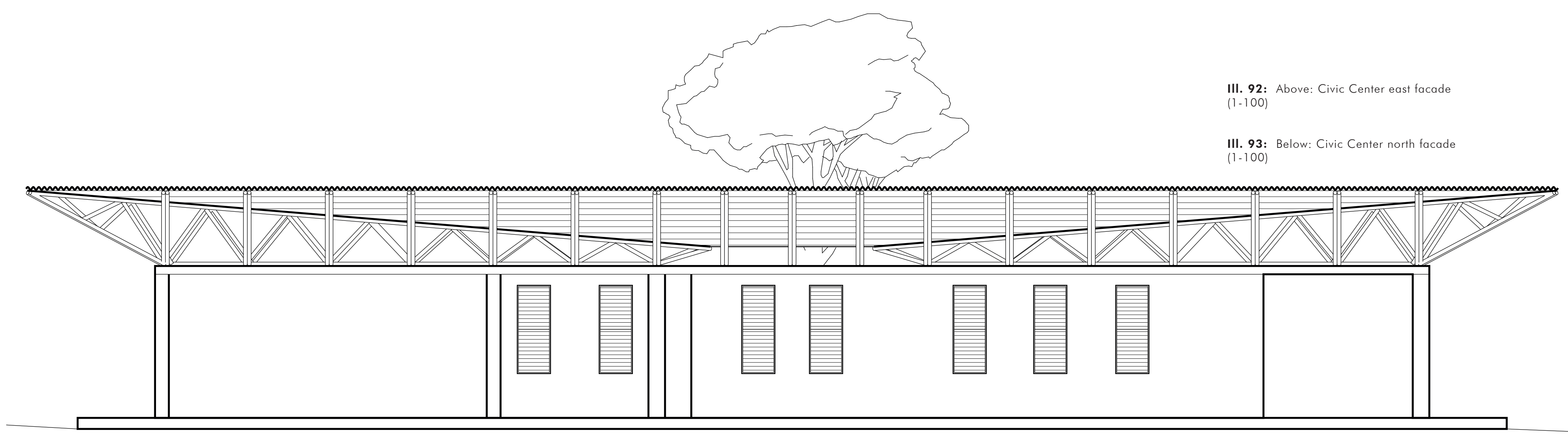




Ill. 90: Above: Civic Center south facade (1-100)

Ill. 91: Below: Civic Center west facade (1-100)





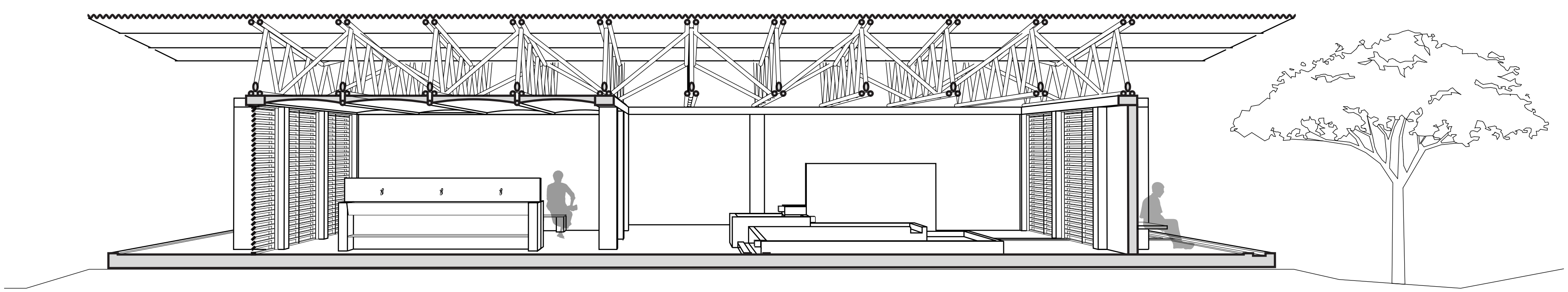
Ill. 92: Above: Civic Center east facade (1-100)

Ill. 93: Below: Civic Center north facade (1-100)

The Waterpost

Ill. 94: Water Post

Ill. 95: Water Post Environment



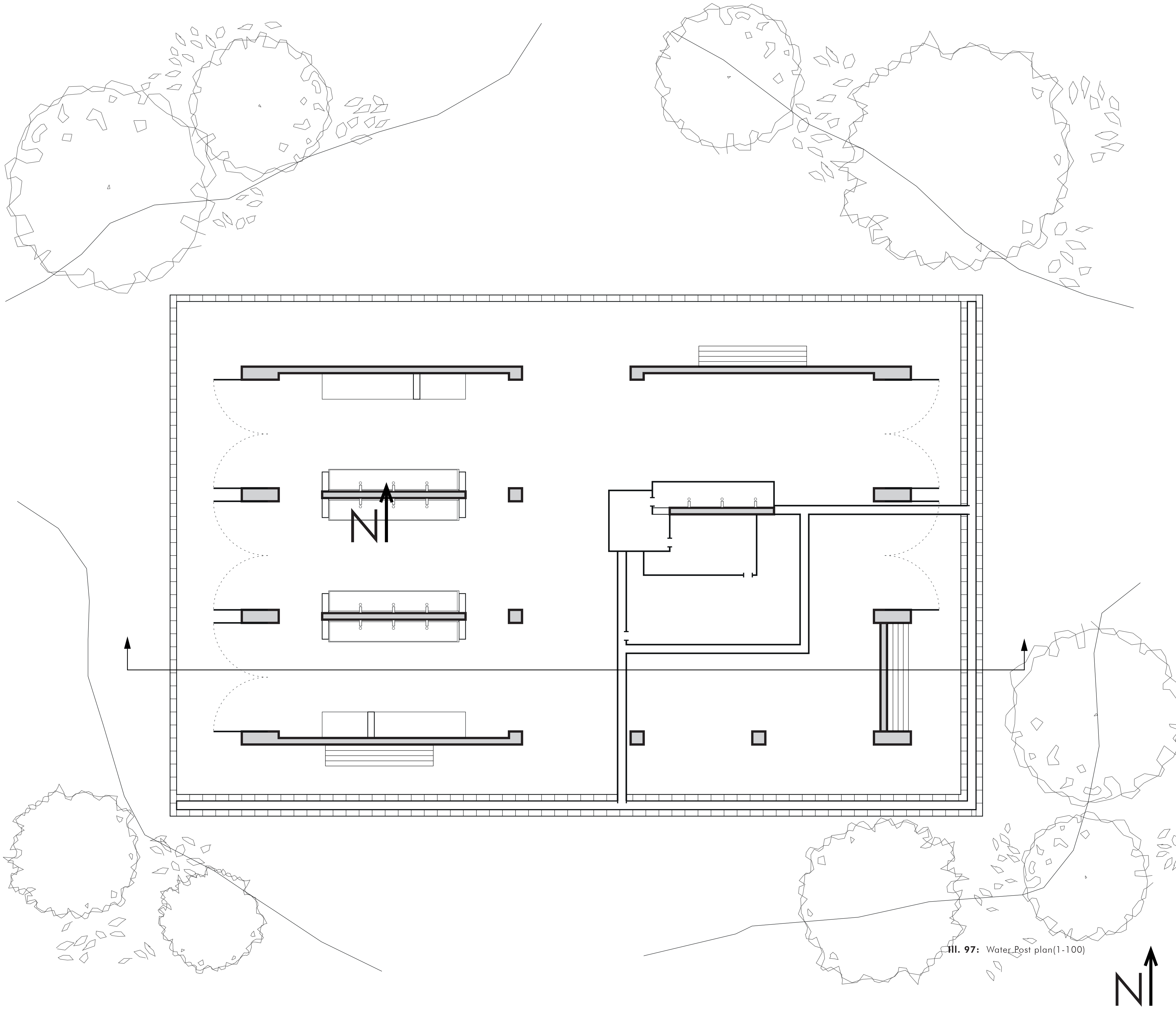
Ill. 96: Water Post Section (1-100)

A Water Post within each cluster supplies clean water to be used for consumption and household purposes. It is connected to a local well, that can be maintained from the administration area near the settlement proper.

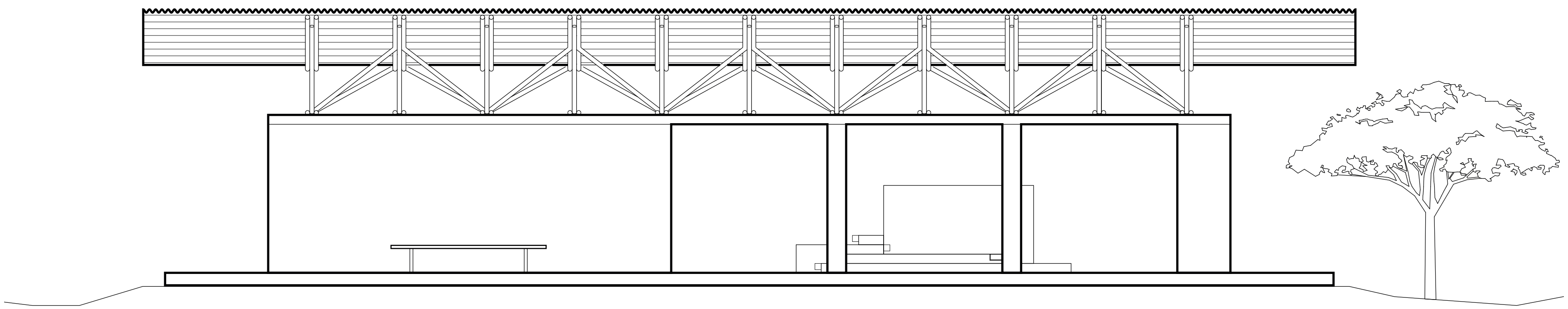
Making water easily accessible to all inhabitants within a cluster provides the foundation for life to thrive, by satisfying one of the basic physiological needs. But beyond providing this amenity, the building housing the water post also acts as an informal gathering space. It has the potential to bring together members of the community, both outside but also within. A washing room is placed under the roof to be used by the inhabitants.

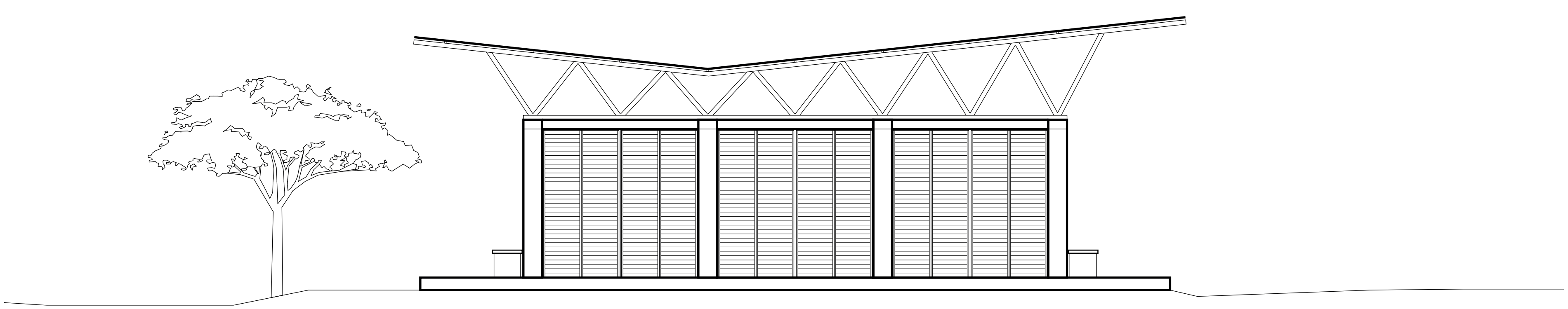
The butterfly roof opens up in two directions and like the civic center it signifies a welcoming gesture. The perceived openness extends to other parts of the building as well. Openings in all facades makes the water post approachable, and doors to the washing area can be opened or closed to accommodate different weather conditions. The area outside can be planted to create additional shading, making it suitable as a local hub within any given community.

Excess grey water from the washing room can be collected and used for irrigation. The inevitably spill that occurs when the water post is in use helps cool the surrounding area through evaporative cooling. To exploit this effect, water is passed through a series of open basins which keeps it moving, before it eventually is drained into the soil around the building.



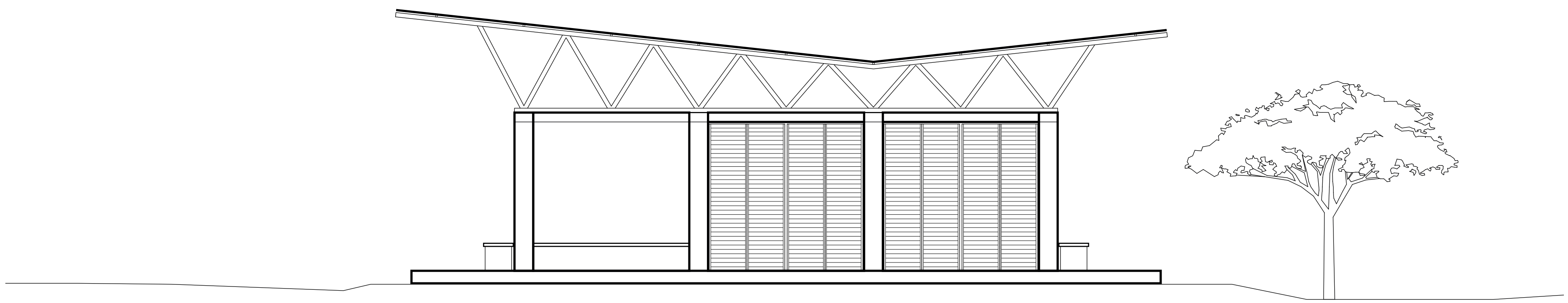
Ill. 97: Water Post plan(1-100)

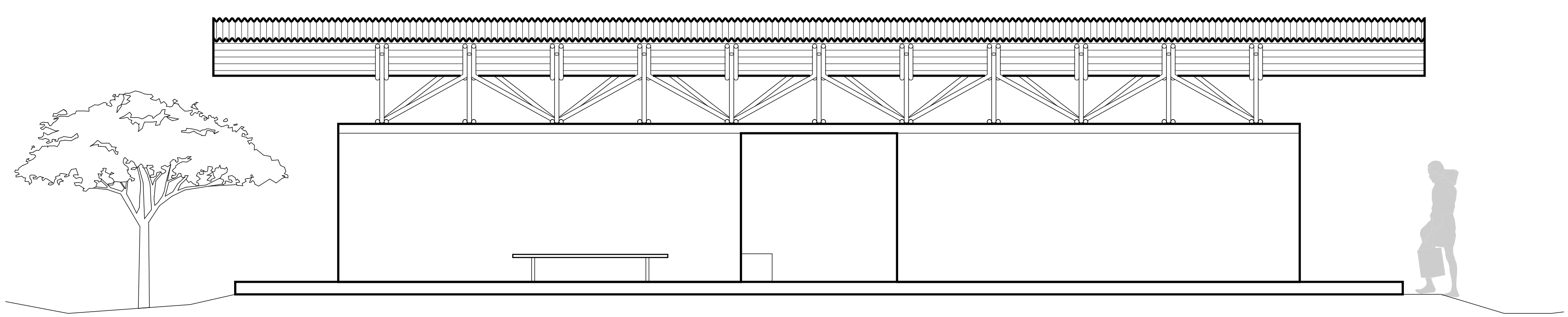




Ill. 98: Above: Water Post south facade (1-100)

Ill. 99: Below: Waterpost west facade (1-100)





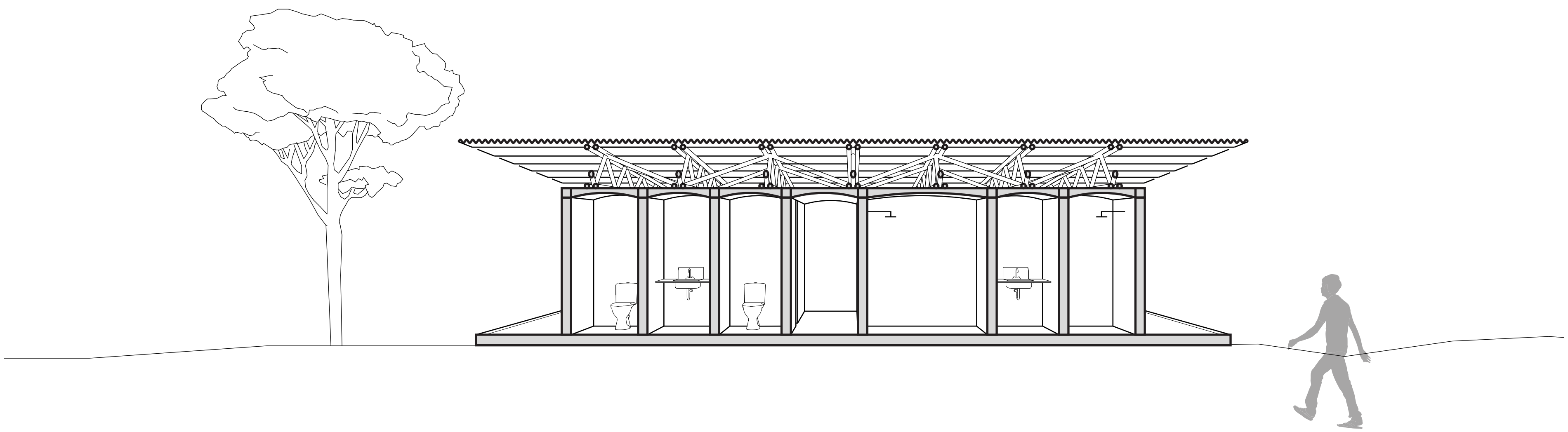
Ill. 100: Above: Water Post east facade (1-100)

Ill. 101: Below: Water Post north facade (1-100)

The Communal Bathhouse

Ill. 102: Bath House

Ill. 103: Bath House Environment



Ill. 104: Bath House Section (1-100)

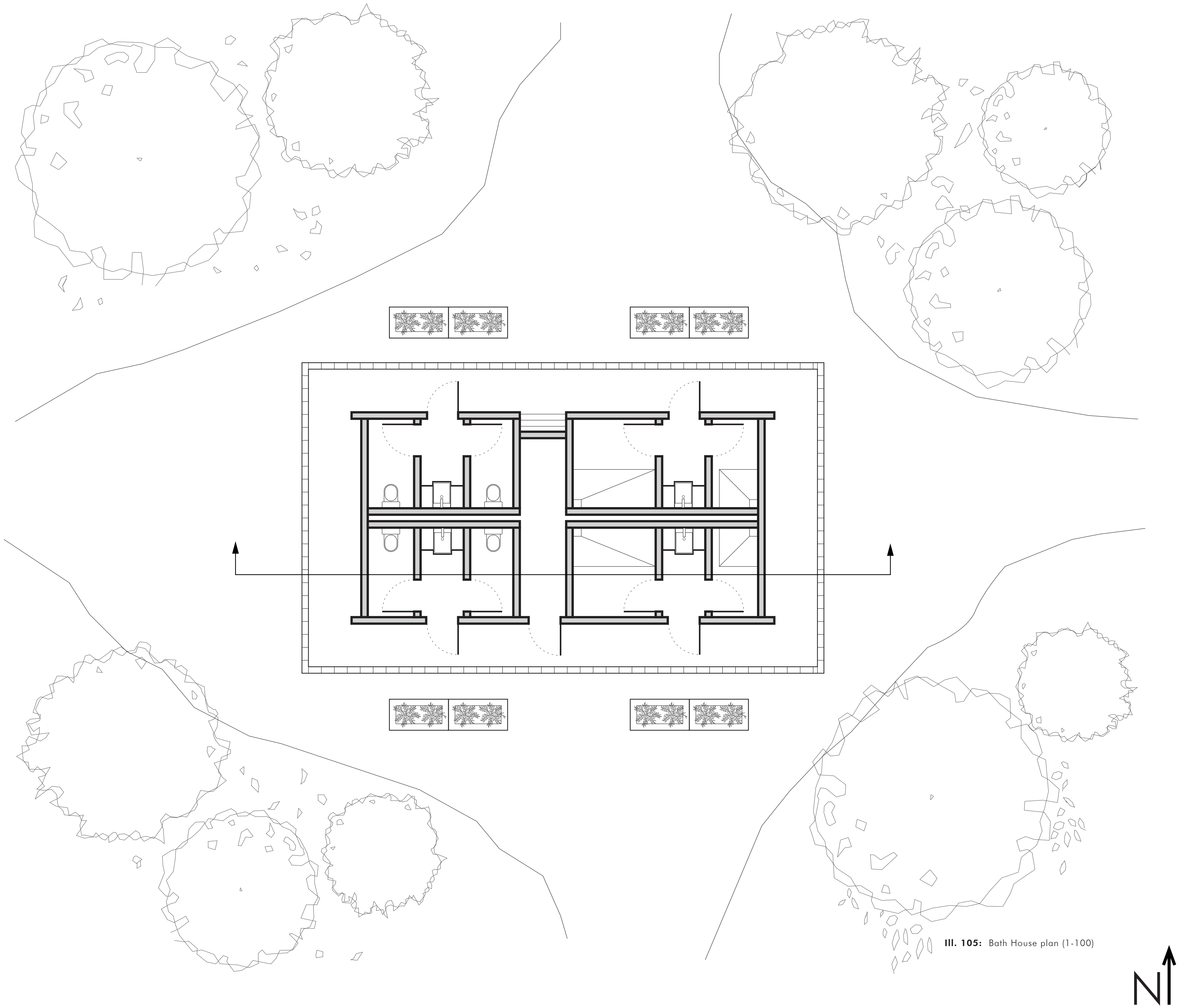
Communal Bathhouses are placed inside each cluster of dwellings and provide a clean environment for its inhabitants to use. The purpose of these buildings is to maintain a high standard of hygiene compared to sanitation strategies in traditional refugee camps. Instead of semi-open pit latrines, toilets with running water are installed. Bath stalls have their own separate rooms and some of these are larger to accommodate family bathing.

A maintenance space for water management is located inside the bathhouse, with separate tanks for black water and grey water, the latter of which can be used to supply toilets or irrigate the surrounding area.

