Waste as Resource

Recycling Housing Components in the informal
settlement of Kibera, Nairobi, Kenya

by
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A thesis
presented to the University of Waterloo
in fulfillment of the
thesis requirement for the degree of
Master of Architecture

Waterloo, Ontario, Canada, 2023
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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

Amidst rapid urbanization, large self-built settlements such as Kibera in the capital city of Nairobi, Kenya, confront numerous environmental crises like flooding, alongside critical issues like limited nutrition, overall stability, inadequate access to potable water and essential services. Despite the challenges, the people of Kibera have demonstrated innovative practices by recycling waste and utilizing unconventional materials in their daily lives. Given the substantial movement of people and material within the settlement, this study proposes to augment architectural resilience that responds adeptly to these dynamic conditions.

This thesis focuses on investigating the materiality systems of Kibera to develop strategies that integrate architectural resilience within the informal urban fabric and its dwellings. Documentation methods such as using photographs and other digital media have been employed to effectively map the existing construction methods in neighborhoods in Kibera and highlight its distinctive features. Centering material reuse cycles and adopting a cradle-to-cradle approach, this research seeks to establish a recycling economy framework that addresses waste disposal and various stages of material usage within the settlement.

Most current building practices often result in the depletion of valuable resources, which are frequently discarded in landfills, contributing to climate crises and exacerbating rural-to-urban migration patterns. Through an in-depth exploration of discarded materials in Kibera, this thesis proposes a comprehensive and inclusive design strategy addressing multiple scales – collective, urban, individual,and semi-private, to provide better access to materials and facilities for constructing these assemblies. Envisioning a multi-faceted recycling and community centre, it aims to inspire future development while better meeting the infrastructural needs of Kibera's residents.

Acknowledgements

I extend my heartfelt gratitude to Marie-Paule Macdonald, my dedicated supervisor, for her unwavering guidance and support throughout my time under her tutelage. I am equally thankful to David Fortin, whose insightful feedback greatly enriched my work, as well as to Di Tang and Ronald Omyonga for their valuable contributions as committee members. My sincere appreciation also goes to Philip Beesley and Anwar Jaber for their belief in my initial research concepts and for pushing me to excel.

The enlightening discussions I've shared with numerous school owners in Kibera have profoundly deepened my comprehension of the area. I am indebted to them for generously sharing their time, knowledge, and experiences.

Lastly, I couldn't have reached this point without the unwavering encouragement and support of my friends, roommates, and family. Your presence, talks, and belief in me have been my driving force. Thank you, everyone, for being there when I needed you the most.

Dedication

To my Mother, and family, for being my constant pillars of support and love.

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Introduction

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1.1   Introducing the Problem

The escalating concern regarding construction waste, which currently accounts for 30% of the world's total waste,[1] has become a pressing issue as urbanization continues to reshape our global landscape. The construction industry, in great demand in today's rapidly urbanizing world, brings with it a substantial risk to the environment, necessitating a profound re-evaluation of our infrastructure practices. It is crucial to find innovative ways to utilize waste materials in new construction, giving waste a renewed purpose and combating the climate crisis.

Our lifestyle and consumption habits profoundly impact how we perceive and handle waste. Irresponsible dumping, improper sorting, and waste exportation from Western countries to low-income countries exacerbate the detrimental impact on the global ecosystem.[2] These practices have contributed to the emergence of settlements born out of an economic system, capitalism, which is failing the middle and working-class citizens in cities worldwide. Despite these challenges, the marginalized and often overlooked communities demonstrate remarkable creativity in addressing waste management on a smaller, local scale. Despite their economic limitations, resource scarcity, lack of formal education, jobs, and prior experience, their practices offer valuable lessons for the future.[3] Many individuals in these communities sustain themselves through waste-based economies and home-grown businesses, showcasing intricate resilience despite unreliable income.

These unique communities prompt us to question how they seamlessly incorporate recycling initiatives into their informal fabric. What prevents these communities from thriving in better conditions despite the influx of materials? The role of architecture becomes vital in proposing efficient and effective designs that allow for easy adaptation by these communities. This thesis aims to explore the appropriate use of recycled waste within this settlement and develop architectural proposals that facilitate their integration, fostering a more sustainable environment for all.

1.2   Patterns of Sprawl in Africa

Urban sprawl, a significant phenomenon in many African cities, exhibits distinct narratives compared to developed regions such as North America and Europe. Each case of urban sprawl has its own unique fabric that has developed spontaneously over time. The phenomenon of urban sprawl in Africa can be a combined effort of the interplay of population growth, socioeconomic dynamic, and urbanization patterns across the continent. Starting from the late 1960s and early 1970s, the rapid urbanization rates observed in many African cities became the object of scholarly interest in understanding spatial structure and patterns of urbanization.[4] This lead to understanding the urbanization process in Africa and its consequences for the proliferation of informal, improvised settlements and their occupants in African cities.

AAs outlined in R.A. Obudho's book, *Slum and Squatter Settlement in Sub-Saharan Africa*, Africa remains the least urbanized continent. Its population has experienced a notable increase in the past two decades, rising from 4.4% to 5.1%, which is twice the global average.[5] The rapid changes to spatial structures in most African cities often lead to the expansion of urban peripheries without any predetermined planning, driven specifically by rural exodus, and the proliferation of informal settlements. This ultimately results in inefficient land use, lack of basic services and longer commuting distances.[6] More than 30% of the population in many countries in Africa lives in such in-habitable conditions as a result of migration and increasing demand for housing in and around the major cities. This trend increased dramatically, in the post-colonial era as housing construction lagged, failing to meet the needs of the population influx seeking educational and employment opportunities due to its sluggish pace.[7]

As Amis Llyod writes in his book *Housing Africa's Urban Poor* , rural-urban migration was inevitable, regardless of the pursued policies. Policymakers acknowledge the unauthorized settlements as stakeholders in the city-making system at last.[8] The spatial segregation between communities in these unplanned urban sprawls intensifies social inequalities and restricts access to essential services and infrastructure for marginalized populations. Moreover, it depletes environmental resources such as agricultural land and leads to ecological insensitivity, biodiversity loss, and other related issues. The housing crisis and property ownership challenges have left a significant portion of the population in a vulnerable situation, hindering their ability to access government benefits and secure their own living spaces. Consequently, various African governments have implemented schemes that offer serviced plots for low-income new migrants to construct their own houses with proper materials in conditions of urban sprawl.[9] These African governments also provide existing informal homeowners with tenure security and improvements for their dwellings.

Understanding the patterns of urban sprawl within the African context is crucial for

developing a holistic approach that considers social, economic, and environmental factors. Achieving this requires the equal contribution and collaboration of various field experts, such as urban planners, policymakers, and other stakeholders, to devise an all-inclusive urban strategy that fosters sustainable and resilient cities. Several architects, including Koolhaas at Harvard University and Herzog & De Meuron at ETH Studio, have shown interest in various African cities.