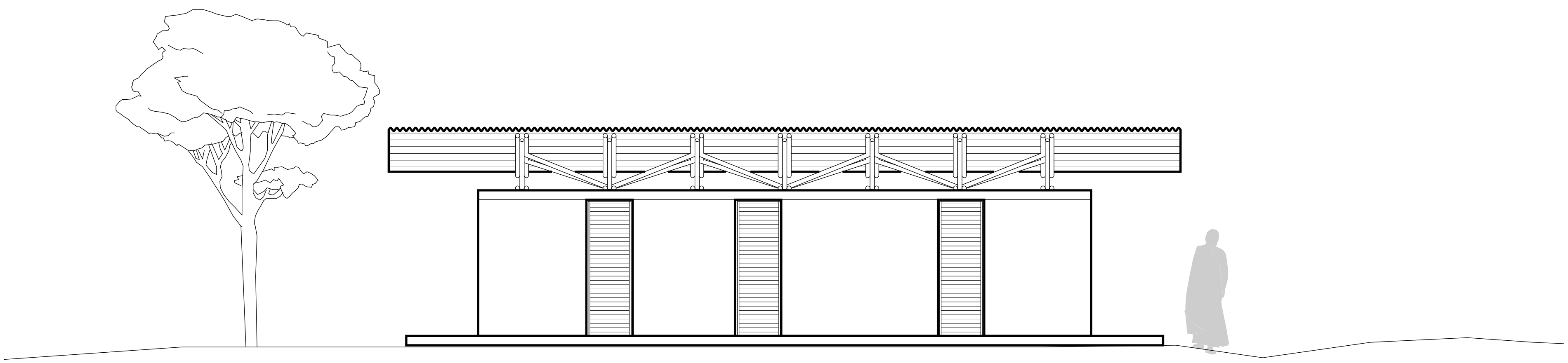
Waste disposal takes place in a nearby designated area, providing access to this amenity within walking distance of individual dwellings, and concentrating it in one location.

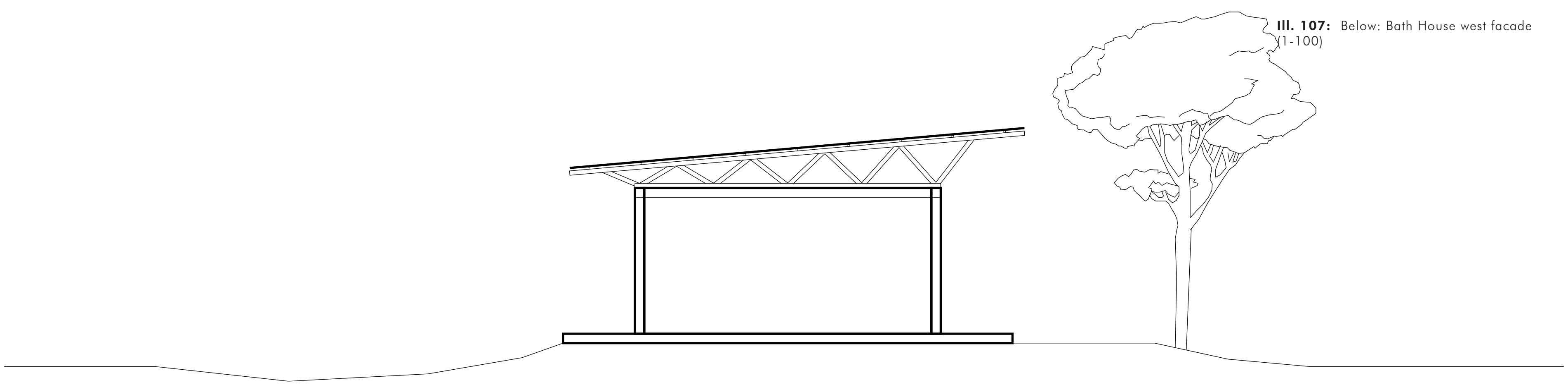
Electricity is generated using photovoltaic panels located on the roof, with junction boxes and batteries placed inside the maintenance space. The panels supply a network of lamp posts arranged in the public outdoor spaces, which provides security when walking around the community during evening and nighttime.

A greater sense of security is also afforded through the placement the building, since it opens up to the surrounding area, rather than being tucked away at the edge of the settlement. The Bathhouse is gender sensitive, with entrances for the female and male specific areas facing opposite directions. Privacy is maintained by arranging the individual stalls so that they open into small hallways inside the building.



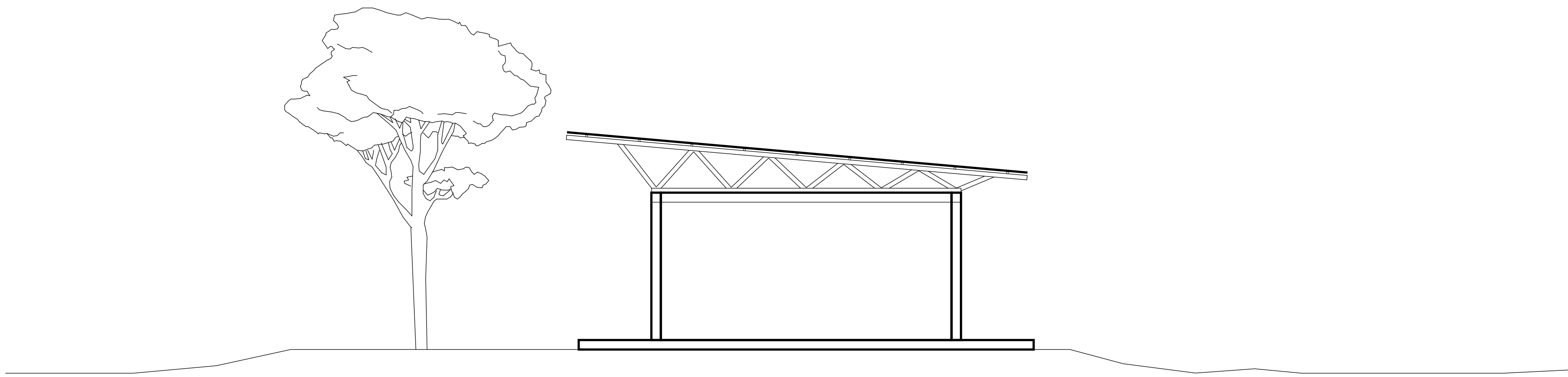
Ill. 105: Bath House plan (1-100)

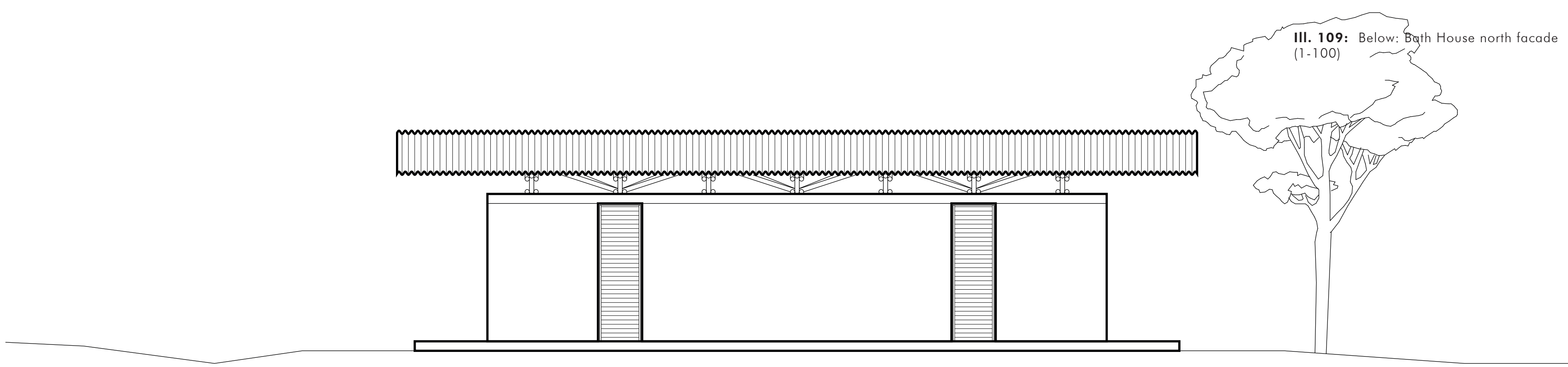




Ill. 106: Above: Bath House south facade (1-100)

Ill. 107: Below: Bath House west facade (1-100)



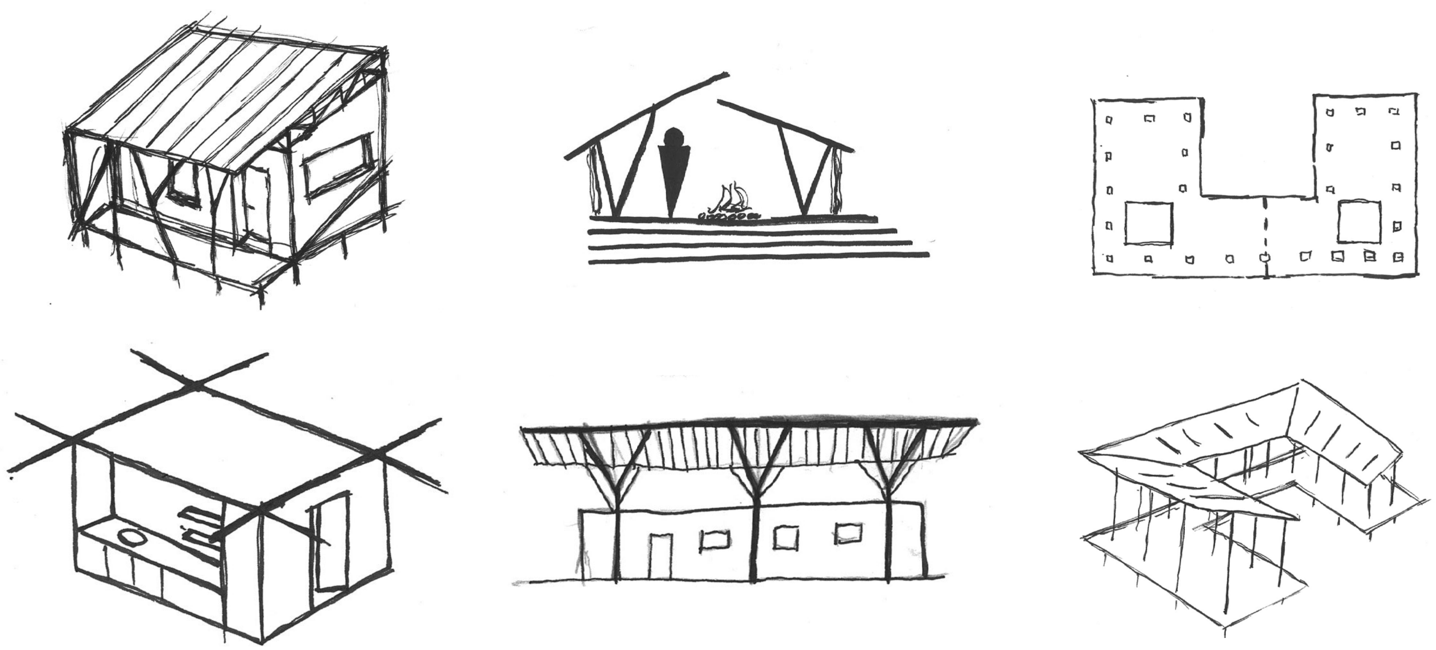


Ill. 108: Above: Bath House east facade (1-100)

Ill. 109: Below: Bath House north facade (1-100)

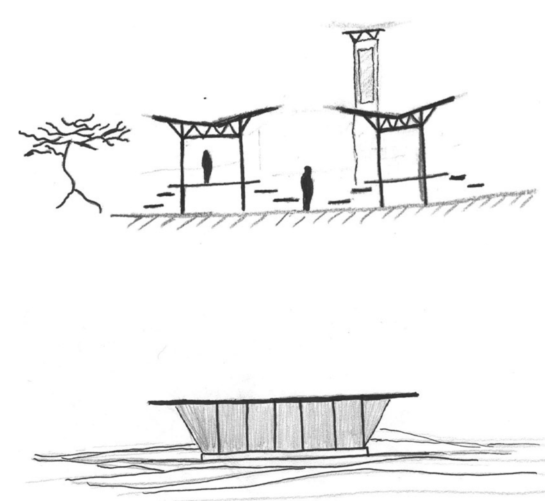
PROCESS

Initial Thoughts

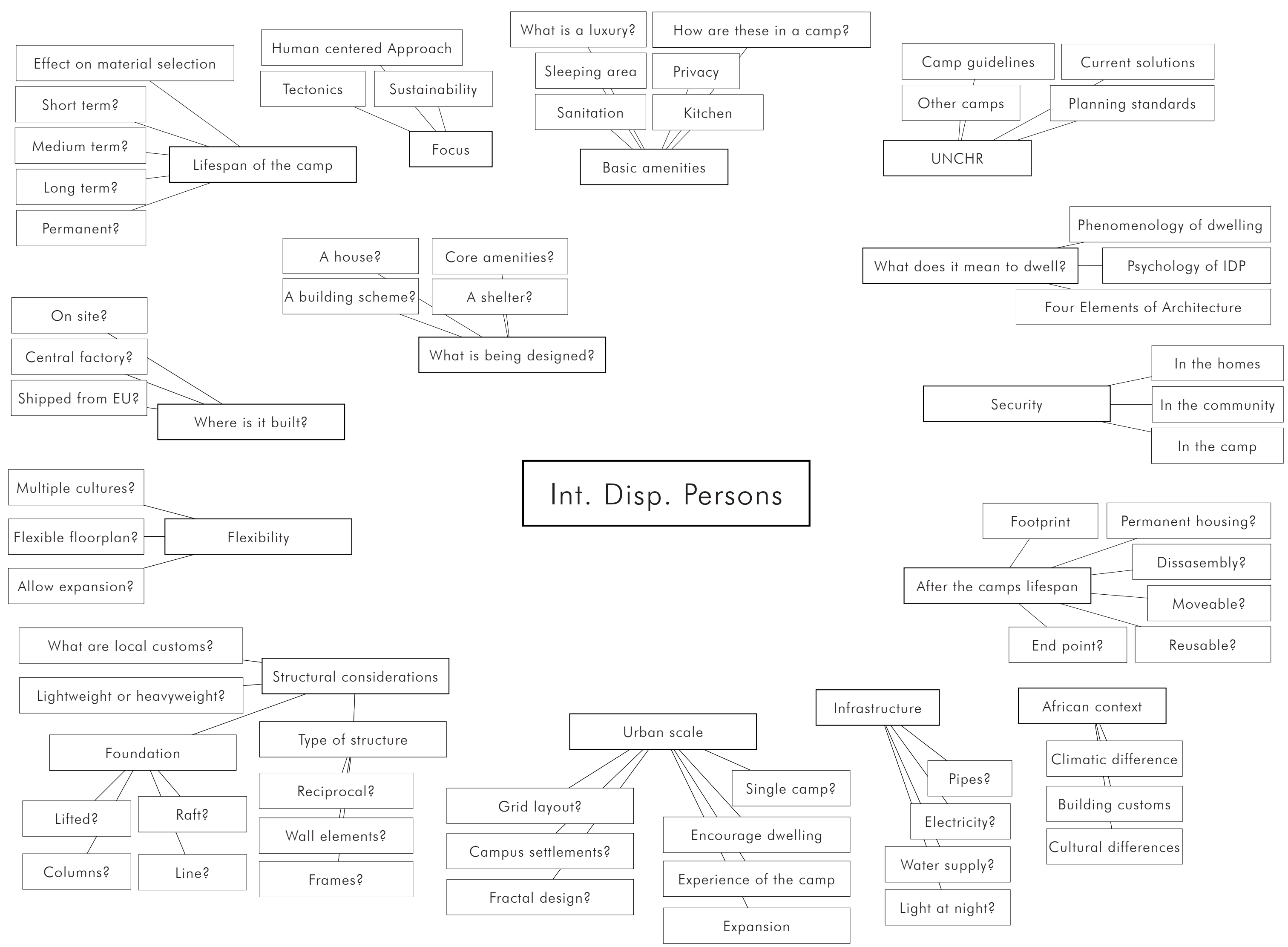


Adjacent sketches represent various early design directions, which were brainstormed during the first weeks of the project. These sketches led to discussions concerning what type of project would be proposed. A map of major points are highlighted on the opposite page.

These discussions led to what would become the intial basis of this project: A housing unit designed to accommodate the requirements of those displaced, forming the basis of dwelling and promoting a sense of place.

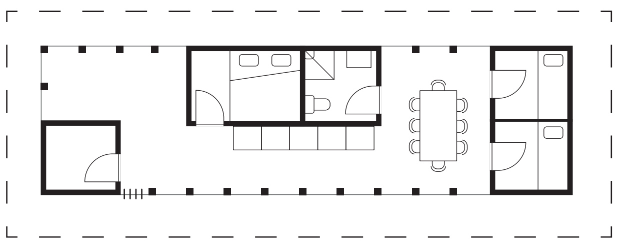


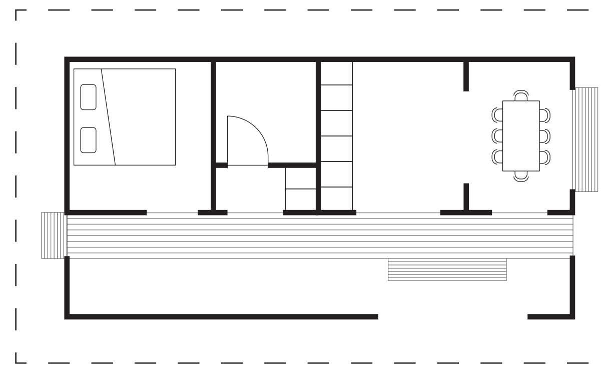
Ill. 110: Initial Sketches



Ill. 111: Initial Brainstorming

Spatiality





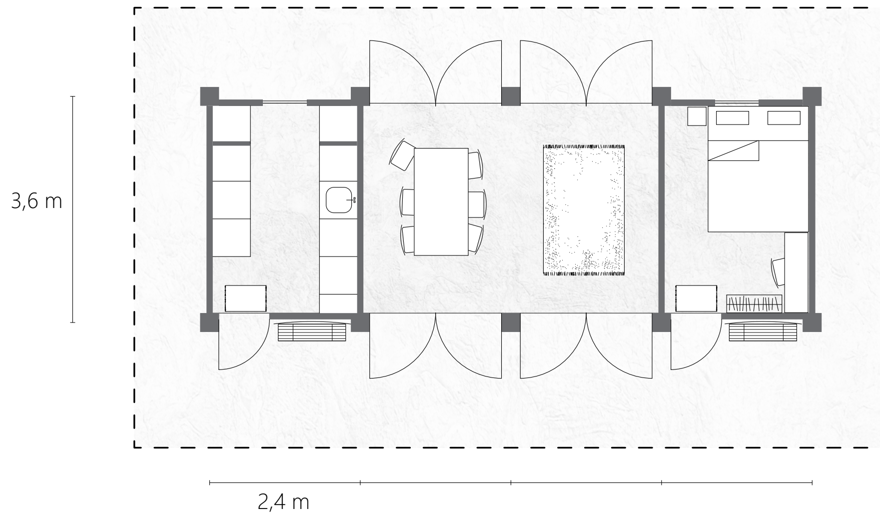
Ill. 112: Layout Sketches

Following the initial sketching and brainstorming, the scale and layout of the houses were investigated. A series of plan designs were created, containing different compositions of amenities, shared functions, and outdoor space. By analyzing these sketches, recurring typologies were identified across multiple iterations. These included a single house layout oriented in the east-west direction, the use of separate buildings to define an outdoor space, and a row house typology with multiple homes in the same building. These typologies each had advantages and disadvantages. Using multiple separate buildings created excellent outdoor spaces, at the cost of more wall to surface area and bigger east/west facing walls, which should be avoided according to our research into climate responsive design. The rowhouse typology mitigated this but blurred the lines between plots and therefore made the possibility of expansion difficult, which was a major point of interest at this time. The single house layout offered the most optimal use of materials along with the possibility of east-west orientation, reducing the amount of solar radiation in the morning and afternoon.

Across these typologies, rooms were often organized in a line, with either an internal or external hallway. A feature that was included on multiple plans was a raised plateau, creating a soft boundary between the house and the rest of the camp.

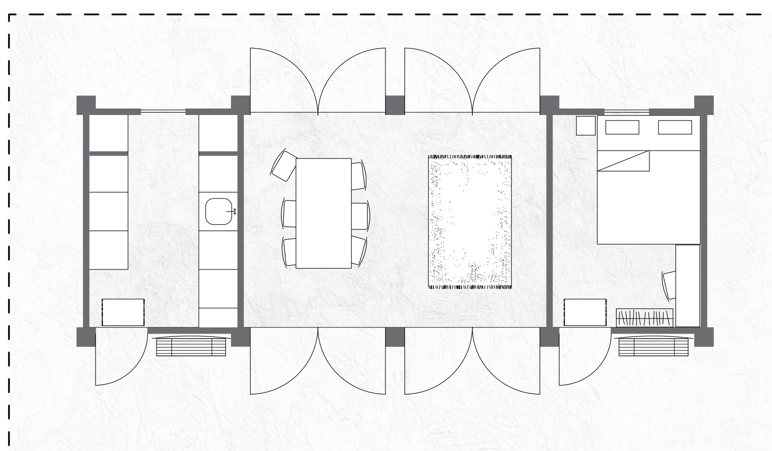
Throughout the layouts, the inclusion of a kitchen and bath sparked multiple discussions detailing what was a necessity and what was a luxury. Should these amenities be implemented in each house, or should they be shared between a few, or multiple households?

Ill. 113: Layout Sketches

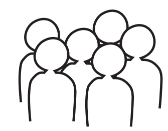


Stage 1

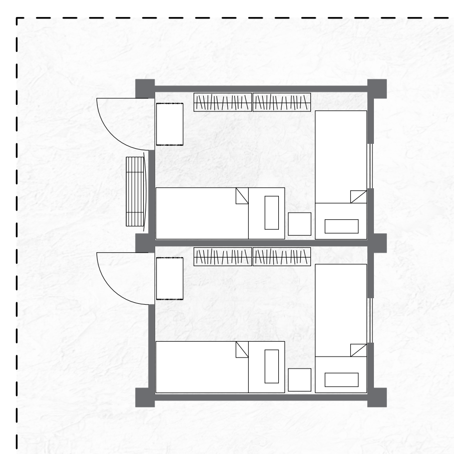
3 People



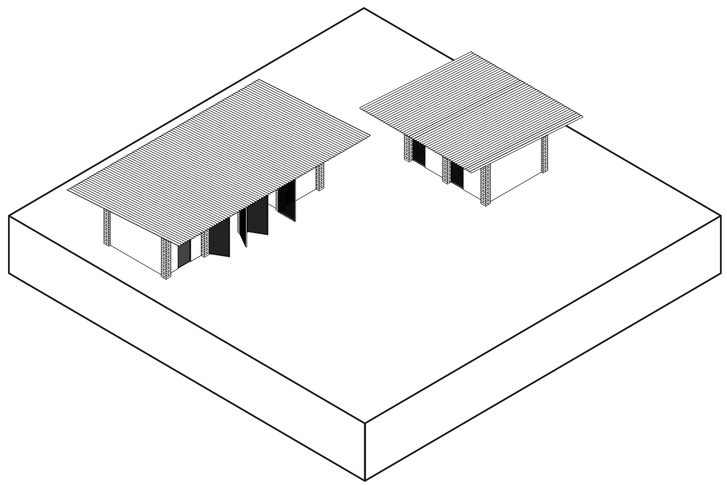
Stage 2

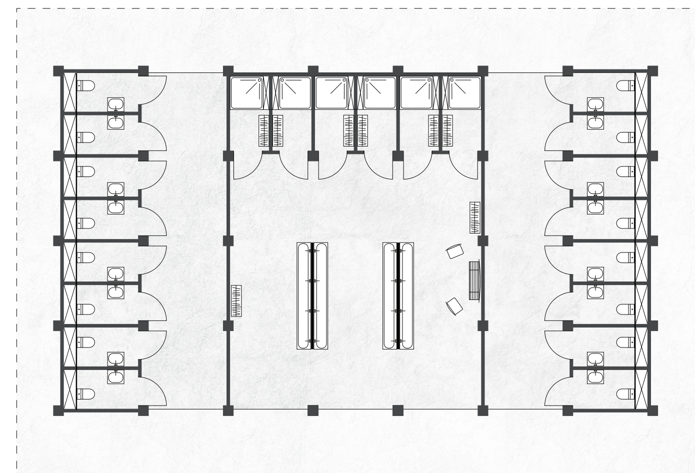


5-6 People



Ill. 114: Concept for Dwelling Expansion





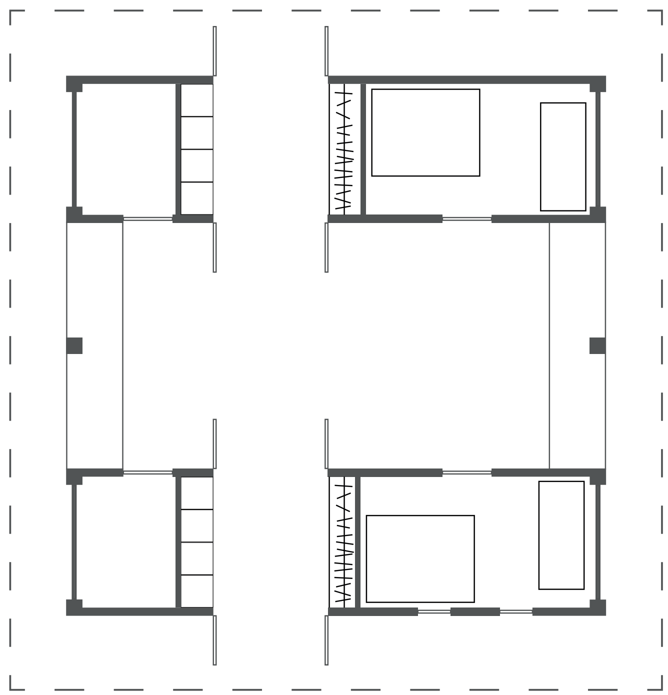
The first iteration of the shelter was a single house layout, split into 3.6m by 2.4m sections. These sections could contain different functions such as kitchens, living spaces and bedrooms. A base house consisting of 4 sections would be constructed on site, and more sections could be added to accommodate more residents.

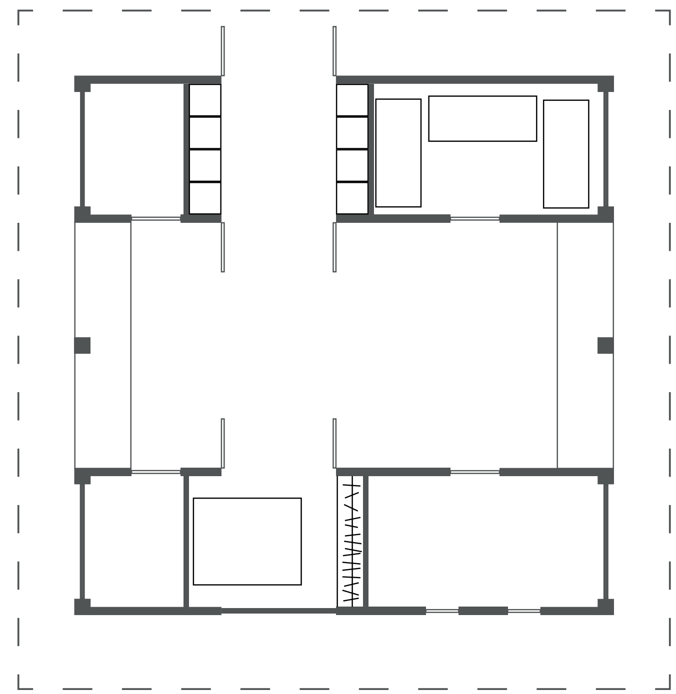
The base house was very reminiscent of a dogtrot house, with an open-ended passageway between two enclosed living spaces. The passageway is used as a common area, and both facades of this common area can be opened and closed fully. All rooms open onto a terrasse which encompassed the house, creating a shaded environment around the entire house. The house is without a toilet or bath, which had been moved to a separate building to reduce the amount of digging that would be required when the house would be built and demolished, and to create a centralized location for sanitation, providing camp officials better control of cleanliness, increasing hygiene. Local water posts in each community would supply clean water, and act as a gathering point between homes.

This layout was presented during midterm critique and received concerns regarding the human aspect of the project, for example in the lack of any internal circulation area. The need to exit the shelter to move between rooms, which was implemented to reduce the internal square meters, would have a negative effect on privacy, safety, and perception of the shelter for the inhabitants. Questions on how the lack of a toilet and shower in or around the house would affect the people living there were raised, and how many households each sanitation facility would accommodate. This feedback led to a re-evaluation of the floorplan, and the scale of the sanitation facility.

Ill. 115: Left: Dwelling Expansion

Ill. 116: Right: Concept for Sanitation Facility





Ill. 117: Concept for Multifamily House

Ill. 118: Concept for Single Family House

Following the feedback received during the midterm session, a critical analysis of the floor plan was conducted. An evaluation of how the inhabitants would experience the shelter was made. The prospect of multiple families living close together led to discussion of how these would interact, and how it might affect the private aspect of dwelling in conjunction with the acclimation process that occurs following displacement.

The last series of iterations rework elements of the first floorplan but rearranges the functions. Two shelters, comprised of storage, kitchen, and a bedroom, are placed opposite one another encompassing a central veranda which is used as the common living space. The roof of the dwelling stretches across both shelters and creates a sheltered environment between. Thermal mass is placed towards this central space, and through thermal inertia reduces the temperature during peak hours of the day. The dwelling consists of two separate shelters, which are mirrored across the central space. These can be used by two smaller households of 1-3 persons sharing the shaded outdoor space, or as a single dwelling for a family of 4-8, by replacing a kitchen with an additional bedroom.

The floor plan was originally a way to use the space created between two separate shelters as a common outdoor space and circulation for two families. However, the lack of a private sheltered space for families to interact morphed the layout into a single-family shelter, with less focus on reducing the total number of square meters and more focus on the qualities a single family can create from using this area as the primary living space.

Materials

The use of locally sourced materials used in vernacular architecture to root the project in the local context is examined, and by presenting modern equivalents and their properties, the basis for a comparative analysis is established. Compressed earth blocks are compared to hollow concrete blocks for compressive elements, and steel rebar is compared to wood and bamboo for mixed compression and tensile members. Thermal and mechanical properties are considered, along with elements of an LCA, specifically the Global Warming Potential from production (A1-A3). Availability of the material in the region is also examined, to reduce the environmental impact from transportation. A short description, as well as pros and cons are listed for each material.

Rebar - Steel

Steel rebar is close to 100% recycled from other metal products and is nearly infinitely recyclable. Steel rebar is typically recycled by demolitions contractors, who sell the rebar as scrap. More than 65% of all reinforcing bars end up being recycled and fed back into the stock for new steel products. Can be produced in Kenya.

Pros

- *Higher strength means less material used overall.*
- *Recyclable*

Cons

- *Low availability may result in further transportation, leading to a higher GWP*
- *Expensive*
- *Rebar is made for tension and not compression, and may buckle*

Timber – Cypress

Cypress wood is an abundant native species in Kenya, and one of the primary woods used for timber in the country. 53.266 hectares of plantation produce Cypress in Kenya, with Baringo County as one of the biggest suppliers. In an analysis made of the demand and supply of wood products in Kenya, made by the Kenyan ministry of environment, water and natural resources, Baringo county has a potential supply of 386.667 timber elements, and a demand of 75.724 elements, giving it one of the biggest surpluses of any counties (Kenya, Ministry of Environment, Water and Natural Resources, 2013). Can be produced in county.

Pros

- *Leading commercial timber in Kenya*
- *Many farms follow REDD+ to reduce deforestation in developing countries*
- *If carbon sequestration is considered, cypress has a net environmental benefit*

Cons

- *Slow growing*
- *Lower lifespan if left untreated*

Bamboo – Bambusa Tulda

Bamboo covers a variety of long-lived woody grasses, that play a pivotal role in ecosystems and biodiversity. Much like wood, they are recognized as an important carbon sink, and can be used as a construction material, which has been the case in many regions of the world for centuries. Due to limited standardization, bamboo has been overlooked for construction purposes, often being relegated to non-engineering and marginally engineered construction (Richard, 2013). Though bamboo is often associated with Asia, it is widely available in Africa as well, primarily in Ethiopia, Kenya, and Uganda (Zhao, et al. 2016)
Can be produced in adjacent counties

Ill. 119: Above: Steel Roof Structure

Ill. 120: Middle: Wooden Structure

Ill. 121: Below: Bamboo Structure

Pros

- *Structure permanent plant – Not necessary to replant*
- *Rapid growth*
- *Biggest part of GWP is from transport – by using bamboo from local plantations, the impact on the environment is greatly reduced.*
- *If carbon sequestration is considered, bamboo has a high net environmental benefit*

Cons

- *Steel fasteners needed for assembly carry a high GWP value, the value of which can vary depending on specifics and complexity of the structure*
- *Low lifetime if left untreated*

Compressed Earth Blocks

The use of Compressed Earth Blocks (CEB) is becoming more prevalent in recent time, due to their environmentally friendly production, ranging from low- to high-tech, along with low cost and abundance of material. When dealing with earth building standards, most countries use three techniques: Adobe, Rammed Earth and CEB. Three quarters of building standard currently under consideration concern the use of CEB (Ruiz et al., 2018).

The strength of the block can vary greatly, depending on factors such as how much force was exerted when the blocks were created, the size of particulates in the soil and whether cement or lime was added. Adding a binder like lime stabilizes the blocks and increases their compressive strength (Ruiz, et al. 2018).

Can be produced in county

Pros

Fire- and bugproof

- *Large part of the GWP for production is from the machine compressing the blocks, which can be done manually instead*

- *Strength can be increased by adding a binder*

Cons

- *If not properly protected from rain, deterioration may occur, depending on the specific composition of the earth used.*

- *The more cement is added, the higher impact each block will have on GWP*

Hollow Concrete Blocks

Hollow concrete blocks (HCB) are concrete masonry blocks, often rectangular. These blocks are often modular. Exact sizes vary by country; however, sizes and total mass are dimensioned so that anyone can handle them with ease. Hollow concrete blocks are versatile in their application but are often used in load bearing structures as a compression member.

Can be produced in neighboring county

Pros

- *More standardized production because of preexisting infrastructure*

- *Ingredients are available in most places*

- *High durability*

- *Low maintenance*

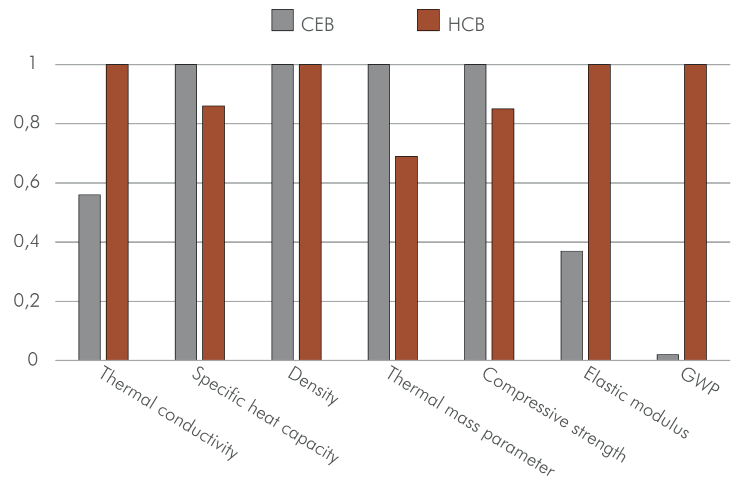
Cons

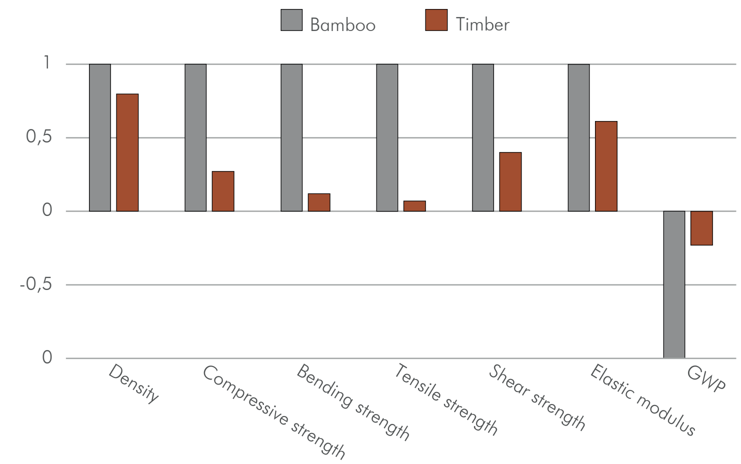
- *Heavy machinery required*

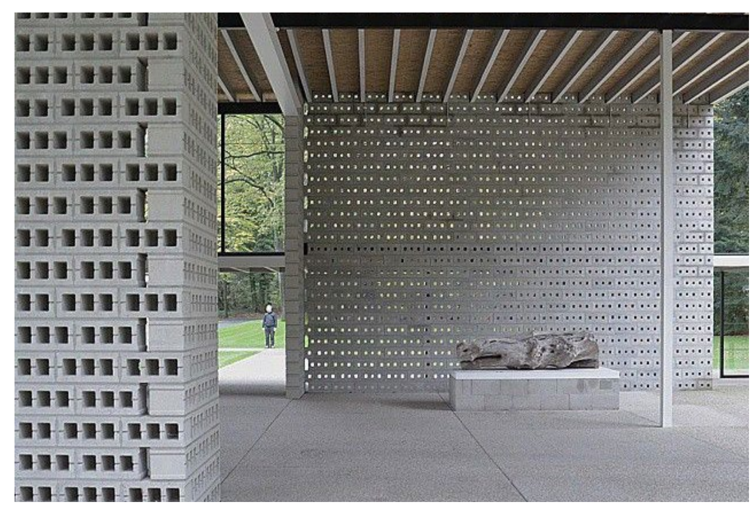
- *High weight compared to strength*

A comparison of relevant properties is carried out between CEB and HCB, as well as timber and bamboo.

For ease of comparison, values are normalized to the maximum value in each category. Full values can be found in appendix 02







Ill. 122: Above, Left: Normalised Material Properties for CEB vs. HCB

Ill. 123: Below, Left: CEB

Ill. 124: Above, Right: Normalised Material Properties for Bamboo vs. Timber

Ill. 125: Below, Right: HCB

Structural System Development

In the sketching phase of the project, loose ideas on how the roof should look were envisioned. Prior to sketching, the implementation of double leaf roofing was settled on, as it creates shade for the building without the transmission of heat, while also ventilating the space beneath.

Through evaluation of sketches four roof types were picked out for further analysis. These were:

- *Flat Roof*
- *Monopitch Roof*
- *Saddle Roof*
- *Butterfly Roof*

These could be considered as archetypes of roofs for the housing units and the process therefore steered towards envisioning the underlying structure supporting the roof. The structure would be the most characteristic part of the roof from perspective of a viewer at ground level.

Section sketching explored the different configuration created by different roof supporting types. Both the spatiality inside the house and the area outside covered by the overhanging roof were considered. These sketches featured structures that included columns placed away from the supporting wall, creating a fluid space between the interior of the building and surrounding outdoor spaces. This concept was later abandoned when development of the building layout changed in favor of this space being placed between the heavy walls of the building.

This change led to the idea of a truss system placed upon heavy walls, which meant that these would also act as load-bearing elements.

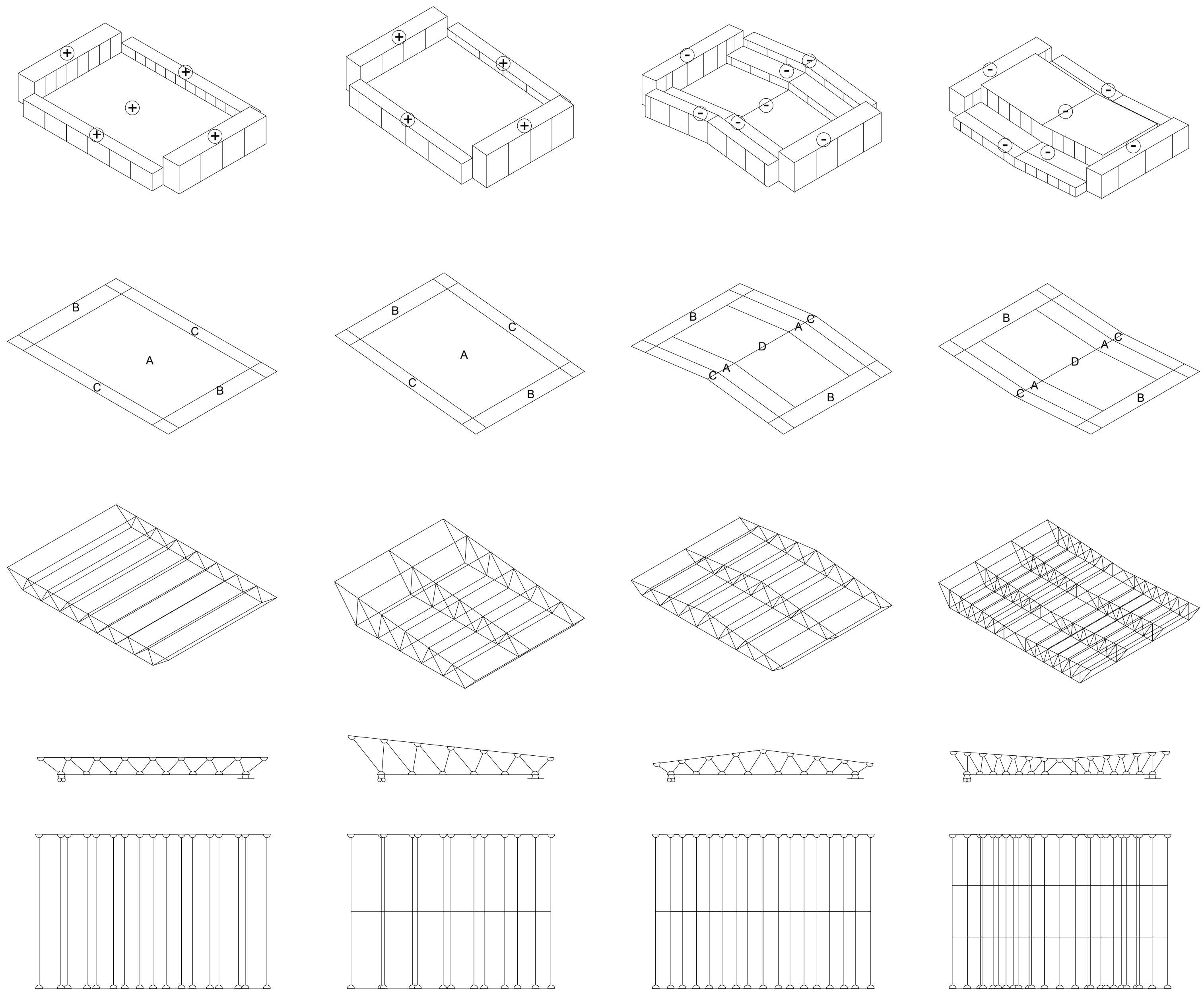
At this point in the process the precise shape of the roof was still not determined. Therefore, an investigation into how this truss system would work with the four roof types identified earlier was initialized. Two types of trusses were tested: A 2D frame structure and the 3D spatial truss system.

To compare these structural systems, a simulation of the construction was produced using the Karamba3D tool and plugin inside Grasshopper. With four roof types and configurations of the supporting structures, eight different models were tested. All eight models are optimized using a multi-objective optimizer, aiming to minimize the amount of material and maximize the utilization of the construction elements.