Koolhaas analyzed African cities through a postcolonial lens, uncovering what he referred to as a "postcolonial impulse." His project with Harvard University students focused on Lagos, exploring categories like "property," "line," and "wall" as part of urban mutation, and delving into concepts like secondhand markets.[10] His interpretation of these ideas through filmography sparked both acclaim and criticism. Following Koolhaas' growing interest, other architects such as Herzog & De Meuron turned their attention to the rapidly expanding city of Nairobi, initiating collaborative studies with ETH Studio Basel. They saw the capital city as a potential hub for global exchange of ideas and communication.[11]

Both projects were carried out in close collaboration with local experts to avoid imposing a Western perspective. Documenting the settlements through photographs and statistics, these studios detailed the theories of these genetic cities, generating increased interest in African urban formations. An interdisciplinary approach can now delve deeper into exploring the uncharted aspects of these cities. Initiating a bottom-up approach is essential for their future development and prosperity.

1.3   Positioning

Informal Settlements are a widespread phenomena found around the world, but they are prevalent in the global South. They represent complex and vibrant urban landscapes that emerge as a result of rapid urbanization, migration, and economic disparities.[12] Personally, I hail from Mumbai, the financial capital of India, which is experiencing extensive growth and is home to Asia's largest settlement, known as "Dharavi".
Mumbai, characterized by its bustling population and intricate social fabric, struggles with resource degradation and challenges in material management. However, Dharavi stands as a remarkable example of the adaptive resilience of informal settlements. It has emerged as a thriving neighborhood that embraces waste as a valuable resource, engaging in recycling, reprocessing, and upcycling activities to create a range of useful products.[13] As a resident living in close proximity, I have witnessed its growth and evolution over the past decade. The settlement has become a hub of innovation and creativity, particularly for plastic waste. It has transformed into a very functional and circular economy within an informal context.[14] Dharavi stands as a striking example of "architecture without architects," much like other squatter settlements that embrace the power of vernacular aesthetics in their effective

incremental housing approach.[15]

Driven by my curiosity about Dharavi's dynamics, I undertook a broader exploration of similar settlements worldwide. My research unwrapped diverse examples such as Kibera in Kenya, Johannesburg in South Africa, Lagos in Nigeria, and Caracas in Venezuela[16]. These settlements have attracted scholarly attention and artistic approaches in numerous disciplines. These informal settlements with their adaptive strategies have challenged the notions of urban planning.

In Latin America, where government leadership is often lacking, designers from Caracas have taken an entrepreneurial approach, generating theoretical projects and funding their own initiatives in collaboration with non-governmental and community-based organizations.[17] They have devised elaborate and well-conceived plans for upgrading the entire San Rafael-Unido neighborhood and implementing urban façade projects. Policymakers have taken notice of their potential, exploring alternative approaches to infrastructure and global problems.

By utilizing waste materials in creative ways, employing innovative construction methods, and supporting community-led initiatives, these settlements offer opportunities to address pressing issues like housing shortages, environmental sustainability, and social equity. The dynamic strategies of these informal settlements pave the way for reimagining urban development and fostering a more inclusive and sustainable future.

Among the various settlements I explored, Kibera, as the largest informal settlement in Africa, has particularly fascinated me. It has countless possibilities and strengths, showing an impressive ability to be creative with limited resources. Kibera's lively energy and flexible use of materials match well with what I personally am interested in and what I aim for in architecture. In my thesis, I want to study Kibera and understand how they use materials to create and maintain their living spaces.

By learning about informal settlements and what makes them innovative, I now have a better understanding of the different types of cities that exist outside of official planning methods in most western and developed countries. These formal approaches to development often cannot be directly applied to contexts in the Global South. Conversely, informal settlements in the Global South challenge us to rethink urban development, emphasizing the importance of participatory approaches, inclusive policies, and the recognition of the intrinsic value within informal economies.

1.4   Kibera

Kibera, situated in the capital city of Nairobi in Kenya, has a history rooted in urbanization and social dynamics. It originated in 1912 as a temporary settlement for Nubian soldiers during the colonial era.[18] Soldiers with consistent dedication to the railway and infrastructure development for more than twelve years were allotted a plot in Kibera on their discharge. However, their detribalized status prevented them from any formal rights on the land, which resulted in the ambiguous land use in Kibera eventually getting developed into the biggest informal settlement in the African continent.[19]

Initially with a population of 2,000 Nubian inhabitants, its numbers grew significantly in 1963, prior to Kenya's independence.[20] This rapid influx of migrants contributed to the expansion of Kibera as a large settlement without proper planning and infrastructure, leading to the emergence of what is commonly referred to as "slum structures".[21] Despite attempts to eradicate these settlements, they thrived due to colonial rule, which benefited from the labor force of African settlers without investing in urban planning or providing basic services. The lack of investment and planning during this period allowed the settlements to grow within the city. Kibera has persisted as an unauthorized settlement.[22]

It currently spans approximately 2.5 km2 and is home to over 250,000 people.[23] Its central strategic location within Nairobi has significant implications as it acts as a dividing line between the more affluent areas, which boast amenities such as airports, golf courses, dams, and forests.[24] This division creates a distinct pattern that connects the formal and informal sectors of the city, allowing for further urbanization. Because of its large population, Kibera faces considerable challenges. The unemployment rate is nearly 50%, and the literacy rate stands at a mere 40%.[25] The residents have experienced worsening health conditions with a major population suffering with HIV/AIDS and a very poor sanitation system, leading to the emergence of a concerning practice known as "flying toilets". Lack of proper education regarding contraceptives and an increase in young female pregnancy has been found in Kibera. These factors contribute to a range of social issues within the settlement. The history of Kibera reflects broader issues faced by informal settlements and highlights the need for sustainable urban planning and recognition of the agency and resilience of its' residents.

Fig 1.2:   Plan of Kibera highlighting the fabric and demographics

Middle Income Residential

Mashimoni

Kianda

Makina

Laini Saba

Soweto East

Soweto West

Nairobi Golf Course

Jamhuri Park

Raila

Gatewekera

Kismu N'Dogo

Kambi Muru

Nairobi Dam

Lindi

Silanga

Middle Income Residential

2.5 sq Km

270,070 People

9

10

1.4.1 SocioEconomic systems, Ecological Patterns and Environment

Denial of land rights and limited job opportunities after urban development projects during British rule initiated a second layer of socio-economic issues in Kibera. As the government withdrew its responsibility for development and management while still owning the land, Kibera's residents formed their own economy at the household level, though still relying on government organizations for basic amenities. For Example, the United Nations Human Settlements Programme (UN-Habitat) helps the people of Kibera and supports their rights.[26] Kibera has social and economic differences, with many people not having jobs and relying on informal work. It is challenging for residents to receive education and healthcare, and the lack of good infrastructure makes things even more difficult. Environmentally, overcrowding, poor waste management, and insufficient water and sanitation infrastructure contribute to degradation. Community-driven initiatives strive for sustainable practices. To make Kibera better for the people living there, a collective effort must be made to consider their social, economic, ecological, and environmental needs. This means collaborating to create opportunities for everyone, improving their living conditions, and taking care of the environment.

1.4.2 Housing Patterns

Housing in Kibera is diverse, with a majority of materials being constructed informally from unreliable and makeshift materials despite several slum upgrading initiatives. It has 95% of households living below the poverty line.[27] However, there is a positive trend toward transforming these houses into more sustainable and developed structures. The continuous need for movement of the residents has made them vulnerable and lose faith in the law and system.

The issue of housing in Kibera is closely connected to the conversation of land rights. There are a few major stakeholders to understand this at a minute level, the first and foremost, the owner of the land is the government.[28] They own all the rights to the land and have a longer term vision to develop Kibera and its surroundings. Secondly, there are structure owners, who only own most of the structures, formal or informal.[29] The legal documentation of these owners under the provision by the government, are bought mostly by the government officials. Moving forward, the structure owners lease the houses to the tenants with the authority of unnotified evacuation. The tenants, being the ultimate users, face all the discriminations and difficulties within the fabric.[30] The absence of effective authority and clear property rights definitions has led residents to seek informal means to secure their rights to the land they occupy.[31]

There are two types of housing that can be studied to showcase a shift in the housing systems in Kibera that can inspire a change at a larger scale:

1.4.2.1 Kenya Slum Upgrading Program (KENSUP)

The Kenya Slum Upgrading program was initiated by UN-Habitat in collaboration with the local government involved with Kibera, whose world headquarters is situated in close proximity to the neighborhood of Kibera. The development of this strategic plan, which happens to have a lot of disagreement and loopholes, took about 3 decades to formulate, initiated in 2003.[32] They constructed affordable housing units on the periphery of the village of east Soweto, to rehabilitate people from Kibera and improve their lives.[33] They achieved the construction of 30 co-operative societies relocating about 1200 households, alongside putting in applications for some slum upgrading and prevention policies and other upcoming units to the central government[34]. These programs run on giving the residents security by handing over the houses which might be the same size as their slum shacks but have proper plumbing and structure on a small mortgage system which sums up to the same price as the rent for the shacks per month. This program gives the residents a sense of ownership, rights, and legitimacy that they had never possessed before. One of these rights is the right to sell, which can then be traded with middle-class families under a "secret" arrangement. This would provide the residents to arrange enough money for their children's education or start a small business, even if that means they would have to go back to informal lives.

The only drawback that the Government of Kenya has not yet accommodated, is the fact that the housing and commercial value of the real-estate increases with time. This could also mean that the increasing value makes the house's monthly mortgage unaffordable for the dwellers. Furthermore, these upgrading programs are for housing only, and they do not have any intervention for the shops, workshops, or small factories. This detachment from the possibility to engage in a business environment could lock the dwellers into a permanent dependency.

1.4.2.2   Incremental Housing

In the informal sector of Sub-Saharan Africa, a common housing pattern is incremental housing, where houses are built and improved gradually, one component at a time. Typically found on the outskirts of cities, this process involves upgrading infrastructure, self-building, and asserting land ownership rights.[35] It empowers residents to finance their homes more effectively, often through savings and small loans. However, challenges arise due to rising land and construction material costs. To address this, private banks have established micro-financing systems, offering loans for each building element, facilitating smoother construction processes.[36]

This housing approach provides an opportunity for policymakers to support innovation and gradually replace makeshift dwellings with improved housing policies.[37] On the other hand, the downside of this pattern is that residents often end up living in informal settlements like Kibera for more than a decade, negatively impacting their well-being and quality of life. The desire to save for the future often leads them to neglect their current living conditions, enduring inhabitable circumstances.

Year 03
(Foundation)

Year 04
(1st Wall)

Year 06
(Other Walls)

Year 08
(1st Dwelling)

Year 13
(Another Floor)

Year 18
(Some Extension)
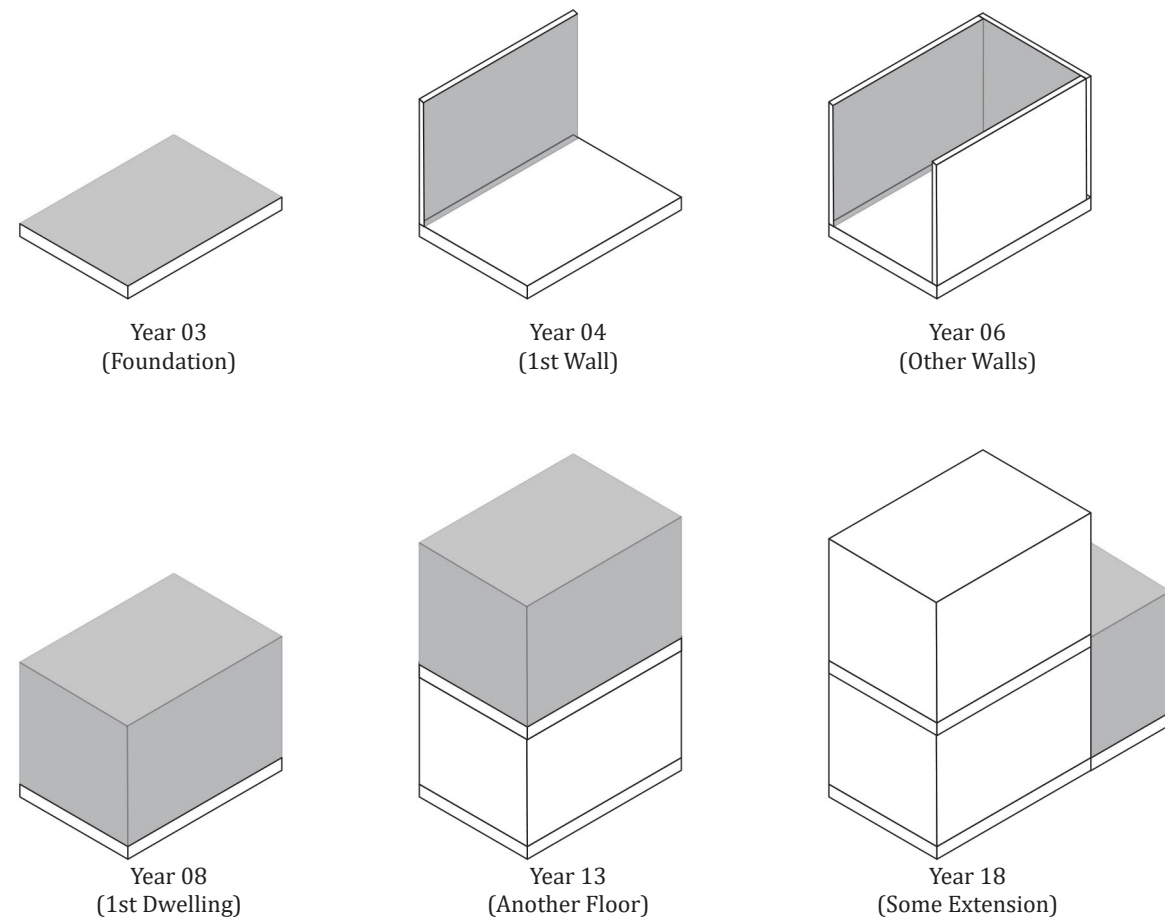
Fig 1.3:   Process of Incremental housing