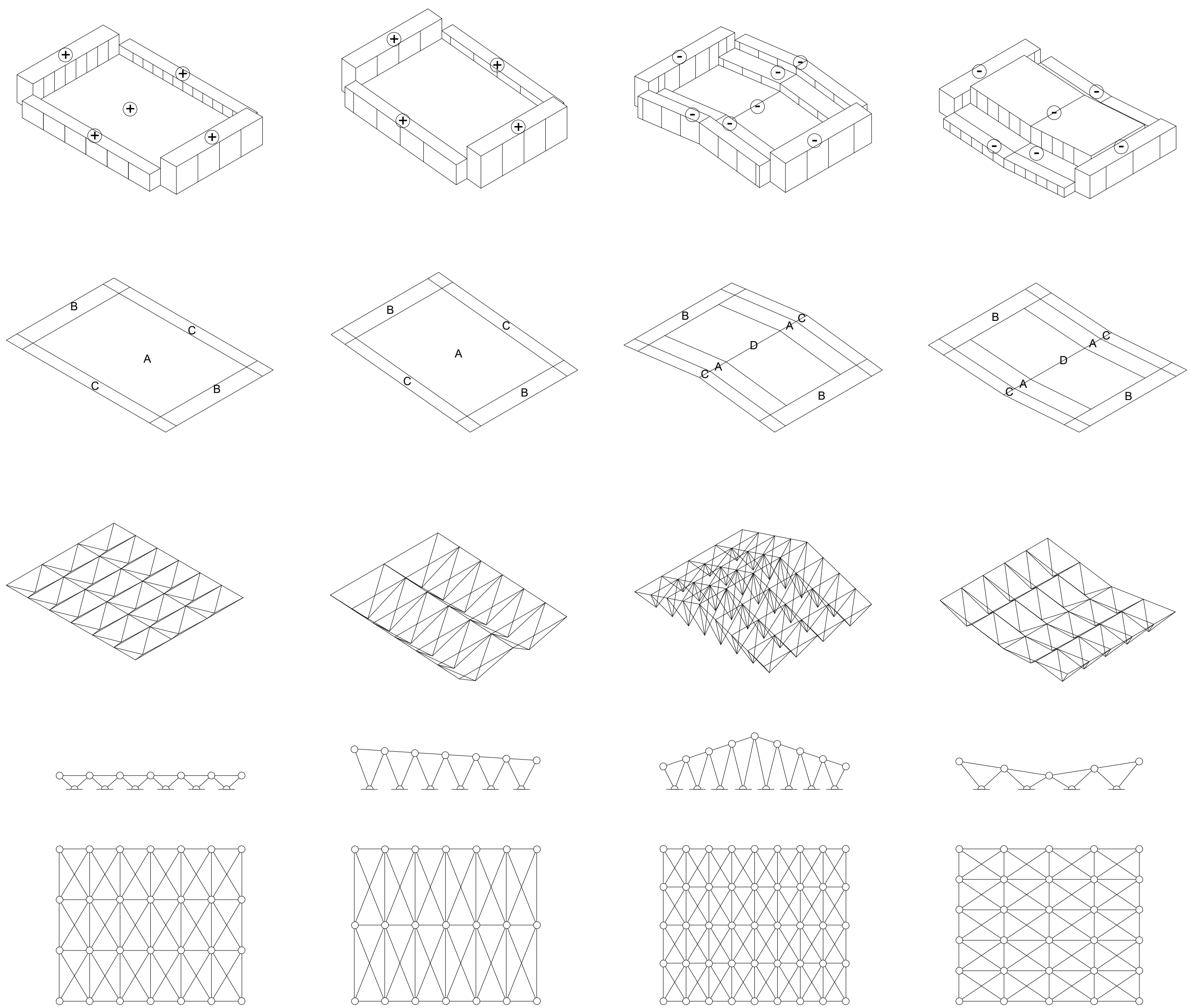
Initially, the optimization would also encompass the minimization of a CO_2 equivalent value introduced in the material section. The GWP was determined as the most appropriate value for the simulation to be carried out. But trial showed that the optimization favored large elements made of bamboo, since it has a negative GWP impact for production. The additional material required would lead to more frequent and heavier transportation required for building, which is not desirable. Therefore, minimization of the total mass of the construction was chosen as a goal. While it is not a direct measure of the environmental impact, the expected lesser amount of material required would still have a positive influence on other factors such as the buildability.

The other goal is the degree of utilization, which is considered to ensure that no more material than what is required is used. At the same time it would help verify that elements would not break, as the results exceeding the upper limit of utilization were discarded.

The initial optimization was prepared with a set of parameters. Since the project was still in an early stage, there were not as many constraints.



Ill. 126: 2D Structural Systems



Ill. 127: 3D Structural Systems

The parameters defined for system 2D trusses were:

- *Height of the roof*
- *Angle of the roof*
- *Number of trusses*
- *Number of divisions in each truss*
- *Material: Bamboo or Steel*

The parameters in the 3D truss were:

- *Height of the roof*
- *Angle of the roof*
- *Number of truss center points in both x direction*
- *Number of truss center points in both y direction*
- *Material: Bamboo or steel*

The inclusion of many parameters reflects the fact that decission making was to be based partly on these simulations, rather than using it as a tool for verification of structures afterwards. Therefore, the investigation served to provide a general idea of which structure would be most suitable for further design development, and not just consider a hypothetical scenario with a specific angle and/or amount of trusses, which would be subject to change anyway. The only specified parameters of the model are the length and width of the building, which is determined as 12x10 meters as well as the range the different variables of the simulation could adjust within.

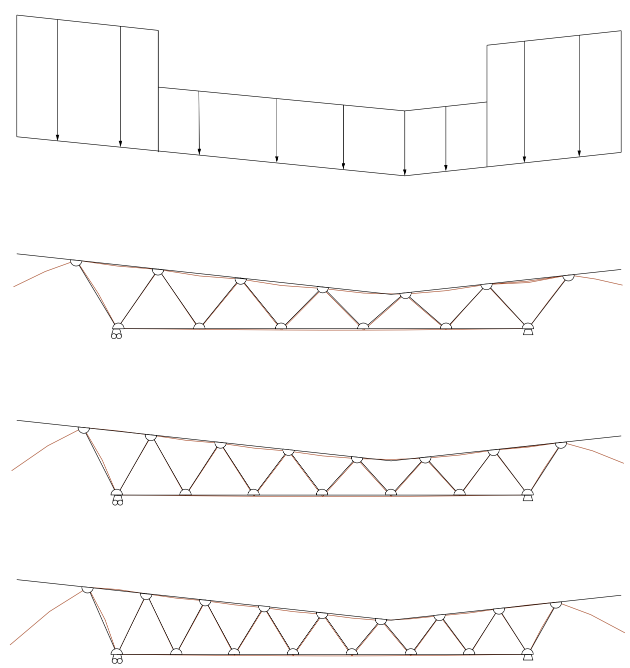
The loads acting on the roof are the gravitational loads and wind loads. The gravitational loads are calculated by Karamba3D based on the volume and the specific weight of of material. The wind loads are calculated based on Eurocode 1 part 1-4 detailing Wind actions. The pitched roofs have different coefficients based on the angle of the roof, which are calculated in real-time in the script. This is considered in the optimization.

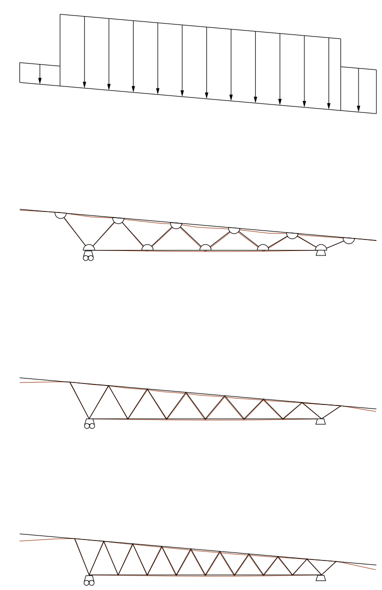
Results of the 2D and 3D truss investigation
What is immediately apparent when looking at the results is that the butterfly 3D truss was found to be most optimal when constucted of steel while the others are most suitable using bamboo. This also heavily affects the mass of the construction, being calculated as ten times higher than the second heaviest.

There was a preference for using bamboo as the main material in the trusses, but to en ensure that it is the most beneficial solution, the optimization process included both steel and bamboo as a parameter. It was therefore a welcome result, that bamboo turned out to be a favourable choice of material in the majority of the configuration considered.

When looking further into the results it is clear that the butterfly structure both in 2D and 3D are overall heavier than the rest. The best structure according to the investigation is the flat roof both in 2D and 3D, closely followed by the pitched roof.

When referring to the Climate Responsive Building Design study in Chapter 3, the UN-Habitat report advise the use of slanted roof as this has great advantages concerning ventilation of the double leafed roof by incorporating the venturi-effect for ventilation. All of these factors together resulted in the choice of a monopitch roof constructed of bamboo for subsequent investigations.





Follow-up Investigation

In the penultimate iterations, a roof shape was decided based upon the angle and how this would be viewed from the courtyard space. The extend of the overhang was based on a criterian that the north and south façades of the buildings should remain shaded throughout the day.

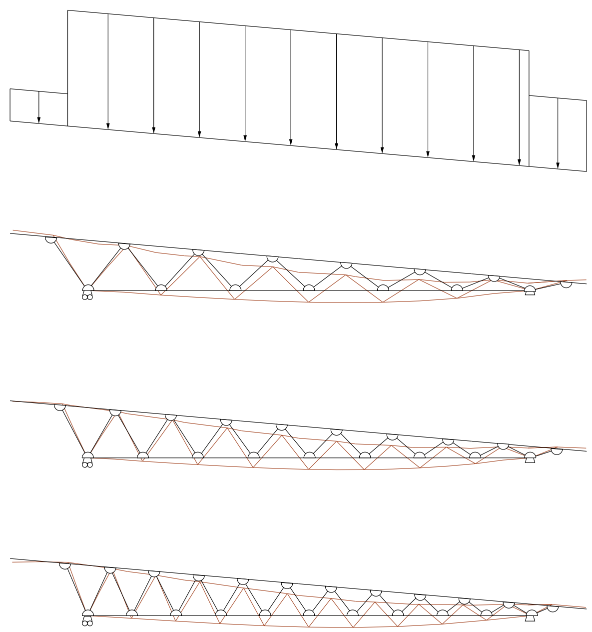
A 5 degree pitch was chosen based on the experience of the roof when viewed from the courtyard space. 3 degrees was seen as to narrow while 7 and 10 degrees proved too steep. In comparison the slanted roof from the investigation earlier in the process, resulted in a roof angled at 6 degrees. See Appendix 03. To establish a visual connection between the buildings in the settlement, the roof of the Civic Center, Water Post and Bath House also have one or more surfaces with a 5 degree inclination. Their form and structure is dependent on other factors however, such as the suggestion of a welcoming gesture. This is apparant in the Civic Center, where the layout of the building creates four entrances, and the roof opens up in all four directions, creating a welcoming facade. The roof is inclines down to a central courtyard, creating a more intimate space within.

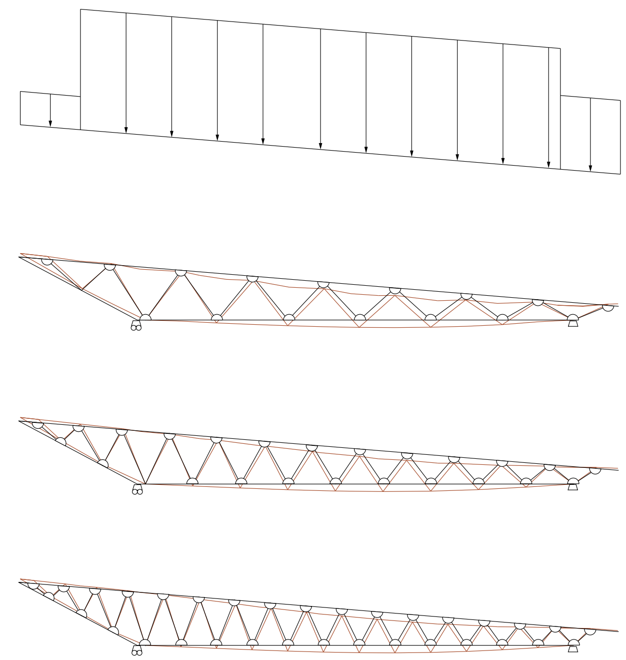
The Water Post opens up to the north and south, creating a butterfly roof and also suggesting entrances. Even though the initial investigation showed that the butterfly roof is not an effective construction, the welcoming act was prioritized. It was however reserved for only one building in each cluster.

The Bath House has entrance from two sides but maintains a monopitch roof to remain simple and refrain from drawing attention in the urban landscape. This reflects the purpose and function of the building, as it does not need the wel-

Ill. 128: Left: 2D Structure for Water Post Roof Free body- and displacement diagram

Ill. 129: Right: 2D Structure for Bath House Roof Free body- and displacement diagram





Ill. 130: Left: 2D Structure for House Roof Free body- and displacement diagram

Ill. 131: Right: 2D Structure for Civic Center Roof Free body- and displacement diagram

coming act in the same way the more extroverted spaces created around the Civic Center and Water Post do. These need to act as local hubs for people to gather, and should therefore emphasize the inviting aspect of the architecture. They house many different functions, whereas the Bath House serves as the destination for a very specific amenity.

The roof was once again calculated and optimized with the same end goals as the initial investigation. This time the size, angle and height of the roofs were predefined, and the only variable was the number of divisions in the truss. Therefore, a simpler model was more appropriate to analyse, in which only the most critical trusses were taken into consideration. This simulation was used to finalize the structure and define the appearance of the four building typologies. Results for mass and displacement can be found in appendix 05

The purposes of each typology helps establish the individual buildings as destinations, and this aspect is mirrored in the architecture. The use of a truss-system with coinciding inclinations on surfaces establishes a connection between all buildings. The structure is adaptable to different situations prompted by the architecture and the activtivities that take place within.

Solar Incidence

Based on the idea discussed in climate responsive building section earlier, utilizing high thermal mass to stay cool during the course of the day by releasing heat energy throughout the night, the design would need heavy walls shaded from the direct sunlight present during the day, as the heat is assumed to come in the form of a direct solar load.

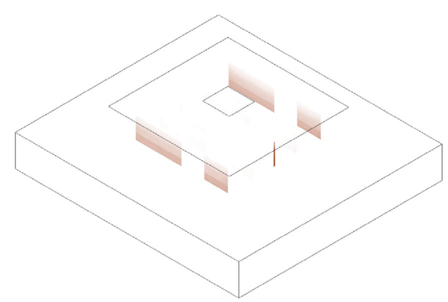
The main shading of the building comes from the roof structure covering the entire house. To ensure that these walls with high thermal mall is shaded as much as possible, a simulation of the incident radiance on the surfaces was conducted using Ladybug for Grasshopper.

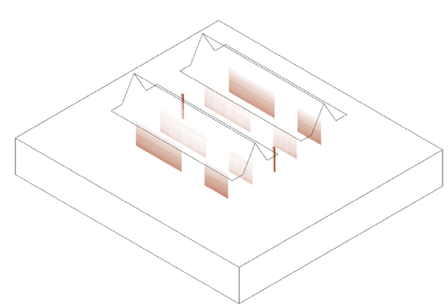
Four different housing configurations were used. The heavy walls of these plans were isolated, as were columns in the plans where present. Four different roof type were applied to these walls; though these are not completely identical as toacknowledge the fact that the plans differ a lot.

When considering the graphical representation of the simulation it is clear that east and west facing walls have a considerably higher heat gain than the north/south walls. It also becomes clear that walls placed below the roof and inner walls receive less sun than those directly facing the outside.

Using the evidence obtained through a simulation, a tendency is identified. Roof C has considerably lower radiance than the other types examined. So, what causes this pitched roof to create so much more shading? The direct cause is unknown, because it should let in more sun in the east and west façade, which as stated earlier receive a lot of sun. And the overhang is not greater in this roof than the others. Though in plan 4 it does not have a hole in the center as the others do. Therefore, an additional calculation was done on roof A over plan 4. To decrease some of the sunlight through the hole, the hole was added a parapet with the height of 0.5 meter. This decreased the radiance from 270 kWh/m² to 262 kWh/m², now being the lowest of the investigation. Further tests of roof C on plan 4 with an opening in the middle resulted in it being deemed the most efficient (plan 4 with roof A,B,C,D roof D with plan 1,2,3,4).

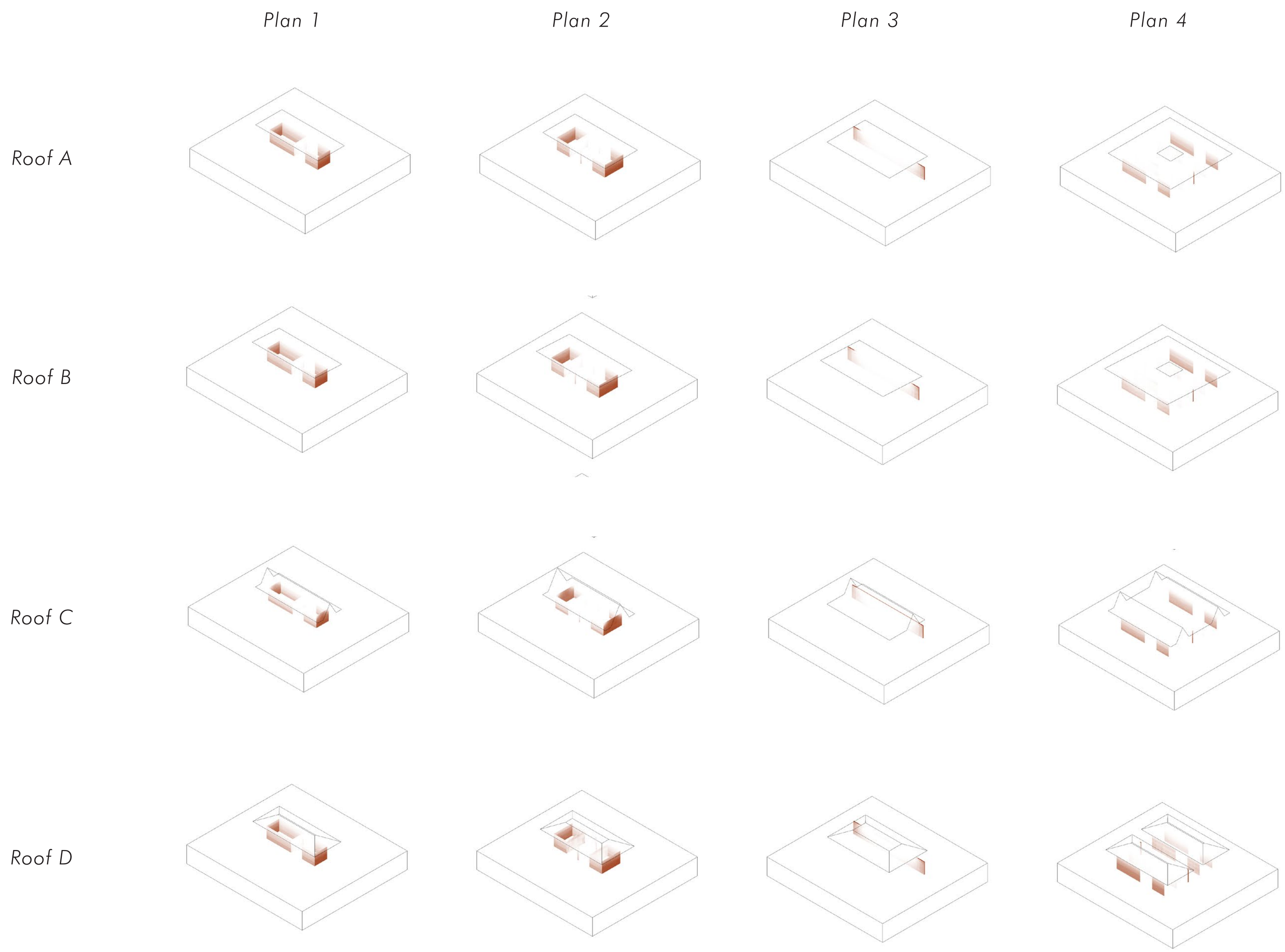
This suggests that the shape of the roof is not the crucial part, but rather the approach to overhang and perforation.





Ill. 132: Above: Opening in Roof

Ill. 133: Below: Removal of Overhang



Ill. 134: Table of Roof Types + Plan Solution for Solar Incidence Simulation

Roof Opening

This investigation is an extension to the previous investigation exploring the roof as shading over the heavy walls in the housing unit.

It seeks to investigate the effects of a perforation in the roof, which would allow daylight to enter the courtyard room while keeping the CEB walls shaded so they do not accumulate heat through radiance. The inclusion of an opening in the roof serves to accentuate the sensation of an intermediate zone between the fully closed rooms and the surroundings.

The Light level will be calculated as lux level in the courtyard, shaded by the same objects.

Both are calculated in the Ladybug/Honeybee interface in Grasshopper, based on Energy+ and Radiance calculations. The calculation will evaluate a one year time frame, measuring the solar loads throughout every hour of the year. But because the opening is a permanent feature, the calculation will not be divided into smaller sections; such as winter/summer or equinox to equinox. When studying the sun path in previous section of the report, one can see that the sun does not fall lower on the north horizon than the south horizon. This indicates that it is possible to obtain the wanted result.

The simulation does not account for reflection of the surroundings, meaning that the sun hitting the ground and bouncing to the wall will not be considered. This should be seen as a source of error, but since it is the case in all simulations, it may be disregarded.

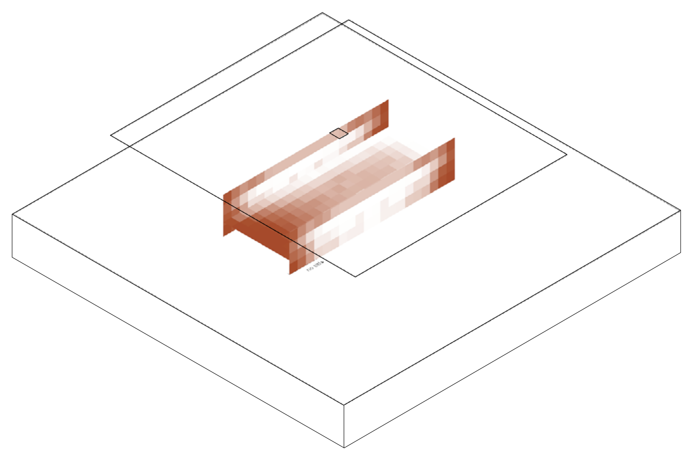
The four different roof types introduced earlier were to be considered again; flat, slanted, saddle, and butterfly. In the middle of these roofs an opening is place. In the simulation the hole can have the dimensions; 0.2-2.0 in the x-, and 0.2-1.5 in the y-direction. The reason for the dimension being lower in the y-direction, is an assessment that the edges of the hole comes too close to the walls of the courtyard, which is intuitively undesirable. Therefore, it was constrained to save calculation time. The opening can also be supplied with a parapet up till 0.8 meters. The ultimate perhaps being too extreme but was included as there was no intuitive basis for how it would work.

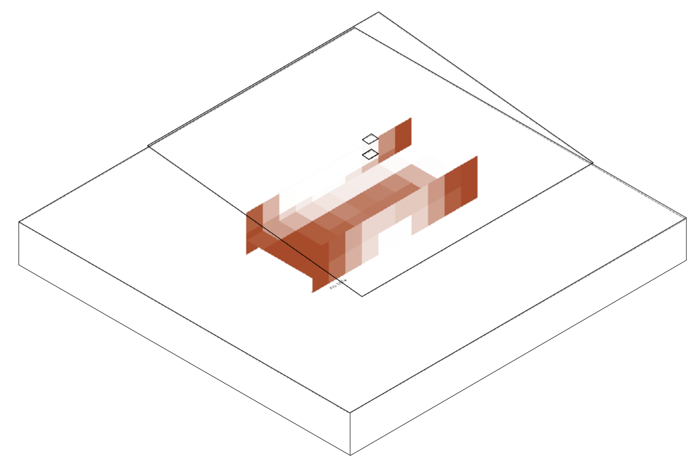
The simulation was coupled with a multi-objective optimizer seeking to maximize lux level in a height of 1 meter over the floor, while minimizing the radiance level on the walls.

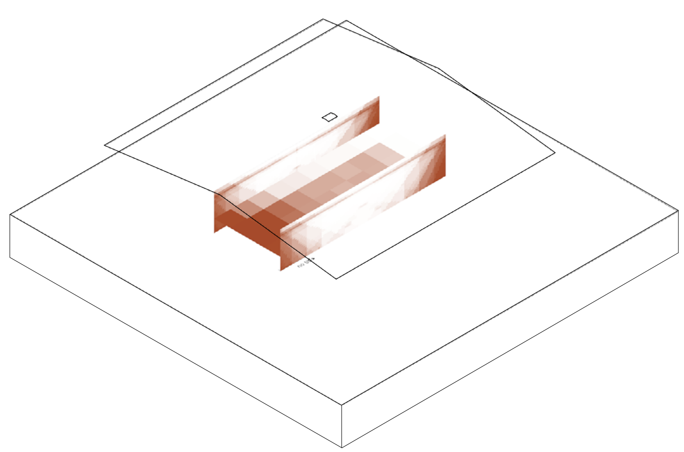
Conclusion

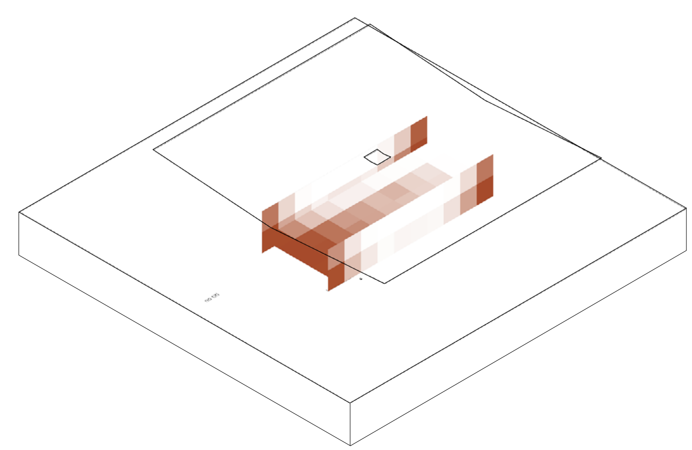
The trial resulted in an unexpected outcome. According to the optimization, the hole in the roof should be as small as possible. This led to review into why the simulation returned these results. The reason for this was that the hole in the roof did not add that much daylight since one end of the courtyard is open, letting in light. Therefore, the simulation solely aimed to minimize radiance, which of course is the smallest hole possible. It is possible to see on the screen captions in appendix 11, that the illuminance is steady at the same value while the radiance changes.

This led to the conclusion, along with other considerations, to abandon the idea of the hole in the roof. Other considerations being that a hole in the roof would decrease or completely remove the effect of the stack- and venturi-effects.









Ill. 135: Above Left: Flat Roof

Ill. 136: Above, Right: Monopitch Roof

Ill. 137: Below, Left: Saddle Roof

Ill. 138: Below, Right: Butterfly Roof

Thermal Comfort

The courtyard is design on the idea that two heavy walls with high thermal mass will create a more evenly leveled temperature throughout the day, resulting in lower temperatures in the daytime and higher temperatures in the nighttime. This should increase the thermal comfort of the area, creating an incentive to use the space.

Different investigations have been conducted through the process:

- *The width of the courtyard*

- *The enclosure of the courtyard*

- *Ventilation*

The investigations are performed through Ladybug and Honeybee for Grasshopper, using OpenStudio Energy simulation. A model composed of 3 zones is used; north house, courtyard, and south house, though focus will only be on the courtyard. The model is fitted with the appropriate materials, roof shading, and windows (which were current at the time of the simulations). For material values see appendix 07.

The simulation is conducted without gains from people or utilities, as this would be hard to predict, since the housing should accommodate a variety of different families/people. Likewise, there is not added heating and cooling system as this investigation seeks to develop the passive climate responsive building strategy previously mentioned.

To obtain an overview of how the building performs, the results will be evaluated graphically over a time period of a year, showing the hours of the day in a graph with the operative temperature hightlighted. The operative temperature will be compared to the outside dry bulb temperature.

Width

In an early stage of designing the courtyard space the plan was still not determined based on furniture or layout. Thus, it was desirable to investigate if the width of the space would have an impact upon the thermal comfort. The results from the simulation did show that the difference between the set parameters of 2, 4, and 6 meters was unnoticeable. This meant that the layout was free to develop without restrictions posed by a too narrow space between buildings.

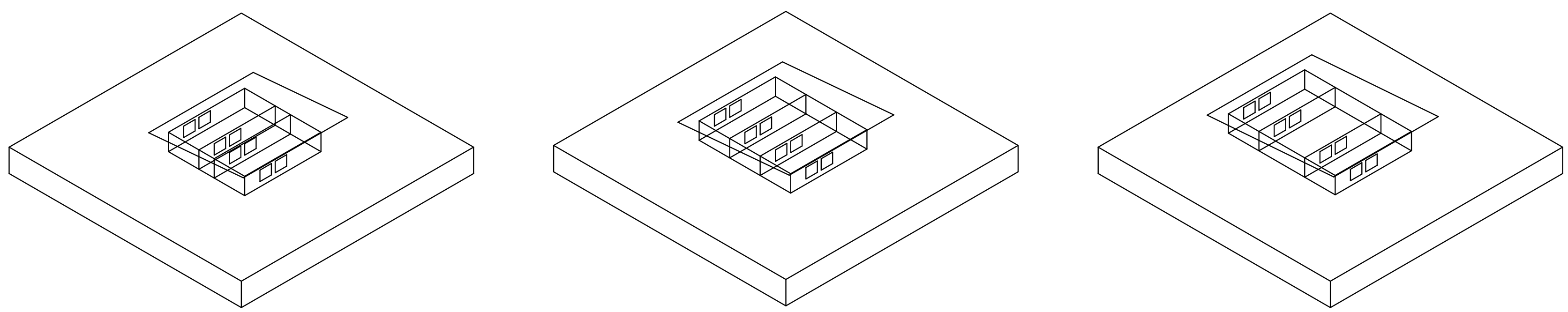
The enclosure of the courtyard

Another question about the courtyard that arose, was the question of the appropriate amount of enclosure. This question came from the discussion on how the natural ventilation in the space would be utilized. If the courtyard is open in both ends it would create a duct, allowing wind to pass through utilizing the venturi-effect. This would give a near constant stream of air to cool down the room. The downside is the lack of control. Residents would not be able to shut off the wind stream, neither could they enclose the space from the surrounding area.

The second opportunity is to close off one end. The wind would not be able to pass through, but the area would be shaded, and wind has the possibility of passing via the double leaf roof, creating ventilation.

The third option is to close off both and rely on natural ventilation by the use of doors and windows. This would create the opportunity for control over the ventilation by the users, and the option to shut off the surroundings.

Examining the results of the three cases one can see a tendency. All three are cooler during the day and warmer during the night, which is the desirable result to gain from the courtyard. Then, when comparing the first case, where the courtyard is completely open, with the other two, one can see that it cools the most during the day. But this then tran-



Ill. 139: Left: 2 meter wide courtyard

Ill. 140: Middle: 4 meter wide courtyard

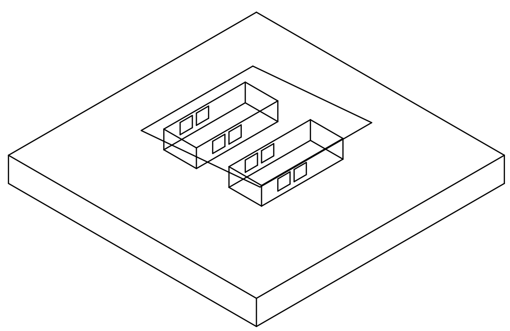
Ill. 141: Right: 6 meter wide courtyard

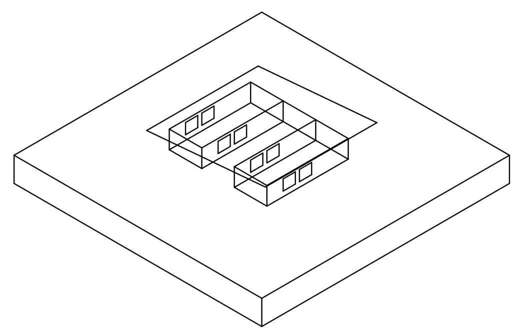
scends into the night where it does not retain as much heat as the other two cases. Ultimately keeping a lower temperature during the night, which is the not the goal as the temperatures decreases under 20 degrees.

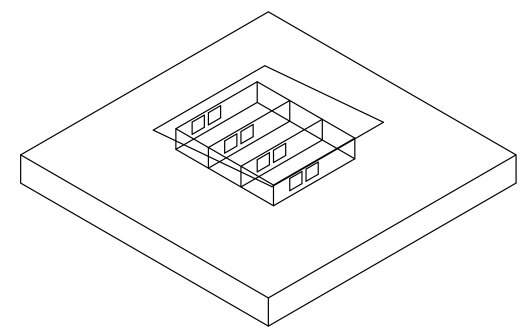
The second case, which is only open in one end, almost keeps a status quo with the outside temperature during the day. Sometimes even being warmer. While this results in warmer night temperature, it is not a viable solution.

Then in the third case a promising result arises. The temperature is cooler during the day and warmer during the night. It is not as cool as the open solution, but it keeps the heat during the night, lowering the overall temperature flux between day and night, ensuring higher thermal comfort.
Natural ventilation in the courtyard. Earlier in the report it is suggested to use night ventilation to keep the courtyard cooler. To investigate the effects of this a calculation of the space with no ventilation, full natural ventilation, and night ventilation (programmed as turning on when the outside temperature drops below 20 degrees) is performed.

No ventilation is not the best choice, as it is preferable to have the option of exfiltrating polluted air and at the same time provide users control over the environment. This is an important factor to consider when looking at the results; because the variant with no ventilation returns promising results with cooling through the day and heat in the night, which is the desired effect. When compared to only the variant with ventilation, the no ventilation variant performs better in terms of the thermal time-shift. But when comparing the two to a variant which utilizes only night ventilation, one can see that it keeps cool just as well as the no ventilation variant during the day but keeps the heat during the night.







This confirms the theory that night ventilation will increase the thermal comfort.

When examining the temperature over a year for this last variant, it becomes evident that temperatures stay between 19 and 25 degree most of time, rising above 25 degrees only in the very hot month of February, where the dry bulb temperature sits above 32 degrees. All while keeping a nice temperature in the nighttime around 16-19 degrees, even in nights when the temperature drops below 10 degrees, which can occur all throughout the year in Kenya. All these findings suggest a good thermal environment can be achieved with these passive, and one active (as in the user have to do something actively), initiatives.

Ill. 142: Left: Fully open

Ill. 143: Middle: One Side Open

Ill. 144: Right: Fully Closed

Foundation

Through initial sketching and research of vernacular architecture in east Africa, the use of a plateau is introduced to the project. This plateau is used to create an informal boundary, which can be used by the inhabitants as a sheltered walkway around the house. The first iterations were in the form of a lightweight raised platform, with ventilation below. These iterations were based on a desire to reduce the need for foundation of the building, in the hopes that when the dwelling was no longer needed, there would be a minimal footprint left behind. These iterations were quickly set aside however, as research into various aspects of climate responsive design showed the need for dense thermal mass, as well as showing that a ventilated space below the floor would have a negative effect on indoor comfort in this climate.

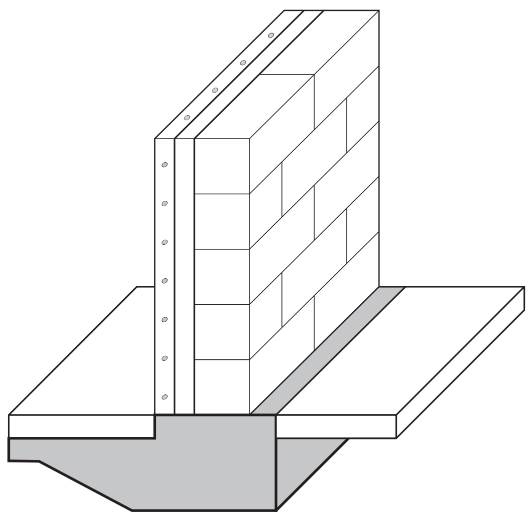
As the shelter now had to be placed on the ground, discussions concerning the driver to reduce the footprint after demolition became more prevalent. Four different foundations were drafted, each varying in complexity and extent of footprint, as well as the amount of heavy machinery and digging required during construction and deconstruction

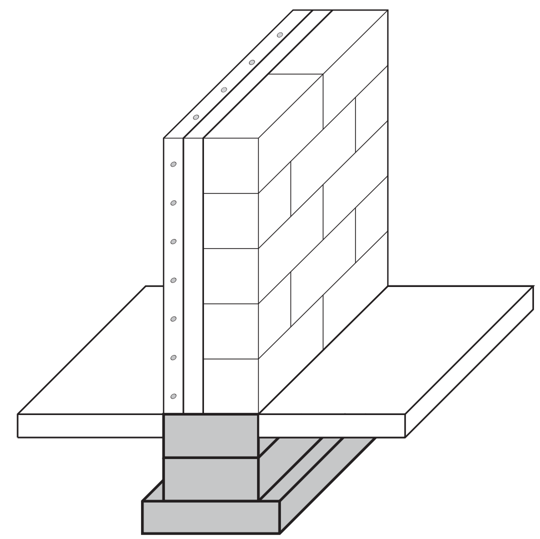
Raft foundation
A raft foundation comprised of a layer of concrete across the plan of the building, with a thicker rim located below the load bearing walls. This foundation would leave the biggest footprint and require the most amount of concrete, heavy machinery and rebar.

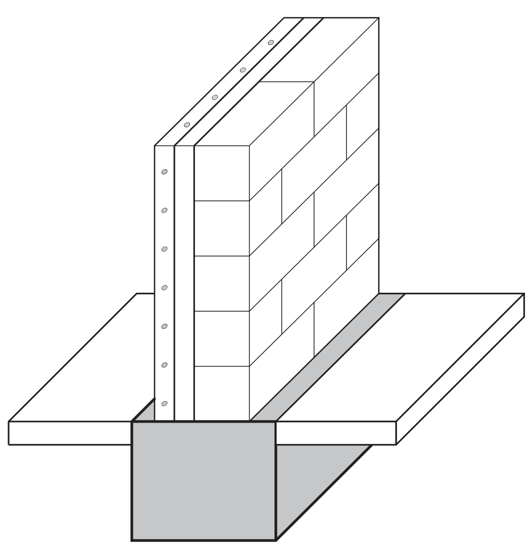
Strip foundation
A strip foundation consisting of blocks or poured concrete in layers, buried into the ground below the load bearing wall. The lowest of the layers would be wider than the rest, creating a sort of anchor and base. This requires extensive sitework for both establishment and dismantling of the strip.

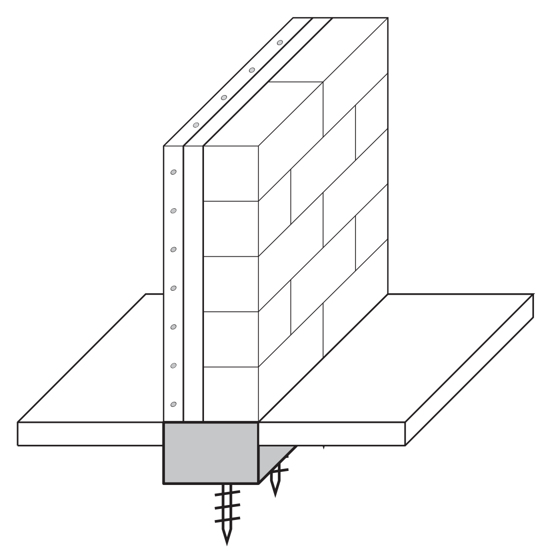
Deep strip foundation
In a variation of the strip foundation, a heftier block is placed below the load bearing walls. This would require heavy machinery, as the blocks that would be buried are larger than the other variation of strip foundation, both for construction and deconstruction.

Pile foundation
A combination of strip foundation and pile foundation, this version uses steel helical foundation piles to support a smaller ring of blocks, located below the load bearing walls. This would require a lesser amount of digging compared to the deeper strip foundations. The piles function mainly to stabilize the wall and can be dug up and repurposed after decomission of the house.









Ill. 145: Above, Left: Raft Foundation

Ill. 146: Above, Right: Strip Foundation

Ill. 147: Below, Left: Deep Strip Foundation

Ill. 148: Below, Right: Pile Foundation

Urban Space

Settlement layout
A major part of this thesis is the development of a settlement layout, in conjunction with the development of a housing scheme. This settlement layout should aim to encourage the act associated with dwelling as discussed in Chapter 2, by accomodating the different modes of dwelling. These spaces should be placed in a hierarchy ranging from public to private, from the natural dwelling of the camp to the collective dwelling occurring between homes.

This hierarchy can be linked to the infrastructure of the camp using spatial syntax, in which the roads with most connections should be the largest, while the roads with the fewest connections should be the smallest. While this stems from the studies into the phenomenology of dwelling, it is also reflected in case studies of Kakuma and can even be seen in many small towns in Denmark, with communities forming around cul-de-sacs since these streets do not facilitate the flow of unsolicited traffic. As such, the act of dwelling in this space can be more focused on the collective dwelling, created in the space between buildings.

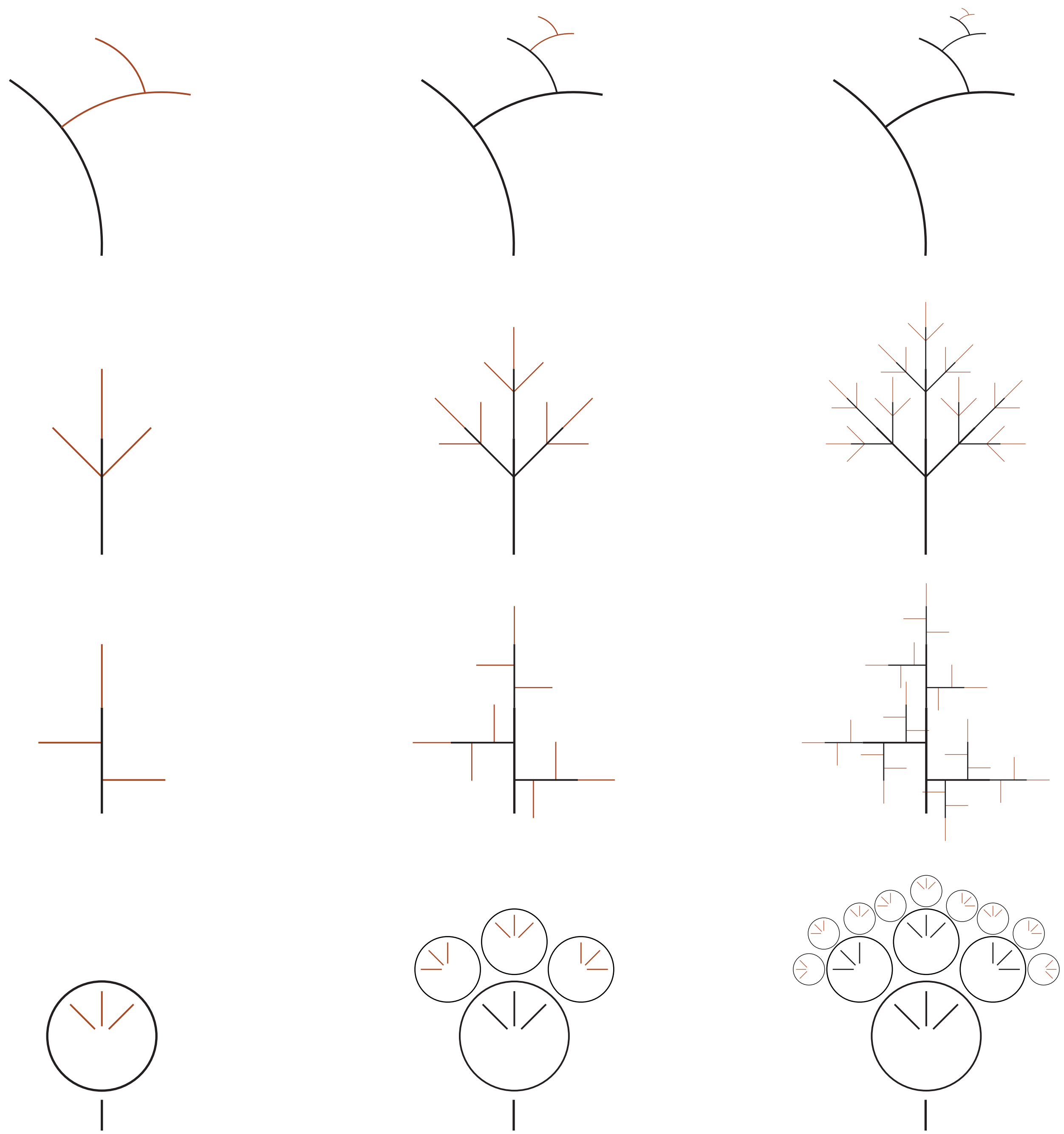
The use of fractals to determine the hierarchy of roads is proposed early in the project and used as the basis for development of camp layout. As fractals are infinitely self-replicating, the idea of a continuously expanding network of roads following the same principle is established, with community clusters connected to this network like grapes on a vine. These communities would contain sixteen houses, as well as amenities such as a Bath House, a Water Post, and initially also a Civic Center.

The fractal process shows promise at a smaller scale, but as the camp grows the distances created by the ever-scaling lengths of streets creates passages multiple kilometers long. The length of these elements also contributes to the creation of large, open areas between clusters, the scale of which would also be ever increasing. These problems of scaling occur when the approach is predominantly mathematical, and as a product of an infinitely scaling fractal being paired with a non-scaling cluster formation.

The shape of these clusters also influence which fractals can be used, as the tiling effect of the clusters will have to work in conjunction with said fractal. There is, however, still potential in the use of fractals for planning the camp, but the scope and mathematical rigidity of these should be managed.

The infinitely scaling properties of the fractal were of great interest at the start of the thesis, as at this point the project scale was still ambiguous. As the thesis became more specific in the size and context, this scaling aspect became less important while the human perception of the spaces was becoming more central to the design. The fractal approach is therefore flipped, to create spaces of "where not to build" on a predefined site, creating a hierarchy of road sizes branching out to form infrastructure. This approach is overlayed on a grid pattern, with the grid lines being shifted or removed to accommodate the fractal. The communities are then placed on top of this, and individual house plots shifted to reduce the amount of unused space between clusters.