1.4.3 Recycling Community

There are observable patterns as influenced by a mix of KENSUP, a municipal housing program, and other housing practices in Kibera, where recycling and reusing practices have become embedded in the community's way of life over the years. As residents gather funds to improve their informal homes or become structure owners, they often utilize materials from the demolished sites to expand their houses vertically. This added structure sometimes becomes occupied by those who were initially relocated to upgrade housing that proves unaffordable for them.

As we understood above, the housing provided through slum upgrading programs tends to be expensive and undermines the community's overall value. The majority of the population relies on small businesses running from their self-built homes on the streets. However, these businesses cease to exist in the new mid-rise apartment buildings, leading to a loss of income. Living within these tiny houses in this community has made them interdependent and has helped them reinforce their community values. Relocating to midrise houses indeed provides the residents with improved living spaces, but it comes at the cost of losing their economic and communal value, a trade-off that has not been widely embraced. Consequently, the relocated population resettles in the remaining land, resulting in increased density with each cycle of the relocation process with reduced quality of life.

TRANSITIONAL/GENERATIONAL
DEVELOPMENT

MICRO-LEVEL

FIRST GENERATION

UPGRADING STRUCTURES

SECOND GENERATION
(RECYCLED FLOORS)

RELOCATING TO
RECYCLED STRUCTURES
(RELOACTING TO 90% OF
LAND BACK)

$$$$

GOVERNMENT / INITIATIVES
DEVELOPMENT

MACRO-LEVEL

$$

PROPOSAL FOR URBAN
INFRASTRUCTURES

SLUM UPGRADING
RESIDENCES

HUGE SETTLEMENTS
(VACATING 10% OF LAND)
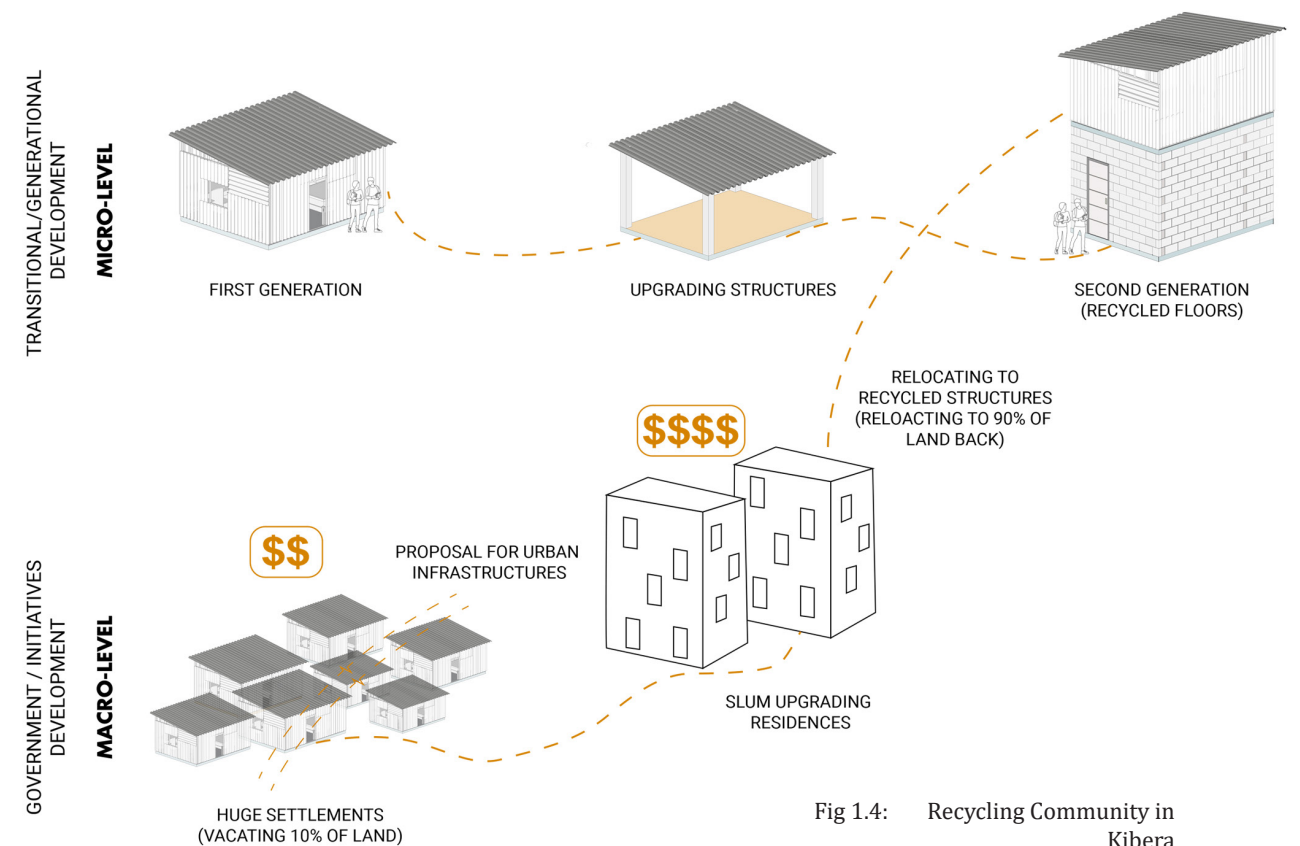
Fig 1.4:   Recycling Community in
Kibera

1.5 Core Question and Approach

Research Question

This research explores the materiality of informal settlements in Kibera, Kenya. The construction industry is a major contributor to global waste, with much of it ending up in landfills. However, informal settlements, known for their resilience, have shown innovative ways of utilizing this waste. This study seeks to address a fundamental question:

How can we effectively incorporate the recycling of construction waste into the architectural tectonics of Kibera's informal community?

To answer this primary question, I explore three concepts. Firstly, investigating the possibility of establishing a program that aligns with the process of recycling construction waste. Considering the challenges of living in such a fabric, including financial constraints, I explore how recycling waste becomes a preferred alternative to purchasing new materials. Additionally, I analyze the potential of implementing a process or strategy that not only reduces construction costs but also contributes to a greener environment.

This study recognizes Kibera's ideology of self-built construction, and in doing so, I seek to understand how a new design process can further empower and involve community members as active participants. Furthermore, if there could be a difference between personal scale customization and a broader vision of change that can be achieved through recycling materials.

These secondary questions emerge from the central narrative of this thesis and together contribute to formulating a comprehensive design approach. By addressing these questions, this project aims to create innovative solutions for sustainable architecture in the informal settlement of Kibera.

Approach and Methodology

The central approach of this thesis involves the comprehensive documentation of materials utilized in the existing Kibera settlement and an assessment of their feasibility to be integrated in the proposed material recycling centre. Ideally, this project would include deep community enagegement to ensure that the voices of people living in Kibera could lead the discussion. However, due to limitations in time and finances, this documentation will primarily be conducted using digital media as a tool for identifying materials and mapping their resources. A collection of photographs taken by local photographers, depicting daily

life in these Nairobi settlements, and various documentary films showcasing Kibera's architecture will be the primary sources for this research.

Chapter 02 delves into the concept of informal settlement on a global scale. By exploring the perspective of scholars from different disciplines who have written about this topic in various contexts, the chapter outlines the common practices employed in informal settlements worldwide. Examples from other cities and countries' settlements where communties are employing similar strategies for handling construction waste and embracing circular economies are examined to gain insights into theirdaily life choices.

Chapter 03 provides an in-depth analysis of Kibera, specifically focusing on the materials present in the settlement. Utilizing a longitudinal study of the streets over the past two decades, the chapter identifies the materials that have gained prominence and evolved over time. Based on this analysis, the most efficient and suitable materials are determined, taking various factors and resources into consideration. Case studies of projects with similar approaches implemented in Kibera are examined to draw inspiration and ascertain the most appropriate design strategy for this unique fabric.

Chapter 04 shifts the focus to the dwelling and structure level, documenting the materials and technology used within the houses. The chapter explores how each element within the dwellings serves various purposes throughout the day, contributing to the creation of new spaces as part of daily chores. Beyond individual dwellings, the study expands to encompass the entire community and its shared language of design and construction. This comprehensive documentation serves as a foundation for developing a cohesive design strategy, which will be further elaborated upon in Chapter 05. This final chapter also outlines the different objectives of the proposed design strategy.

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Chapter 02:
Understanding the Informal

Fig 2.1: Demolition and Evacuation in Kibera

Caracas
Capital, Venezuela
11,000/sq mi

Manshiyet Naser
Cairo, Egypt
47,663/sq km

Dharavi
Mumbai, India
717,780/sq mi

Tondo
Manila, Philippines
69,000/sq km

Skid Row
Los Angeles, USA
Tent City

Camp Hope
Mexico
Tent City

Za'atari Camp
Jordan
Refugee Camp

Kutupalong
Bangladesh
Refugee Camp

Main Informal Settlements
in the global South

Traditional Centres of international
Migration growth

Main International Migration Routes

Top Bilateral Migration Corridors
with largest average annual change

Dadaab
Kenya
Refugee Camp

Global level of Poverty

92.3	Sub-Saharan Africa
65.2	South Asia
23.8	East Asia and Pacific
12.4	Latin America and Carribean
9.8	Arab States
0.2	Europe and Central Asia
<0.2	North America

Makoko
Lagos, Nigeria
(Floating settlement)
48,258/sq km

Kibera
Nairobi, Kenya
100,000/sq km

Favelas
Sao Paulo, Brazil
18,690/sq mi

Khayelitsha
Cape Town, South Africa
26,000/sq km

Kampungs
Jakarta, Indonesia
30,000/sq km

Fig 2.2: World Map with patterns of Migrations

2.1   Informal settlements

The informal settlement is a significant urban phenomenon that has gained worldwide attention from many scholars and researchers. There are many terms used to characterize these settlements like slums, shantytowns, squatter settlements, tent cities in North America, or favelas in Latin America that have many negative connotations. Marie Huchzermeyer[1] mentions that the term 'slum' most commonly used to address these settlements was derived in the 1820s from the original word 'slump', commonly referred to as a 'marshy place'.[2] The new academic term "informal settlements" itself, parallels the reality that these settlements are actually growing rapidly. The use of the term "informal" implies a lack of formal recognition, legally hinting at the existence of a distinct, alternative space for living. What are informal settlements? Who are these people we are talking about? Asef Bayat highlights the challenges and terms faced by the inhabitants of these settlements, where they are often economically exploited, politically repressed, socially stigmatized, and culturally excluded from being fully integrated into our urban society.[3] This has become the reality for these inhabitants. They experience the phenomenon academically acknowledged as "quiet encroachment", where ordinary people silently and gradually advance to assert their presence, claim rights, and create a sense of belonging within the constraints of the informal settlements. It involves activities, such as the incremental expansion of dwellings, the establishment of small businesses, and forming community networks to improve their everyday lives.[4]

The way we perceive these settlements is due to certain past political decisions that instill the image of the 'slum' with many negative connotations and appearances. This would then interest the government by discouraging people from using the informal as a stepping stone to access the formal cities. As Roger Kurtz explains, an example in Nairobi in the book *Cities with Slums and urban obsessions urban Fears[5]*, the initial formation of settlements in Nairobi was due to the decisions taken by the authority to not improve the 'living conditions' of the informal sector to control and present obstacles to further migration of people in the city with their hope of upgrading settlements.[6] Many stakeholders and actors are equally responsible for making and remaking these cities constructed by their residents. As Faustin Maganga and Michael Bratton suggest, the cities can be defined in two ways - the informal sector regulated by the locally designed rules, and the formal sector, regulated by the formal laws of the country.[7] This creates an environment of highly interdependent communities that are believed to be a part of urban space and their independent knowledge of existence. Despite their integration in many cases, they still live separately and parallel to each other. This underserved part of the Global South is largely forced to play "catch up" in terms of its development and infrastructure.[8]

Several efforts have been made by local government, policymakers, and other stakeholders to improvise the conditions and resolve some issues of the marginalized communities by collaborating with inhabitants and other communal and non-governmental organizations working on the ground like in the case of Nairobi. But as AbdouMaliq Simone mentions in his research, urban practices are extremely varied and rapidly evolving which makes it difficult for the stakeholders to neatly categorize defined uses of spaces and resources or establish social patterns[9] for a successful strategy to implement. AbdouMaliq Simone[10] has access to resources and data to theorize the patterns of the Global South and has opened up this new perspective of analysis for other scholars. The levels of exploration that scholars have started to put together have created interests from different disciplines to come together to find gaps in the knowledge. These gaps of information can be one reason that no strategy is completely fruitful for these communities. They all rely on a greater percentage of tests and trials at a very later stage.