Cluster layout
Through analysis of UNCHR guidelines, the psychology of internally displaced persons, and a design investigation into possible urban structures, a community size of 16 houses, with common amenities and opportunity for collective dwelling was settled. The shape, content, and size of these clusters, how amenities are placed, and which direction buildings are oriented, as well as what effects these aspects have on the perception of the urban environment has been the focal point of iterations and analysis hereof.



Ill. 149: Fractal Scaling Principles

Cluster shape
The specific shape of each cluster can be classified under three typologies:

- *Type one: Tightly packed houses following the roads created by the fractal, these clusters function best when used in a smaller scale. With less space between each road, the cluster shape becomes dictated by the shape of the fractal.*

- *Type two: Freely shaped clusters allowing more space and freedom of shape, these clusters function best when used on a larger scale fractal. With large amounts of space between roads, the clusters are more akin to individual settlements, as large areas between clusters are bare*

- *Type three: A hybrid between type one and type two, shaped clusters are fit closely together and molded to reduce the amount of unused space between communities.*

Location of amenities
A central aspect of the cluster has been the inclusion of common amenities, such as a Water Post to supply fresh water, a communal Bath House to reduce piping and a Civic Center as a gathering point for each community. Initially, every cluster would be equipped with each of these, but as the scale of the Civic Center grew to encompass functions such as schools, clinics, and markets, these were moved out of individual communities and places in central locations around the settlement. Instead, the scope of the Water Post would be increased to include space for gathering. The size, amount, and location of the Bath House varies across iterations. Four distinct strategies for sanitiation were considered:

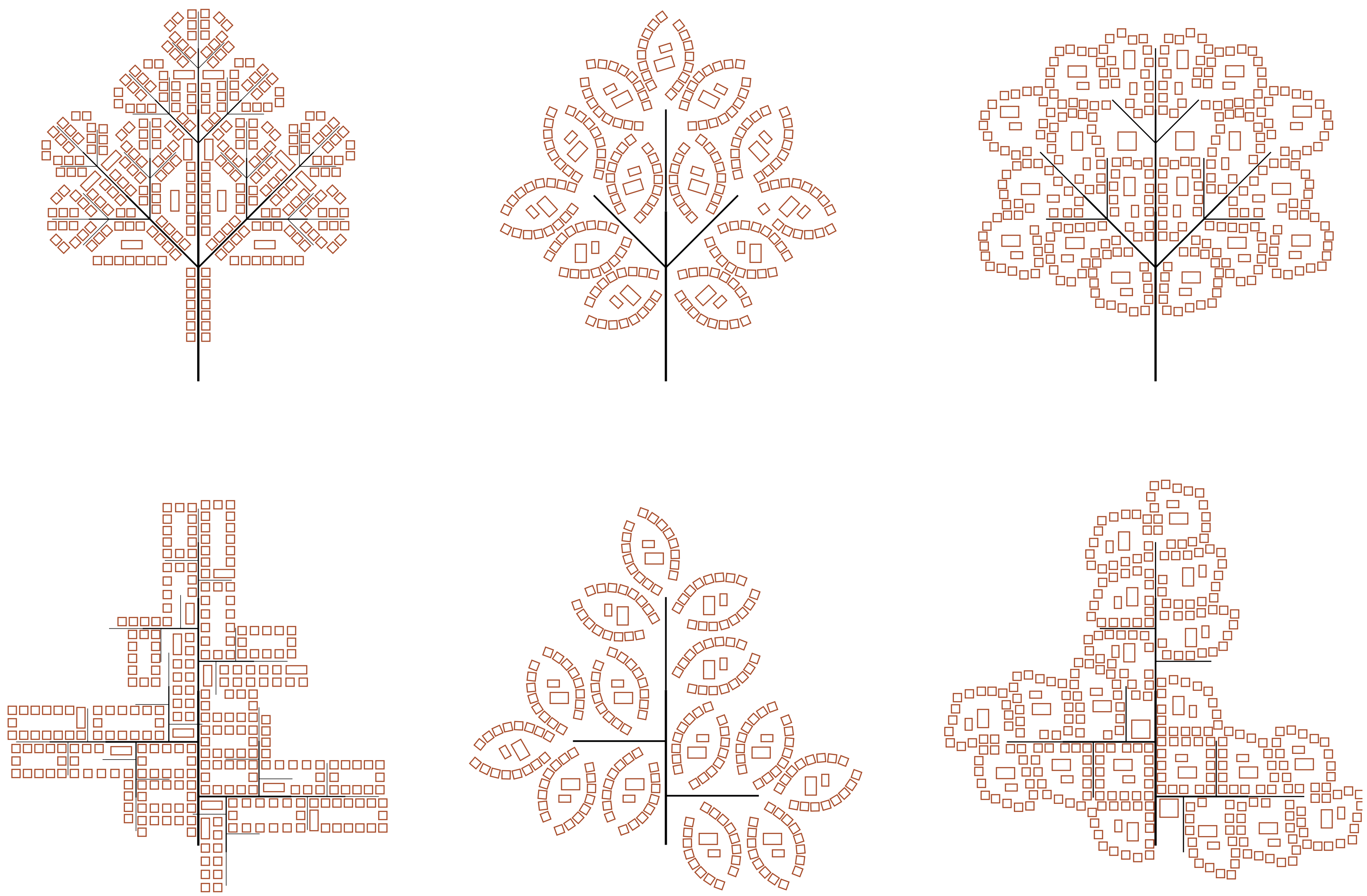
- *A personal bath for each house. Iterations with a personal bath for each house were quickly cut, as this is in direct conflict with the driver to reduce the footprint left by each building.*

- *A bathhouse shared by four to six adjacent plots. While this functions as a compromise between a personal bath and a central bathhouse, this would also require several separate buildings constructed, each with plumbing.*

- *A central bathhouse for each community. While the central bathhouse would allow camp officials the largest amount of control, in terms of hygiene and cleaning, a large central bathhouse may seem imposing in the urban space of a cluster.*

- *A personal dry toilet placed on each plot, along with a smaller central bathhouse which includes a few toilets and showers.*

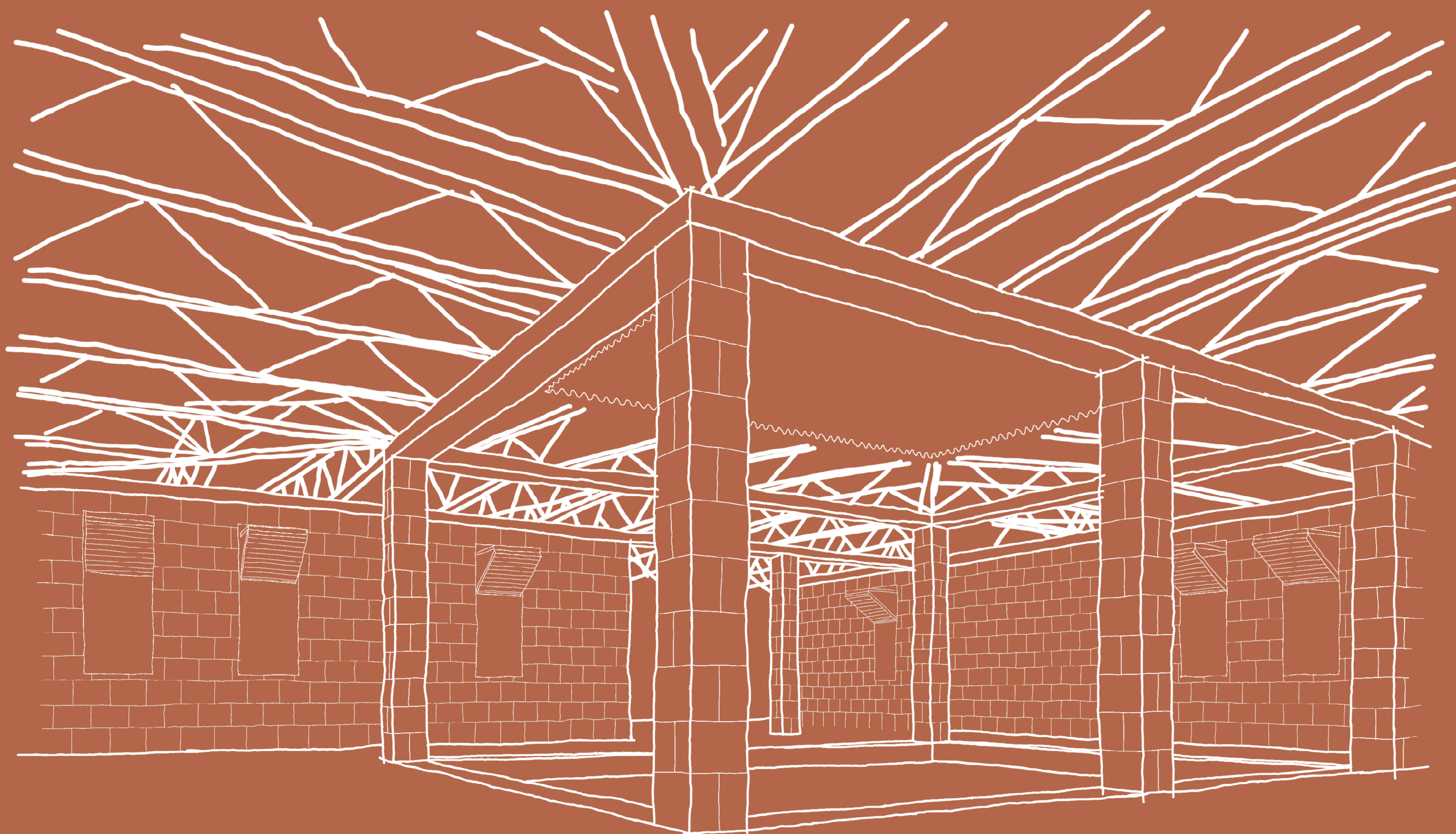
The fourth strategy presented was chosen, which informed the design and layout the Communal Bath House.



Ill. 150: Left Column: Type 1 Fractal

Ill. 151: Middle Column: Type 2 Fractal

Ill. 152: Right Column: Type 3 Fractal



EPILOGUE

Conclusion

This project seeks to address the implications of internal displacement through an architectural proposal for a settlement.

The problem presented in Chapter 1 is motivated by both personal ambitions and societal concerns, leading to the definition of a vision as it appears in Chapter 4. Accompanying design drivers and criteria have informed the architecture throughout the design process.

A methodology has been established, consisting of a Position and an Approach. The former is specified as a Human Centered Position, wherein the experiences and well-being of the individual is essential. Subsequent focus on the act of dwelling and associated verbs of architecture as well as the hierarchy of needs as way to explain behavior and motivations all stem from this position. The approach involves application of various methods and tools to address specific aspects of the design such as urban planning, climatological conditions, requirements, and implementation of common amenities etc.

The nature of the situation surrounding resettlement of IDP's means that the topic must be engaged both on a small and a large scale. Detailing of individual buildings therefore go hand in hand with the design of the urban environment. Design on a small scale with no regard for the experience of the surrounding environment may be detrimental, as is also the case with the opposite approach. These conditions illustrate the complexity of navigating within a design field where the scale is not defined beforehand.

The architectural proposal shown in Chapter 5 marks the culmination of efforts to design a continually developing settlement located near lake Baringo in the Rift Valley of Kenya. It consists of multiple clusters of 16 dwelling each, organized in the urban environment to indicate unique spaces within a larger whole. The principle of arrangement is inspired by fractal patterns in vernacular African architecture, adapted to create a scheme for expanding the settlement on a cluster-by-cluster basis.

The needs and requirement of inhabitants has informed the development of four unique typologies:

- *The Dwelling, providing a space to live, learn and thrive as a family, while also granting safety and security in its capacity as a shelter from the elements*

- *The Civic Center, embracing public amenities and becoming a hub for activities that can help bring people together across multiple communities*

- *The Water Post, offering a space within communities to gather informally, while housing functions that are vital to the operation of a settlement*

- *The Communal Bathhouse, accommodating sanitary functions in a dedicated building, maintaining a high standard of hygiene.*

Use of building materials widely available within reasonable distance of the chosen site has contributed to a smaller expected environmental impact than conventional housing. This was achieved through application of simulations and multi-objective optimization to generate the foundation for a comparative analysis. The results indicate possible directions for the design of structures, with parameters that included minimization of material usage.

Data
Data-collection has proven challenging, as sources often contradict each other when compared. Such is the case with climatological data, reported numbers of IDPs and espe-

cially material properties. These conditions have brought increased attention to proper acquisition of evidence from reliable sources, sometimes involving direct comparisons to determine the usefulness of the information provided. While this is a standard procedure in many project-based situations, the lack of familiarity with a subject necessitates additional literary studies to corroborate the findings.

The inconsistency or outright lack of data in some areas is a testament to the challenges that face many nations in different stages of socio-economic development. While Kenya is among the most developed East African Countries, it is still in the process of economic growth, with a detailed vision for the next ten years.

Perspective

The vision established, specifically for this project, addresses the initial problem and outlines the scope of the project. It is the culmination of many studies and investigations, but also represents a re-development of the position. The ambition to create a long-term solution to the problem reflects a decision made at a point during the process, which eventually framed the entire project in a new perspective.

It was necessary to decide whether a general scheme for settlement organization that could be implemented in any part of the world should be designed, or the project should be firmly rooted in a specific physical context. Rather than trying to consolidate the two wildly different approaches, the latter was chosen.

This choice has helped define what the project should be, which is ultimately reflected in the application of a context-sensitive design. However, the overarching concept of a community consisting of multiple neighborhoods each with their own spaces for gathering and accessing common amenities is applicable to other cases.

In the end, the project represents an effort to push the boundaries of what a settlement may be, and how the topic of internal displacement can be engaged with. A scheme and set of strategies is presented, inspired by the context, either physically or thematically.

Reflection

A Human Centered Design
The Human Centered Design position and accompanying approach that was adopted during the project represents an attempt at establishing a holistic methodology. The breadth and variety of theories applied here bear witness to the complexity of the subject matter. The different fields of study making up the theoretical background include not only environmental design, engineering and architectural theory, but also sociology, psychology, and phenomenology.

A variety of qualitative and quantitative evidence is brought forth which must be mediated with abstract concepts such as the experience of space, human motivation, and the notion of dwelling as a process that occurs on an individual and a collective level. It becomes necessary to establish a framework that allows the designer to navigate and prioritize these subjects accordingly. While some types of evidence lend themselves well to being quantified, others do not. The often-experiential aspects of architecture escape such an analysis yet are crucial to a discussion of the subject.

Methodology
For this project, the defined design drivers and design criteria are bridges not only between theory and practice, but also between the different types of information laid out in Chapter 2. Criteria describe specific goals that mirror conclusions from the initial analysis phase, whereas the drivers relate to conditions that cannot be measured. By being re-evaluated at different points during the project they remain relevant to the current stage of the process while at the same time influencing one another. Such is the case for example, when the ambition to design buildings that address the physical context of the site manifests in a criterion that describes the use of specific climate responsive strategies. Concurrent design development and evaluation of concepts is key to the methodology. Some of the studies have to precede certain design investigations in order to properly inform them and provide the necessary theoretical backing for establishing design drivers and subsequent criteria. However, a majority of the studies and investigations are performed simultaneously, with the latter influencing the former in equal measure. While they are presented in a separate chapter from the design process, they cannot be divorced from it.

The architectural proposal shown in Chapter 5 represents the culmination of several developments and discoveries made throughout the project. Each of the presented building typologies have undergone significant alterations as new information is obtained and applied. This is in accordance with the highly iterative nature of an integrated design process, wherein synthesis of ideas is conditioned by an analysis and a sketching phase that often overlap. While this procedure is a hallmark of the Integrated Design Process as presented by Professor Mary-Ann Knudstrup, it is also deeply embedded within the field of hermeneutics, which has contributed to a definition of the approach for the project.

Urban Layout
Like the individual buildings, the layout of the urban space has been the subject of an extended development before achieving its current form. The principle of fractal scaling observed in many traditional African villages was a source of inspiration, as it seemed to provide a system that could be steer design generation.

Adhering to strict mathematical rules became a hinderance however, as it posed arbitrary restrictions on the organization of individual buildings. It prompted a reassessment of the guiding principle of arrangement, which marks a significant turning point in the project. Generalized principles were abstracted, that maintained some of the qualities of fractal scaling, and could be adapted to the context without limiting other aspects of the architecture.

Project Scope

The Integrated Design Process is conditioned by an initial problem, and this method of framing the subject affects all aspects of a project. It can be argued that the Integrated Design Process is itself a "meta-design", an attempt at structuring the process behind what is being designed (Hillier et al.). What is presented is ultimately a response to the original problem. For this project it was necessary to restate the problem to better reflect the circumstances of an evolving scope. It has come to encompass other aspects of settlement planning and climate responsive design not considered initially. As a result, new design parameters have been implemented throughout the process.

From the onset focus had been on the design of a generalized scheme to accommodate several instances of internal displacement across different regions of the world. It was envisioned in the context of a Kenyan settlement where the urban scheme and building typologies would have been adapted to the context afterwards. However, as the project progressed it became evident that the environmental and psychological aspects of displacement had to be addressed more thoroughly. Thus the project was further situated in a specific location and a humanitarian crisis stemming from events occurring within.

This is a result of an increased focus in the early stages of the design process on the physical and thematic aspects of the subject. It has influenced personal aspirations as well as the articulation of design parameters, and potentially contributed to a radically different approach to the architecture.

What has emerged is an approach to designing emergency housing that is influenced by a long-term perspective. This marks an important distinction between the scheme that is developed in this project and that emergency camps often pictured when discussing the topic of displacement. It coincides with a rephrasing of the milieu created as a settlement and not merely a camp, implying a different temporal aspect. It also harkens back to the act of settling in relation to the philosophical topic of being and dwelling.

The principles of organization and construction reflect these circumstances. Rather than following the grid-structure often associated with camps which stress optimization of the available area, the layout emphasizes the experience of a continually developing settlement. Some spaces cater to individual communities while others are shared by a larger group of people, which may be seen as an embodiment of the collective and communal modes of dwelling. The atmosphere and the character of the environment also indicate a long-term perspective, with buildings that communicate a greater permanence and relation to the site through its materiality.

In the end, the project demonstrates an ambition to harness skills and apply it to address a specific problem deeply rooted in the context, through an architectural proposal. The scale of the settlement and approach adopted for the design development attests to the many factors that must be considered. Consequently, some elements have been designed meticulously, while others are more conceptual in nature. Such is the case for the transition period from an emergency phase and the long-term housing scheme presented in this project. Likewise, distribution and treatment of water and waste as well as supply of electricity is outlined through principles, rather than explicit solutions. The parameters above may well be projects unto themselves. What is presented in this project demonstrates an approach to architecture where individual experience, climate responsive design and the communal aspects are equally important. The group has aspired to create holistic architecture that can accommodate the needs of displaced persons while suggesting a new way to develop long-term settlements.

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Illustrations

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APPENDICES

Appendix 01

Urban structure numbers

Composition	Avarage length	Std. length	Bounding area	Std. area
1-A	44,40	2,71422	2490,00	-0,2887
1-B	26,10	0,16516	2660,00	-0,1042
2-A	37,40	1,73917	1980,00	-0,8421
2-B	20,70	-0,587	1962,00	-0,8617
3-A	21,90	-0,4199	2304,00	-0,4905
3-B	21,70	-0,4477	2544,00	-0,2301
4-A	22,10	-0,392	2500,00	-0,2778
4-B	22,10	-0,392	2500,00	-0,2778
5-A	26,10	0,16516	5244,00	2,70009
5-B	22,10	-0,392	3365,00	0,66091
6-A	21,00	-0,5452	2907,00	0,16387
6-B	27,50	0,36017	4256,00	1,62787
7-A	18,30	-0,9213	2024,00	-0,7944
7-B	17,40	-1,0467	1848,00	-0,9854

Length	
Avg	24,91
Std.deviation	7,179122

Area	
Avg	2756,00
Std.deviation	921,4514

Urban structure
Values from the urban structure investigation. Normalized to easier compare

Appendix 02

Thermal	Thermal conductivity	Specific heat capacity	Density	Thermal mass parameter
Unit	W/mK	J/kg*K	kg/m^3	
CEB	1,1	1150	2000	2,3
HCB	1,95	1000	2000	1,6
Bamboo	0,83	1700	500	0,85
Timber	0,14	1200	390	0,46
Rebar	45	480	7800	3,74

Strength	Compressive	Bending	Tensile	Shear	Elastic modulus
Unit	MPa	MPa	MPa	MPa	MPa
CEB	12				2500-3000
HCB	10,2				8000
Bamboo	79	194	207	9,9	18000
Timber	21	24	14	4	11000
Rebar	500	500	500	81000	210000

LCA	GWP	Availability in region
Unit	kg CO2 eq / kg	
CEB	0,005	Can be produced on site or close by
HCB	0,24	Can be produced in adjacent counties
Bamboo	-6,16	Available in adjacent county
Timber	-1,44	Available in county
Rebar	0,52	Can be produced in Kenya

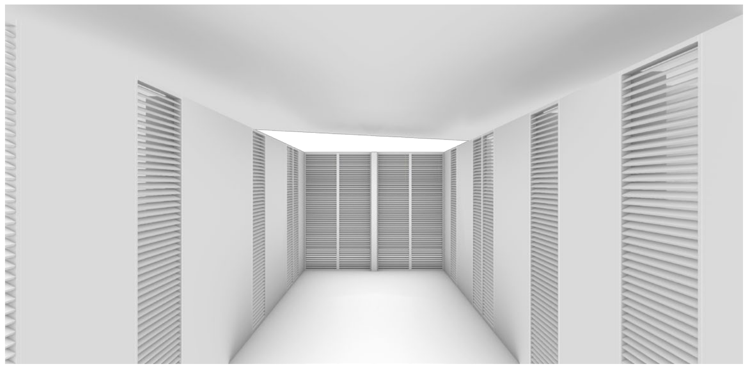
Material properties

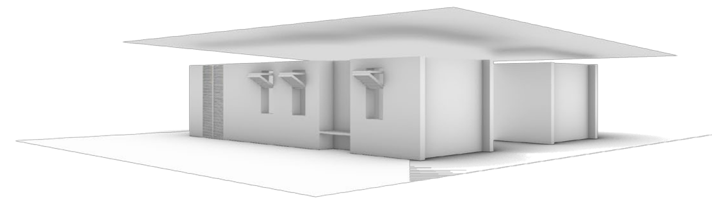
Material properties values, used in the descision process.

Appendix 03

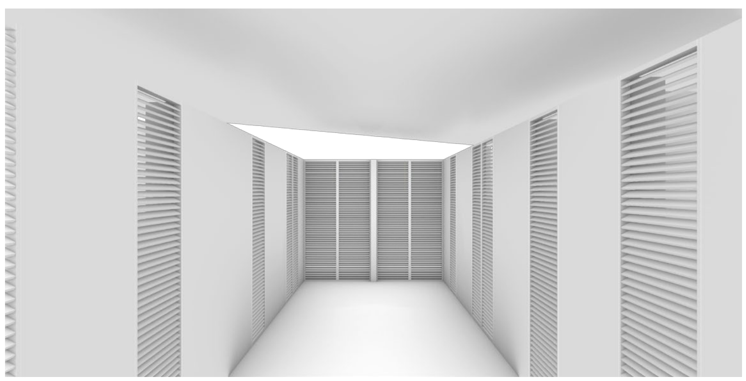
Roof angle investigation
Investigation on how the inclination of the roof affects the apperance of the house and veranda space

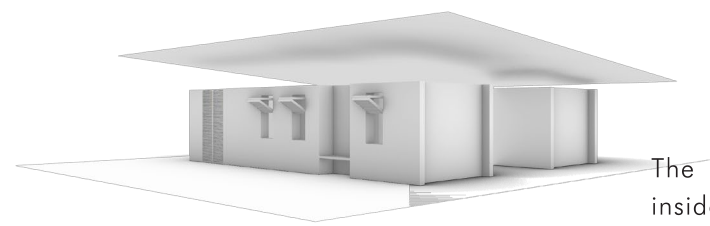
The house seen from the inside and outside with a 3 degree inclined principled roof.



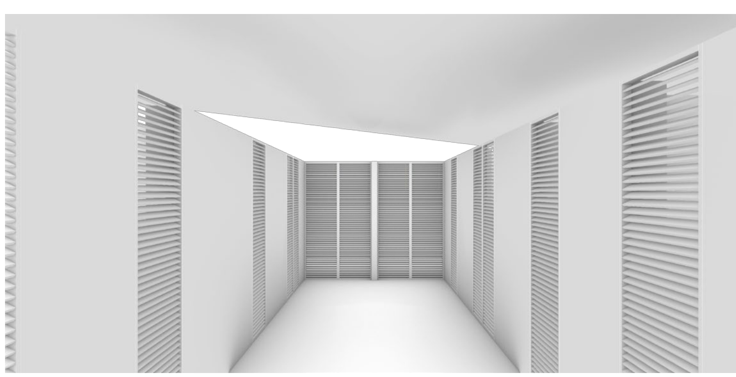


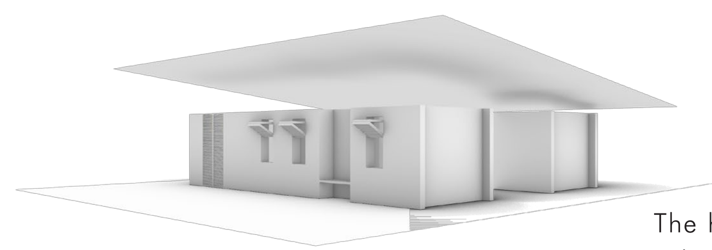
The house seen from the inside and outside with a 5 degree inclined principled roof.



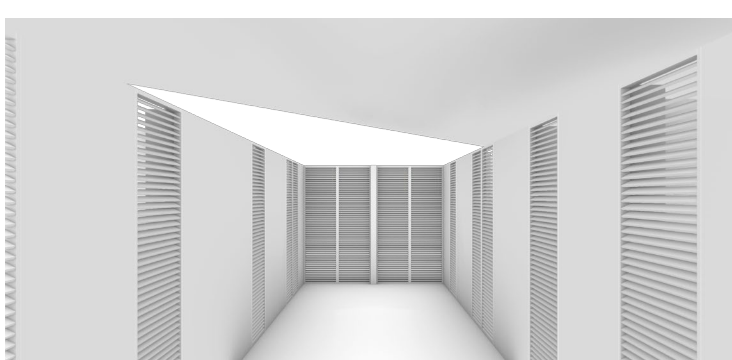


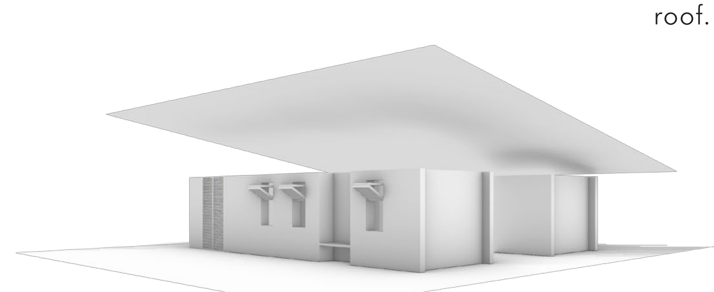
The house seen from the inside and outside with a 7 degree inclined principled roof.





The house seen from the in-side and outside with a 10 degree inclined principled roof.





Appendix 04

Roof structure investigation

Results from the simulation and optimization of the roof structure calculated in Karamba3D.

Roof structures

	2D				3D			
Roof	Flat	Slanted	Saddle	Butterfly	Flat	Slanted	Saddle	Butterfly
Utilization	0,26	0,30	0,19	0,19	0,22	0,12	0,26	0,45
Mass (kg)	314,50	322,20	370,50	693,10	402,98	392,75	737,79	7524,24
Material	Bamboo	Bamboo	Bamboo	Bamboo	Bamboo	Bamboo	Bamboo	Steel
GWP	-1937,32	-1984,8	-2282,3	-4269,5	-2482,3568	-2419,34	-4544,7556	3882,5078

Appendix 05

Roof structure continued

Calculation of truss division of the four structures.

2d final structure analysis

	House			Community			Waterpost			Washhouse		
Division	6	8	10	8	12	16	5	6	7	4	6	8
Mass [kg]	41,72	43,26	45,26	48,73	53,1	58,3	44,51	45,74	47,19	23,48	25,49	26,57
Displacement [cm]	2,91	2,63	2,55	1,92	1,69	1,61	6,79	10,38	13,44	0,51	0,98	1,47

Appendix 06

Roof aperture investigation results

Results from the roof aperture investigation, showcasing the small difference between the different roofs.

Lux and radiance

Roof	Flat	Slanted	Saddle	Butterfly
Lux (lx)	1558	2089	1689	1628
Radiance (kWh)	4880	5571	4521	4521

Appendix 07

Material propoties for simulation

The thermal propoties for materials used in the thermal simulations.

Material values for thermal simulations

		CEB	Wattle and Daub	Insulation
Conductivity	[W/m-K]	1,2	0,83	0,432
Density	[kg/m3]	2080	1180	91
Specific heat	[J/kg-K]	837	1090	837

Appendix 08

Beregning af vindtryk

Beregning af vindtryk I henhold til EN 1991-1-4

Årstidsfaktor	$c_{års}^2$	1	-
Retningsfaktor	c_{dir}^2	1	-
Grundværdi for basisvindhastighed	v_{b0}	45	m/s
Basisvindhastighed	$vb = c_{års} * c_{dir} * v^{b0}$	45	m/s
Luftens densitet	ρ	1,25	kg/m^3
Basishastighedstryk	$qb = 1/2 * \rho * v_b^2$	1265,63	N/m^2

Terrænkategori		3	
Ruhedslængde	z0	0,3	-
Minimumshøjde	zmin	5	m
Terrænfaktor	kr	0,215	-
Designhøjde	z	3,2	m
Ruhedsfaktor	cr = kr * ln(z/z0)	0,51	
Topografifaktor	c0	1	-
Middelvindhastighed	vm = cr * c0 * vb	22,9	m/s
Turbulensintensitet	Iv = 1/(c0 * ln(z/z0))	0,42	-
Konstruktionsfaktor	cscd	1	-
Karakteristisk hastighedstryk	$qp = cscd*[(1+7*Iv)*1/2*\rho*v_m^2]$		
		1,297	kN/m2

ρ

Calculation of wind pressure

Calculations for wind pressure for structural analysis of the roof and truss structure. Calculated in accordance with EN 1991-1-4

Appendix 09

Flat roof

Zone	Factor	Windload
A	0,5	0,65
B	1,8	2,33
C	1,1	1,43

Sided roof

0-5 degrees

Zone	Factor	Windload
A	0,5	0,65
B	0,8	1,04
C	1,1	1,43

6-10 degrees

Zone	Factor	Windload
A	0,8	1,04
B	2,1	2,72
C	1,3	1,69

Pitched roof

0-5 degrees

Zone	Factor	Windload
A	-0,6	-0,78
B	-0,7	-0,91
C	-0,9	-1,17
D	-1,1	-1,43

6-10 degrees

Zone	Factor	Windload
A	-1,8	-2,33
B	-1,8	-2,33
C	-1,9	-2,46
D	-1,9	-2,46

11-15 degrees

Zone	Factor	Windload
A	-1,3	-1,69
B	-1,4	-1,82
C	-1,4	-1,82
D	-1,5	-1,95

16-20 degrees

Zone	Factor	Windload
A	-0,4	-0,52
B	-0,4	-0,52
C	-0,4	-0,52
D	-0,4	-0,52

Butterfly roof

0-5 degrees

Zone	Factor	Windload
A	-0,8	-1,04
B	-0,6	-0,78
C	-0,6	-0,78
D	-0,6	-0,78

6-10 degrees

Zone	Factor	Windload
A	-1,6	-2,08
B	-1,5	-1,95
C	-1,4	-1,82
D	-1,5	-1,95

11-15 degrees

Zone	Factor	Windload
A	-0,8	-1,04
B	-0,8	-1,04
C	-0,7	-0,91
D	-0,6	-0,78

16-20 degrees

Zone	Factor	Windload
A	-1,7	-2,21
B	-1,4	-1,82
C	-1,1	-1,43
D	-0,8	-1,04

Calculation of wind pressure

Zone factor calculations for roof structures. Calculated in accordance with EN 1991-1-4

Appendix 10

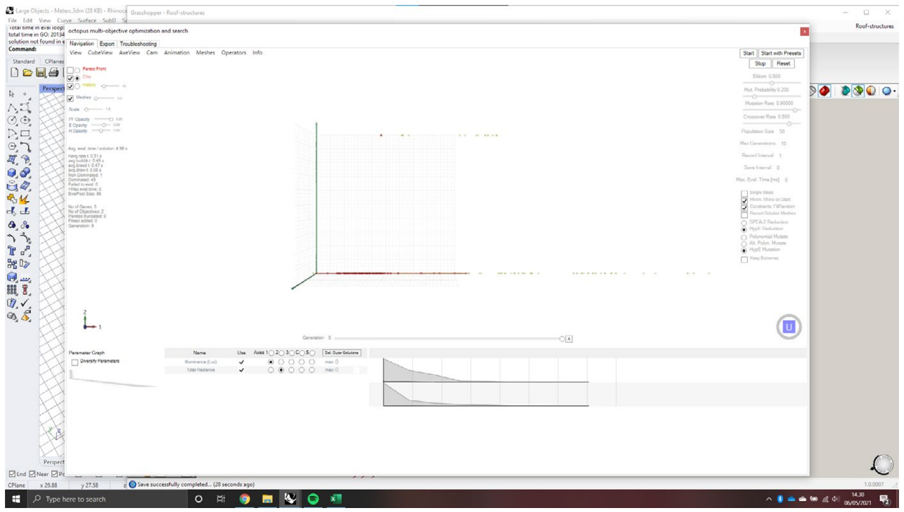
Incident Radiance analysis on heavy walls

		1	2	3	4		Average		4 (altered)	
Area	Plan	55,4	58,1	68,3	66,8	[m2]				
Roof										
1	Total	21221	21993	20964	18063	[kWh]	20560	[kWh]	17505	Parapet
	/m2	383	379	307	270	[kWh/m2]	335	[kWh/m2]	262	
2	Total	21781	22836	21509	19512	[kWh]	21410	[kWh]		
	/m2	393	393	315	292	[kWh/m2]	348	[kWh/m2]		
3	Total	17480	19639	18962	17753	[kWh]	18459	[kWh]	23981	Hole in the middle
	/m2	316	338	278	266	[kWh/m2]	299	[kWh/m2]	359	
4	Total	21509	24568	25472	22797	[kWh]	23587	[kWh]		
	/m2	388	423	373	341	[kWh/m2]	381	[kWh/m2]		
Average	Total	20498	22259	21727	19531	[kWh]				
	/m2	370	383	318	292	[kWh/m2]				

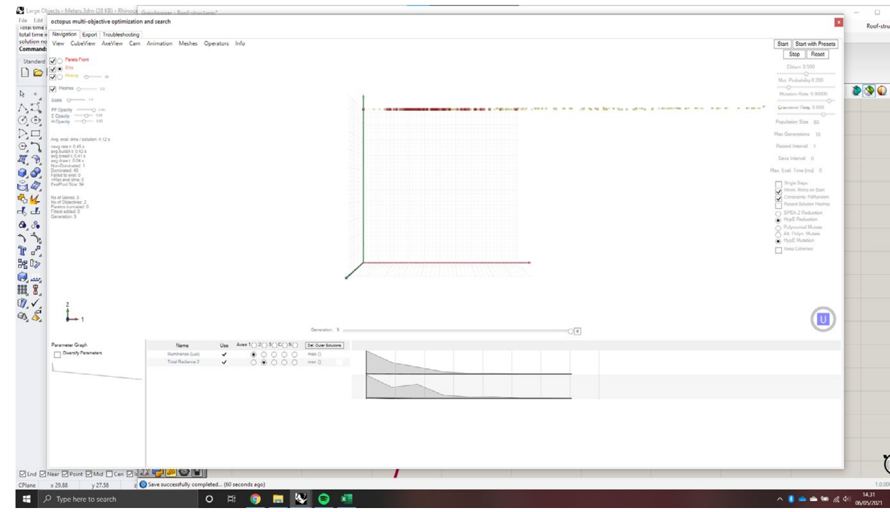
Incident Radiance on heavy wall investigation

Values from the incident radiance calculation used in the Solar Incidence section in Design Process

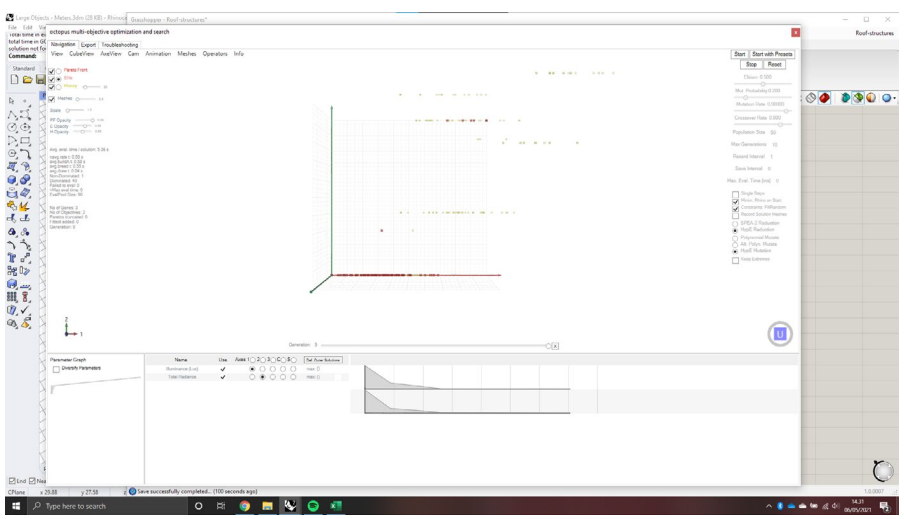
Appendix 11



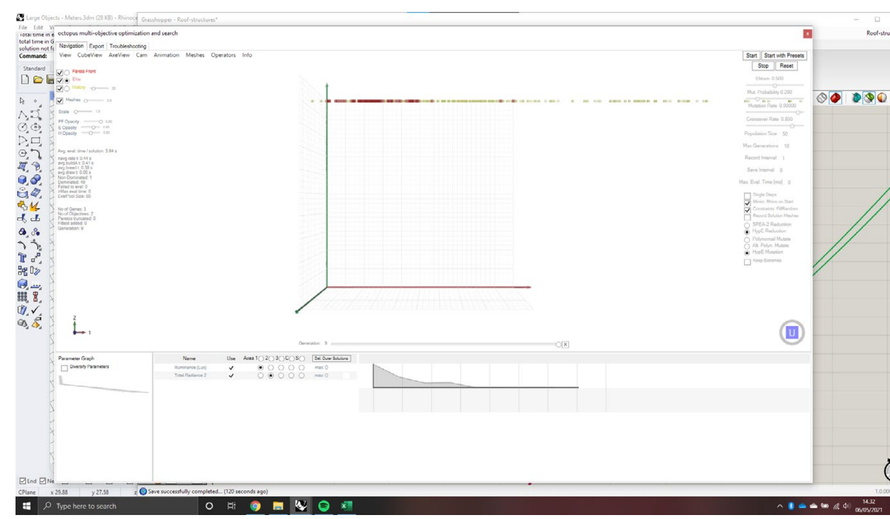
Flat roof



Slanted roof



Saddle roof



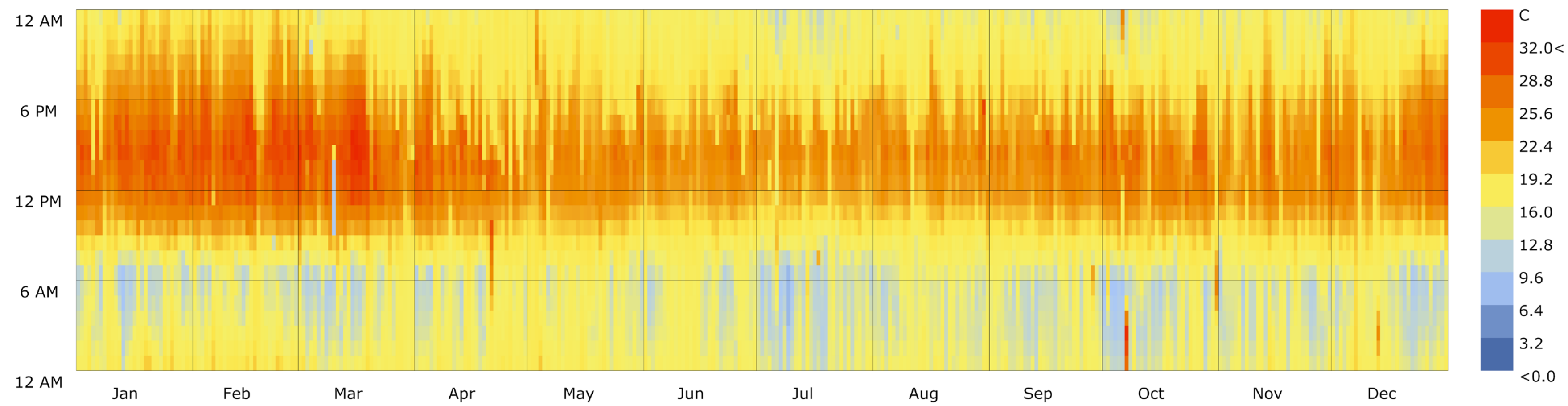
Butterfly roof

Roof aperture optimization

Screenshots from Octopus multi-objective optimizer

X-axis: Radiance [kWh]; Y-axis: Daylight[Lux]

Appendix 12



Width

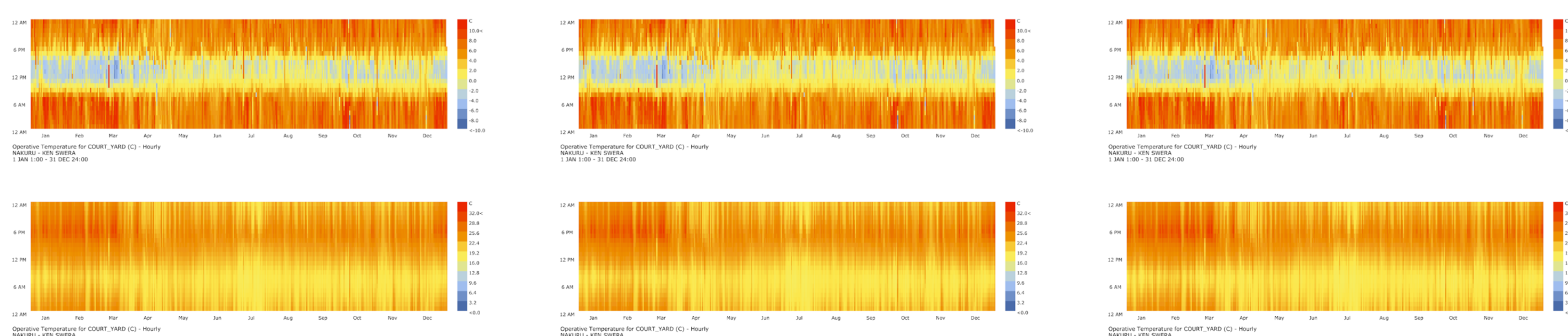
CEB Insul.
Courtyard: 2m width

CEB Insul.
Courtyard: 4m width

CEB Insul.
Courtyard: 6m width

Delta Temp.: Courtyard and outside

Courtyard temp



Simulation graphs-Width

Simulation results from the investigation on how the width would affect the thermal comfort of the courtyard space. X-axis: Months; Y-axis: Hour; temperature legend at the right of the graph