One of the major organizations that plays a role in improving these settlements is UN-Habitat which manages and monitors the improvement of these settlements globally. In their latest report, they acknowledge that tackling urban poverty and inequality is an urgent global priority and can be approached with multidimensional strategies adopted by local governments. If not for Covid-19, Sub-Saharan Africa already lives with almost 23% of its population below the international poverty line, making it 11 times higher than other regions like Latin America and the Caribbean.[11] In order to achieve the goal of ending poverty by 2030 or earlier, the cities and finance departments of the local governments will have to accommodate the existing informal employment, and informal economies, and extend better infrastructure and urban services to underserved communities.[12]

Overlooking negligence to these reports by the local governments, Marie Huchzermeyer has raised valid concerns about the limited scope of the "slum improvement" programs after analyzing several countries' strategies, claiming that even if the targets were achieved, the remaining 90 percent of the inhabitants would still face underserved conditions. This exposes many limitations to the UN's role towards problematic approaches in setting the targets. This contributes to the continuous rise of informal settlements in African cities, despite the threats, sporadic eviction, and even large-scale displacements.[13]

For the past two decades, many researchers from different disciplines such as sociology, urbanism, history, economics, geography, architecture and urban planning have turned their attention towards academic research on cities and ideas relating to poverty and the economy in the global south. This attention has shone a new light on sensitive urban areas that differ from the formal and Western perspectives. Adapting from other discipline theories, much can be used to strategize designs in the architectural discipline. Mapping and spatializing are significant aspects of this discipline, which could benefit by formulating a proper system of documentation through local bodies to map the informal areas which have not been studied or have been modified since the latest documents. It could be an immense source of accurate groundwork for more realistic speculative proposals for urban improvement. Understanding the severity of the changing environment and its effects, and regulating a proper material economy can be a major impetus for change and amelioration of living conditions in these settlements from an architectural perspective.
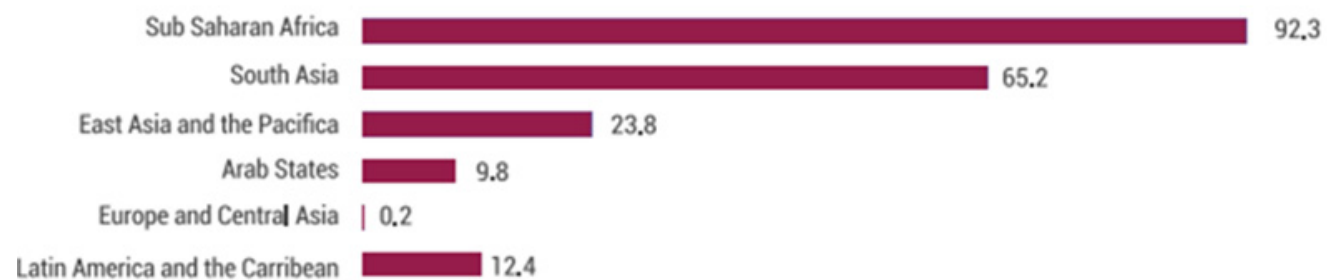
Fig 2.3: Graph showing global level of Poverty

Fig 2.4: Toi Market Fire in 2019 in Kibera (Top)

Fig 2.5: Burnt structures in Toi Market in 2023 (Bottom)

2.2   Construction Waste in informal settlements

The quantity of construction waste has risen in a global context, to almost 30% of the entire waste produced.[14] As the world continues to urbanize, new construction is unavoidable but adapting by incorporating re-used waste into newly built form is an approach that can resonate by mitigating the effects of the climate crisis. With the ever-evolving demand in construction and economy, resources are being taken for granted at all stages.[15] Informal practices of dumping waste in open areas, sending off the waste to landfills after demolitions, or leaving waste to contaminate water, all contribute to environmental deterioration and contaminate the soil and water in many ways. Informal settlements have learned to build their lives with this waste. In low-income contexts like Dharavi, Kibera, Sao Paulo, and many more in the global South, due to scarcity of resources and economics, the residents are often pushed to be innovative with their daily-life tactics and practices. This extends the life cycle of the materials and keeps the movement of these materials until they ultimately become unusable.[16]

As AbdouMaliq Simone highlights, "The residents in cities of the global south live without adequate income and access to some form of stable assets, shelter, and safety nets. They live without access to clean water, sanitation, and power, and enjoy limited protection of rights, laws, and political voices".[17] This further explains the motivation of informal city residents to embody both individual autonomy and a strong sense of communal values, fostering the formation of informal networks and self-help communities. As seen in most Latin American houses, informality is manifested in these self-help constructions at home itself. They tend to engage in painstaking efforts in the construction process often years before services reach them.[18] Hence, the systems and methods used are not very permanent and conventional and are based on the availability of the materials. Also, we know the dwellings in these settlements are made from recycled waste, but due to their weathered conditions, they might carry some hazardous substances that either affect the health of the occupant or need constant repair due to improper connections. In a recent accident in Kibera, the main Toi market, built with locally recycled materials caught fire again after the 2019 fire.[19] The construction material like corrugated metal sheets, timber or metal frames became waste once again which will then be sorted and recycled again in making new make-shift structures.[20]

The availability of waste has more recently affected these low-income countries, which have become the center of import for all the secondary materials, while the developed countries have a higher export rate of all waste materials. Countries of the global South, tend to have a high waste utilization rate. These increasing imports and the marginalized population learn to get along and make a living out of it. There have been many examples where many Western countries like Canada, the US, and some European countries continue to send all of their e-waste[21], used fabrics [22], and plastic waste[23] to counties like Kenya, Senegal, Ghana, and other Asian countries. The enormous terrains used for landfills that these countries have formed are being filled with this waste and give underpaid job opportunities to marginalized people locally. There have been many markets that are now formed to address this waste and sell them as second-hand markets.

The recycling of construction waste maintains significant potential to recreate an entirely new circular economy that can revolve around the use of waste in everyday life in these settlements. As it is cheap and easy to acquire for the residents of the informal settlement, it holds the opportunity for the communities to build the process of using this waste, if somewhat risky, and provide an example of a more sustainable structure to address climate change challenges.

2.3   The Process of Circular Economy

As migration drives a continuously growing population in informal settlements, the urban fabric becomes ever denser over time. Besides many official rules, there will be a rise in several economies like Kibera, Dharavi, Makoko, etc., that move through huge informal circular flows within or at the periphery of the megacities.[24] An increasingly large proportion of Africa's current population of over a billion and a half people (almost 80%) is estimated to be regarded as living in informal settlements, in a continent whose population is estimated to reach almost three billion by 2030.[25] These are estimates of the population that are involved in generating an informal income spread across the global south. The essential principle of 7R (Rethink, Refuse, Reduce, Reuse, Repair, Recycle, and Recover) [26] has evolved into a vital survival strategy for those involved in processes like cradle-to-cradle material lifespans or upcycling. Emphasizing the creation of a positive impact for future generations, this rule goes beyond the traditional cradle-to-cradle approach. Its implementation is crucial for their continued existence.[27] Informal economies, as defined by WIEGO (Women in Informal Employment: Globalization and Organization) are "the various economic activities, businesses, jobs and workers not regulated or protected by the government"[28], this suggests that this population does not rely on the services and benefits from the government and all of their transactions are off record. As scholars have mentioned, the poor in these settlements are often not able to behave as the city's system expects them to, as the urban planning strategies in most of these developing countries do not include the basic issues of the poor and are ill-suited for their socio-economic realities.[29] In several cases, these informal economies catering to waste picking and processing are the only communities that can help keep the cities overall well-being. Therefore, these communities should not be ignored and instead should be recognized for the critical role they play in cities.[30]
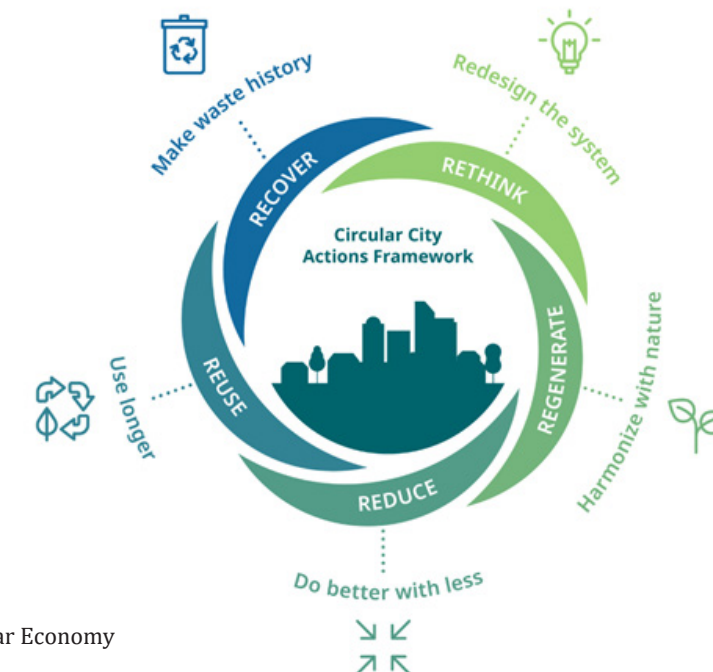
Fig 2.6: Circular Economy

Fig 2.7: Manshiyet Naser, Cairo

A prime example is Manshiyat Naser, Cairo known as Garbage City, which is also an informal area. The residents have made their living out of collecting, sorting, recycling, and reselling garbage. The Zabbaleen[31] community has created an informal economy for themselves and the residents have also created a connection with the formal fabric by collaborating with the government organizations responsible for garbage collection. They have made their unique community and its skills reach out to the middle-class population that was then compelled to hire them for several jobs.[32] They also made an educational community within their area to provide artisan workshops by many skilled individuals for recycling wastes into several pieces of furniture and artifacts sold locally and internationally now.[33]

Dharavi in Mumbai has similarly been labeled as "a plastic recycling goldmine", where every alley has thousands of businesses that sort and process the waste collected from all over the metro city with a population of over 20 million. It is difficult for any city to get through its livelihood without the help of these informal economies, therefore ICLEI (the International Council for Local Environmental Initiatives - Local Government for Sustainability) has taken up the task to map cities and formulate a digital mapping system for similar recycling economies focusing on cities like Nairobi, Accra, Cape Town, Mumbai, etc. It's not just the sense of repair and reuse that forms this circular economy, other activities like the construction system, and shared spaces are all a part of the circular approach.[34] Informal settlements must be involved in the designing of the economic future of any city and must contribute to the informal economy while the strategies continue with a sustainable transition to the formal economy.[35]

2.4   Recycling and reuse in a marginalized area

The homogenized built environment in the settlements is capable of housing different kinds of economic activities and operational styles under its roof.[36] These settlements are a hub of migrations and cultural differentiations with people of different kinds, but the materiality and the arrangement of spaces become similar for everyone in a particular context.[37] It is mostly because of the socio-economic situations and the resource availability that results in differences between cities or countries within different cities or countries. Even then, the innovative ideas or the pattern adopted by people to construct their dwellings and other needed spaces often end up being similar.

There are many factors that have initiated this sustainable system of reusing. One main reason is the economic conditions that prevent them from acquiring the new materials needed in daily life. Instead, they search for salvaged or scrapped pieces around them to fix the minute repairs constantly needed in their homes. Some of the inhabitants are skilled laborers in particular fields that are honed by non-formal education and practices. This background instills flexibility and an innovative approach to problem-solving in everyday life.[38] One other reason to accept the process of recyclability and reusability as a part of everyday life is also discreetly making best use of the money or opportunities. Some of them wear the same clothes for a week in a row to display their limited access to resources and similarly, they leave their homes unrepaired to not signal an infusion of cash into the household.[39] It tells how important it is to differentiate between perception and reality. They sometimes do this intentionally to save up for a long term vision of settling in a more formal community.

Fig 2.8: Initial Stage of Empower Shack Project (Top)

Fig 2.9: Finished stage with community building space in Empower Shack project. (Bottom)

2.5   Case Studies

a) Urban Think tank

Location: Cape Town, South Africa
Year: 2016

Urban Think Tank directed this project, situated in Cape Town in South Africa, in partnership with the local NGO Ikhayalami, BT-Section (Site C) community of Khayelitsha, and ETH Zurich. The concept is to create open-source homes to experiment with a prototype for the informal settlements in South Africa. Recreating the existing footprint of the shacks, the proposal created approximately 51 homes.[40] The strength of the design lies in the collaboration and participation of the residents to make the entire process more economical. A two-story and low-cost prototype has a central core. Fire propagation is mitigated by dividing the continuous dwellings with a concrete block wall spanning all the way to the second story. This design leaves flexibility to extend to more floors if needed by occupying families.