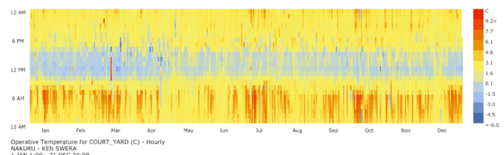
Change of the enclosure

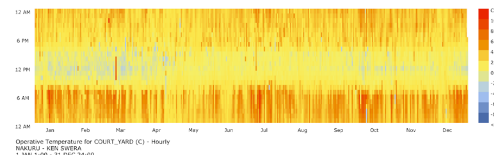
CEB Insul.
Nat. vent.
Open i both ends

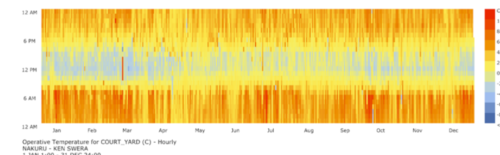
CEB Insul.
Nat. vent.
Closed in one end

CEB Insul.
Nat. vent.
Closed courtyard

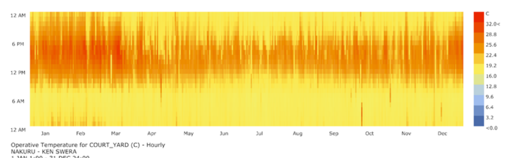
Delta Temp.: Courtyard and outside

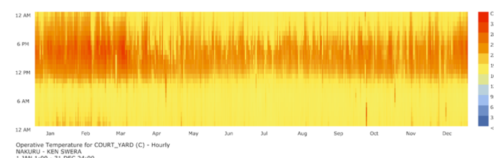


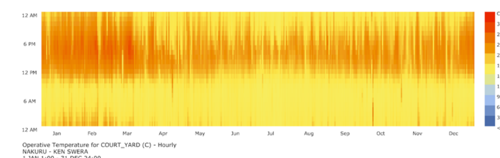




Courtyard temp







Simulation graphs-Change-of-Enclosure

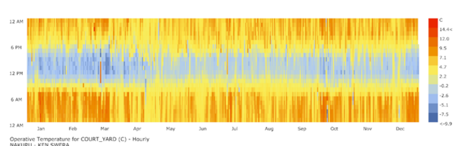
Simulation results from the investigation on how the enclosure of the courtyard space would affect the thermal comfort. All simulations have included principled natural ventilation calculated by Honeybee to ensure wind flux.
X-axis: Months; Y-axis: Hour; temperature legend at the right of the graph

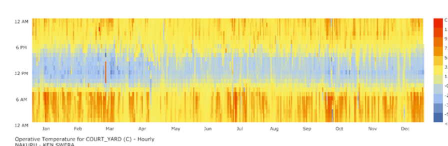
No ventilation
Closed courtyard

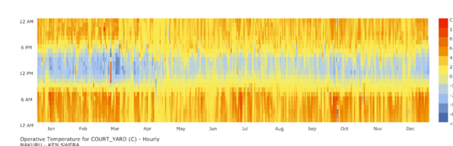
Natural ventilation
Closed courtyard

Natural ventilation max 20 degree
Closed courtyard

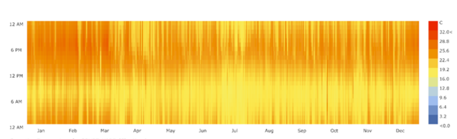
Delta Temp.: Courtyard and outside

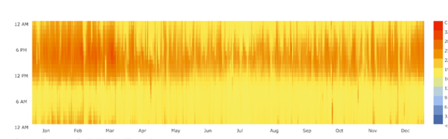


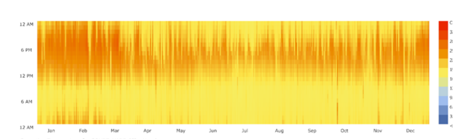




Courtyard temp





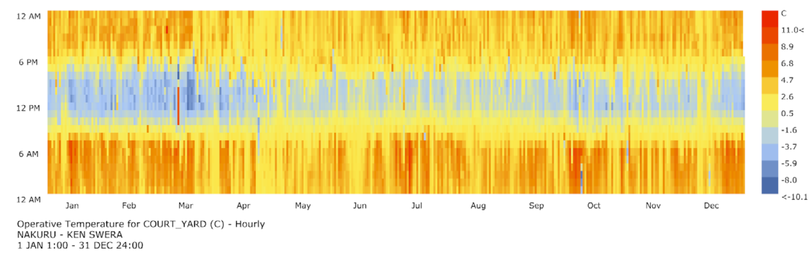


Simulation graphs-Ventilation

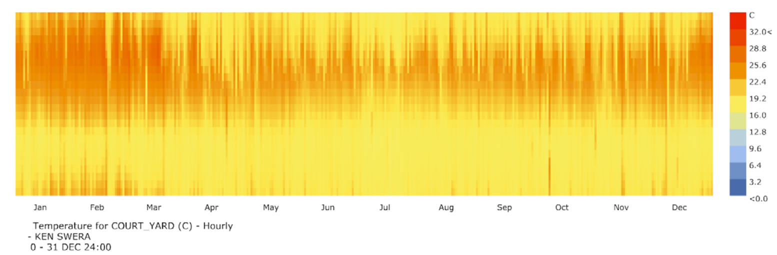
Simulation results from the investigation on how different ventilation strategies would affect the thermal comfort of the courtyard space.
X-axis: Months; Y-axis: Hour; temperature legend at the right of the graph

Natural ventilation max 20 degree
Closed courtyard

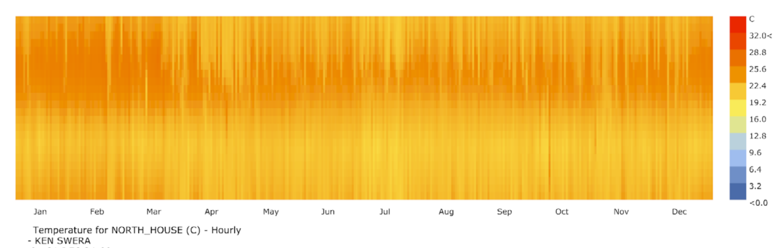
Delta Temp.: Courtyard and outside



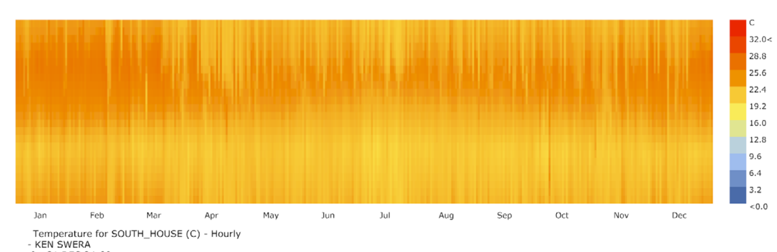
Courtyard temp



North house



South house

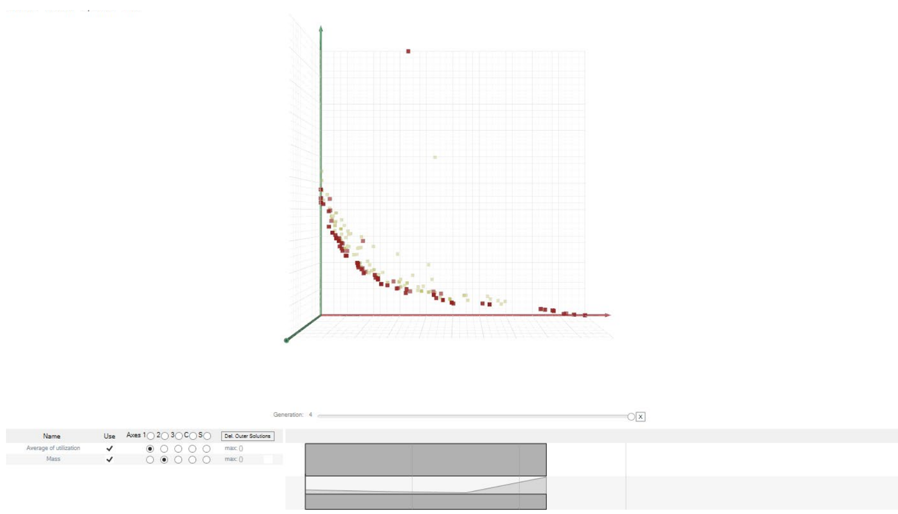


Simulation graphs-House

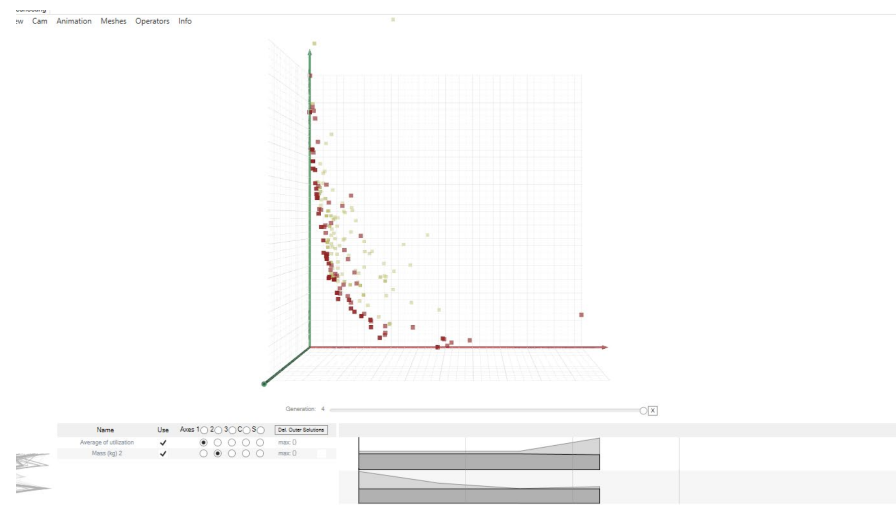
A simulation including the two zones which functions as the closed spaces of the house. It is clear that the temperature in the rooms keep a steady level with little temperature difference day and night. The zones have not been in focus.
X-axis: Months; Y-axis: Hour; temperature legend at the right of the graph

Ill. 153: Urban fractals

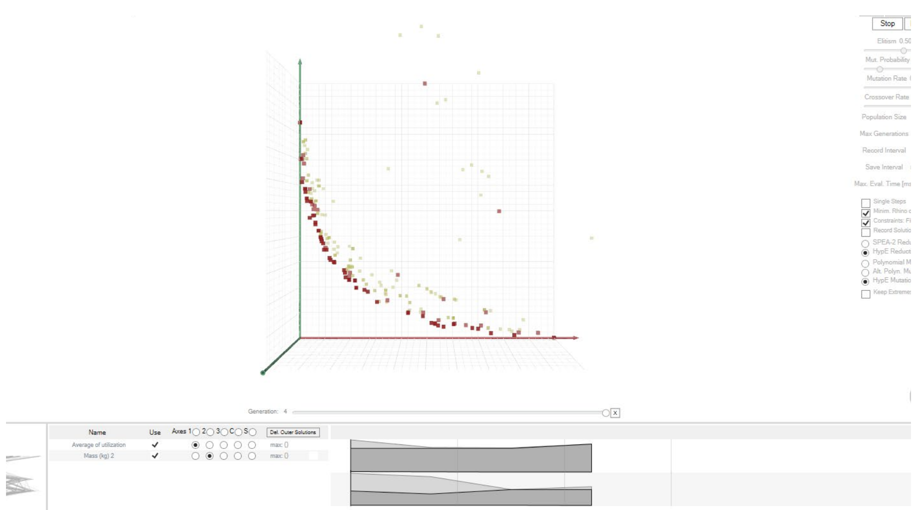
Appendix 13



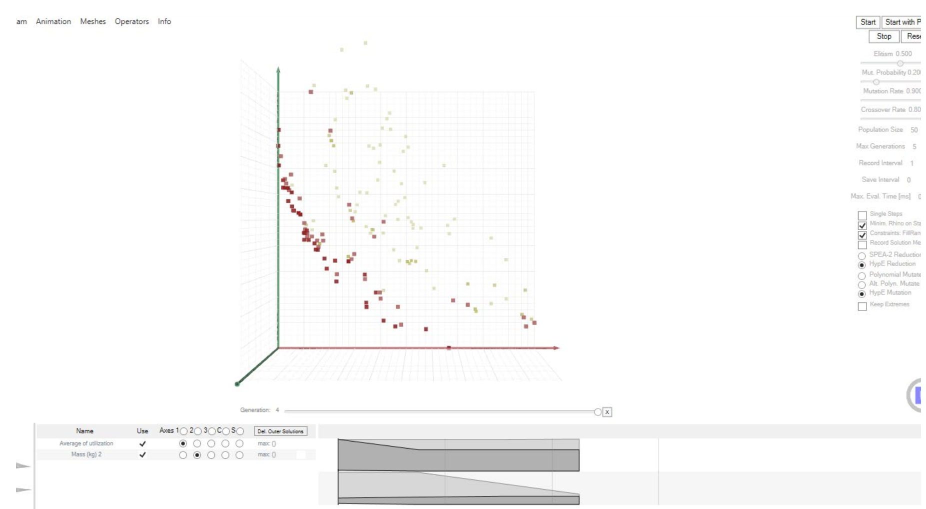
2D flat roof - Pareto front



2D slanted roof - Pareto front

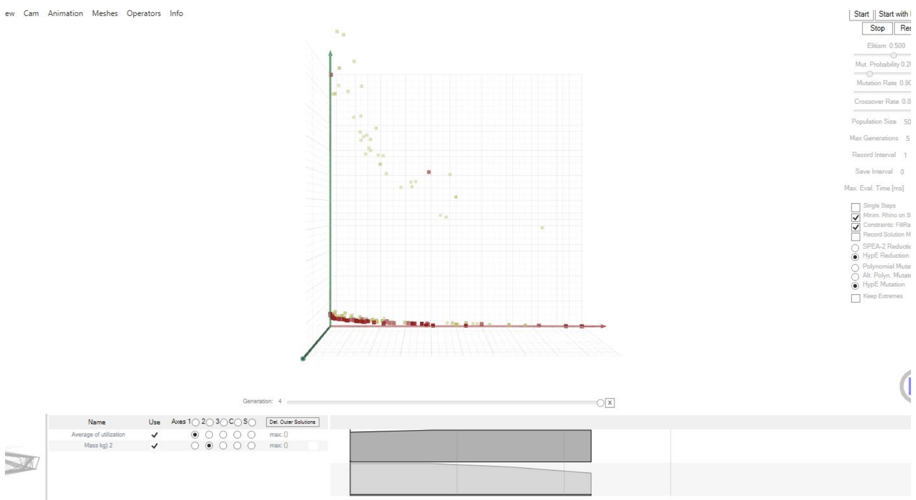


2D saddle roof - Pareto front

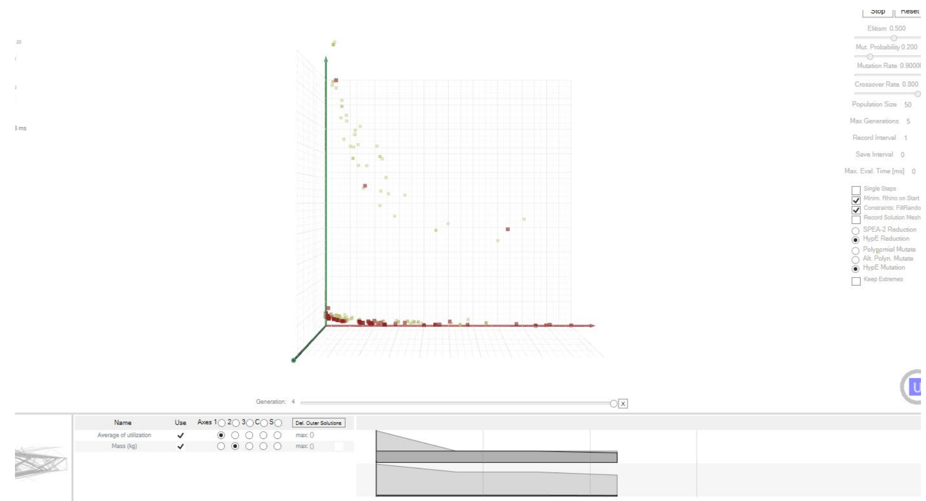


2D butterfly roof - Pareto front

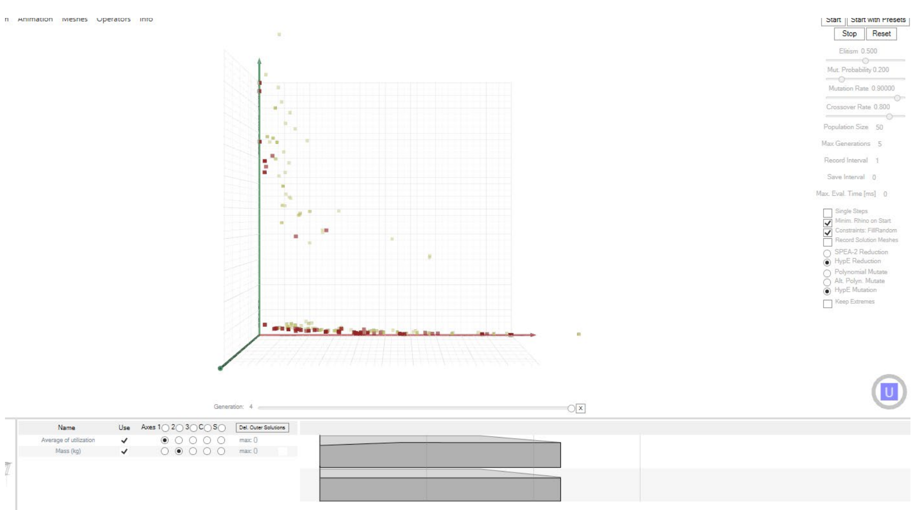
Initial truss calculation - 2D
Screenshot from Octopus multi-objective optimizer show-casing the pareto-front when optimizing between mass and displacement.



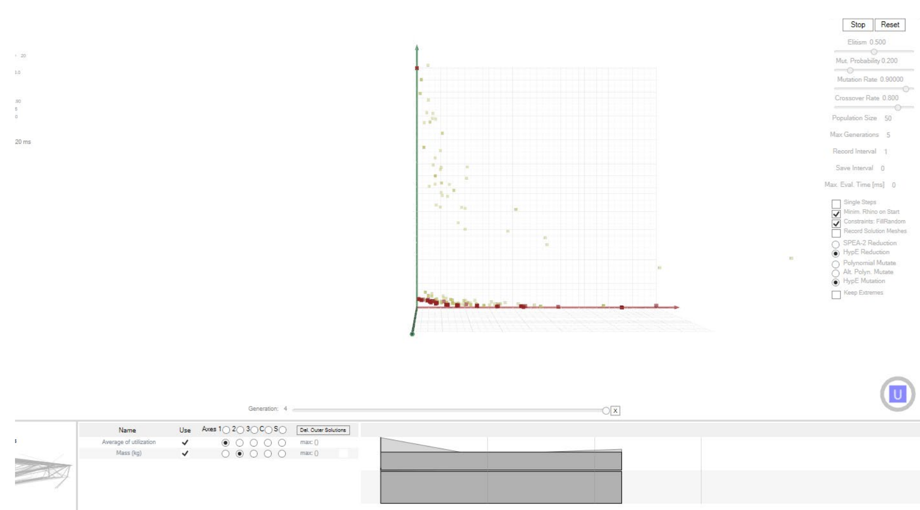
3D flat roof - Pareto front



3D slanted roof - Pareto front



3D saddle roof - Pareto front

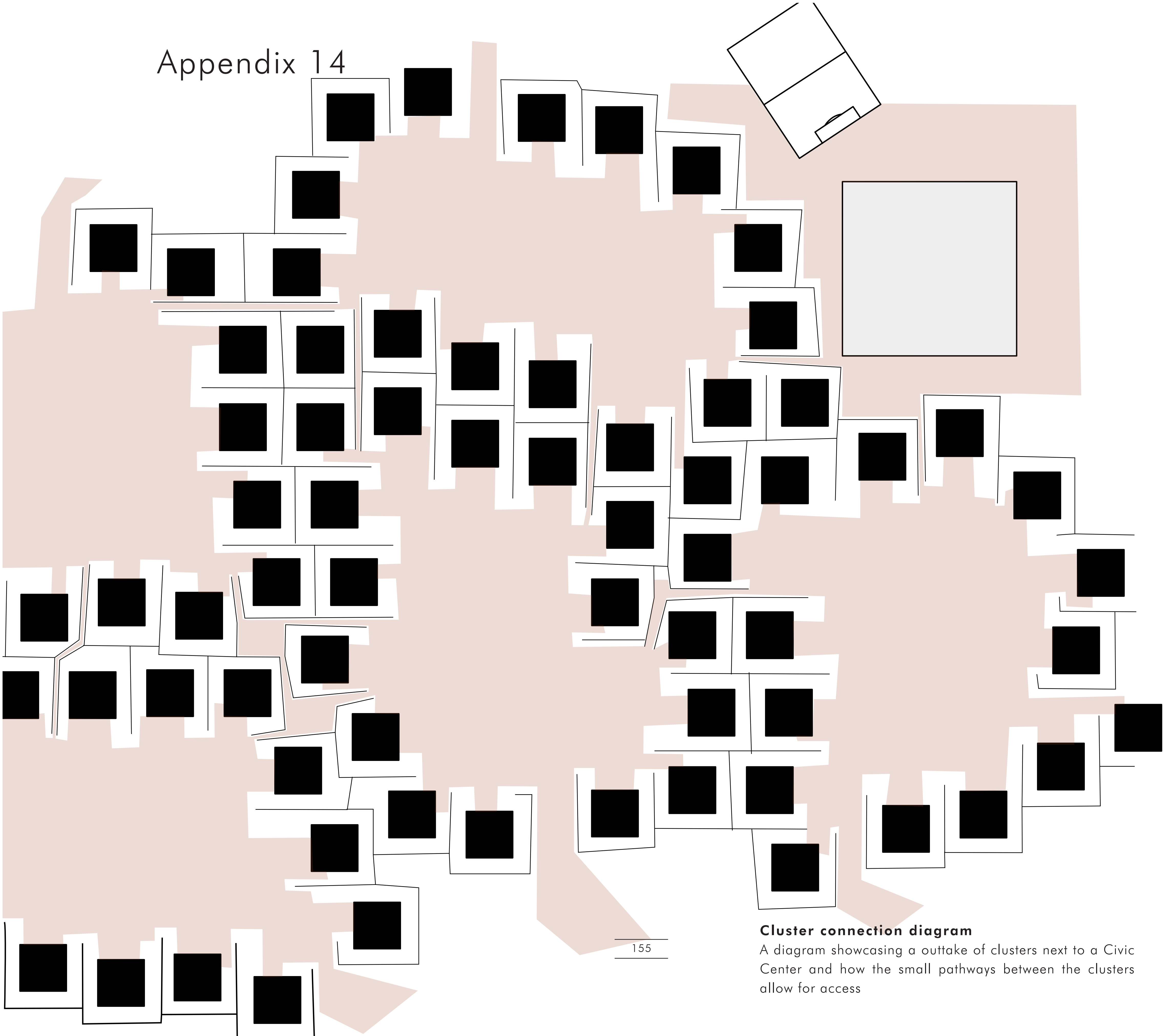


3D butterfly roof - Pareto front

Initial truss calculation - 3D

Screenshot from Octopus multi-objective optimizer showcasing the pareto-front when optimizing between mass and displacement.

Appendix 14



Cluster connection diagram

A diagram showcasing a outtake of clusters next to a Civic Center and how the small pathways between the clusters allow for access