As the designers of the project, DesignSpaceAfrica explain, the building units are affordable to meet financial contribution by reasonably spacious living spaces and services that also meet the building codes. A percentage of the resident's contribution to the construction provides stability to them and the rest is made affordable by the micro-financing schemes. This project initiated the change in the housing policy in South Africa to include more diversity.[41]
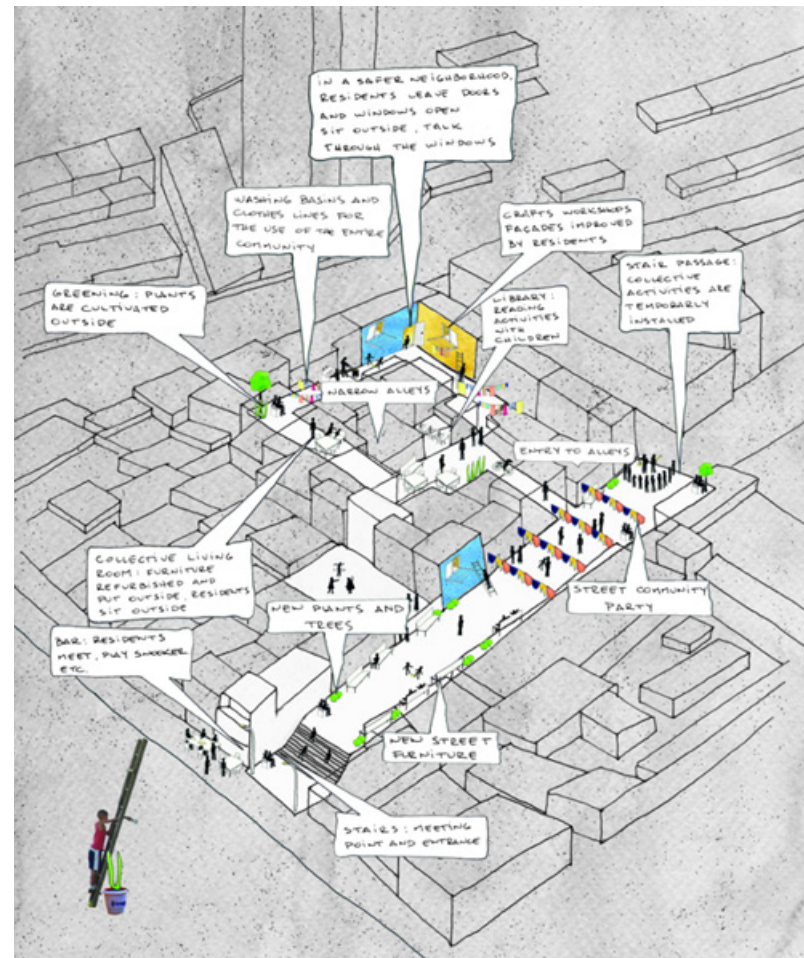
Fig 2.10: Proposed drawing for
BioUrban Developement (Top)

Fig 2.11: In-progress work in Sao
Paulo (Bottom)

b) BioUrban

Location: Mauro Favela, Sao Paulo, Brazil
Year: 2007-2012

BioUrban, situated across the Mauro favela of Sao Paulo is another project I discovered during research into informal settlements that have a strategic approach with materials and spatial programming. Mauro is a compact and dense informal area situated in the inner city filled with mixed-use typologies. This project was executed to understand the use of art and architecture to embrace the social programming of a neighborhood within a short period of time. "The initiative intended to improve life in slums, through social action and do-it-yourself measures, in which the members of the community were involved".[42]
As Jeff Anderson, the curator of this initiative, mentions, "They include the cleaning up of small spaces and areas in front of people's homes, creating flower beds in place of concrete curbs, using color and recycled material to humanize the facades of buildings and exposed infrastructures, creating public artworks, and the staging of collective activities such as painting sessions".[43]

The project began with a small library installation in the neighborhood extending to bigger workshops transforming waste into everyday use objects. The roads and streets, all became a part of the initiative acting as the most resilient spaces that communities can occupy and grow together. This diverse use of space had a very positive impact on the built environment and its safety.

Endnotes:

1.   **Marie Huchzermeyer** is an Academic and Public intellectual in Johannesburg, South Africa with research interests including housing and informal settlement policies across different contexts and from a historical, political, and rights-based perspective. Her publications "Unlawful Occupations: informal Settlements and Urban Policy in South Africa and Brazil" in 2004, "Tenement Cities: From 19th Century Berlin to 21st Century Nairobi" and "Cities with Slums: from informal Settlement Eradication to a Right to the City in Africa" in 2011 has highlighted many undiscovered facts about the cities in the African context and their urban growth over the years.

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10   **AbdouMaliq Simone**, Urbanist and Professor at The University of Sheffield is known for his research on emerging forms of collective life across cities in the Global South. His Key publications like "In Whose Image: political Islam and urban practices in Sudan" in 1994, "For the City Yet to Come: Urban Change in Four African Cities" in 2004, "City Life from Jakarta to Dakar: Movements at the Crossroads" in 2009, have all provided with an in-depth study on the advocacy, policymaking, administrative and context organizational research specifically in the African region.

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31.   **Zabbaleen community** are the Egyptian Christian minority known for their skills for collecting and recycling waste from all over the city. They were initially processing 80% of the city's garbage free of cost until the government took over and they became out-of-job. The responsible organization who were responsible to process only 20% of waste soon realized the importance and network of the Zabbaleen community. Moving forward they made collaborative ties to this community which provided them with more formal and consistent job opportunities.

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Chapter 03:
Mapping Kibera

Fig 3.1: Multipurposed Exteriors
of House

Nairobi

Kibera 2001   140,500

Kibera 2010   190,000

Kibera 2020   250,000

Fig 3.2: Growth of Kibera in last
two decades

3.1 Mapping Kibera

Kibera is one of the largest informal settlements in the African Continent. It is situated in Nairobi, the capital city of Kenya has eight informal settlements just a few kilometers away from each other, making one of the major focus areas for informality. Kibera is one of the biggest and oldest informal settlement, established around the late 1800s under colonial rule. Its population is estimated at approximately 250,000 within an almost 2.5 km2 area which is continuously increasing by peripheral land encroachments.[1] (Figure 3.2)

Surroundings
The positioning of this settlement right near the heart of the city, is very critical. The urban fabric of Kibera divides and separates access to surrounding luxury amenities like the University of Nairobi, Golf course, and Airport are divided by the expanding fabric of urban sprawl. The other natural layer of the surroundings also includes Ngong Forest, Nairobi Dam, and the Ngong river. These are are also impacted by the nature of the lifestyle sustained by the residents of Kibera.[2] The impact of improper garbage circulations affects the water flowing from the dam and eventually ends up piled near the forest.

The new development around Kibera being closer to other urban infrastructure, is being developed as middle-class or higher middle-class residential. New road structures proposed and implemented in Kibera in the last few years to avoid the longer routes for the residents in the city to go all around Kibera. These new roads have resulted in a high number of displacement of the residents.

Mapping
The settlement patterns of Kibera have evolved over decades in terms of typologies, populations, and construction systems. In my analysis, I looked at 3 decades of time to understand this change and adapt materials for the construction.

Fig 3.3 shows a major street Sheikh Mahmoud road that runs through the length of the settlement using a linear street approach to understand this fabric. As we see, the pictures show major transformations that settlements have undergone in the last few years. This shows an evolving material fabric that is further studied in the next chapter. As there are several urban interventions in progress by the government of Kenya, to support the surroundings or to upgrade the life of residents in Kibera, it is also important to understand the major actors involved to make changes to the fabric from various different disciplines. Since there are so many social layers to the urban nature of this settlement, there have been several architectural proposals that have been implemented in the dense fabric of Kibera to improve the daily life of the residents.

Fig 3.3: Mapping Kibera

Legend:
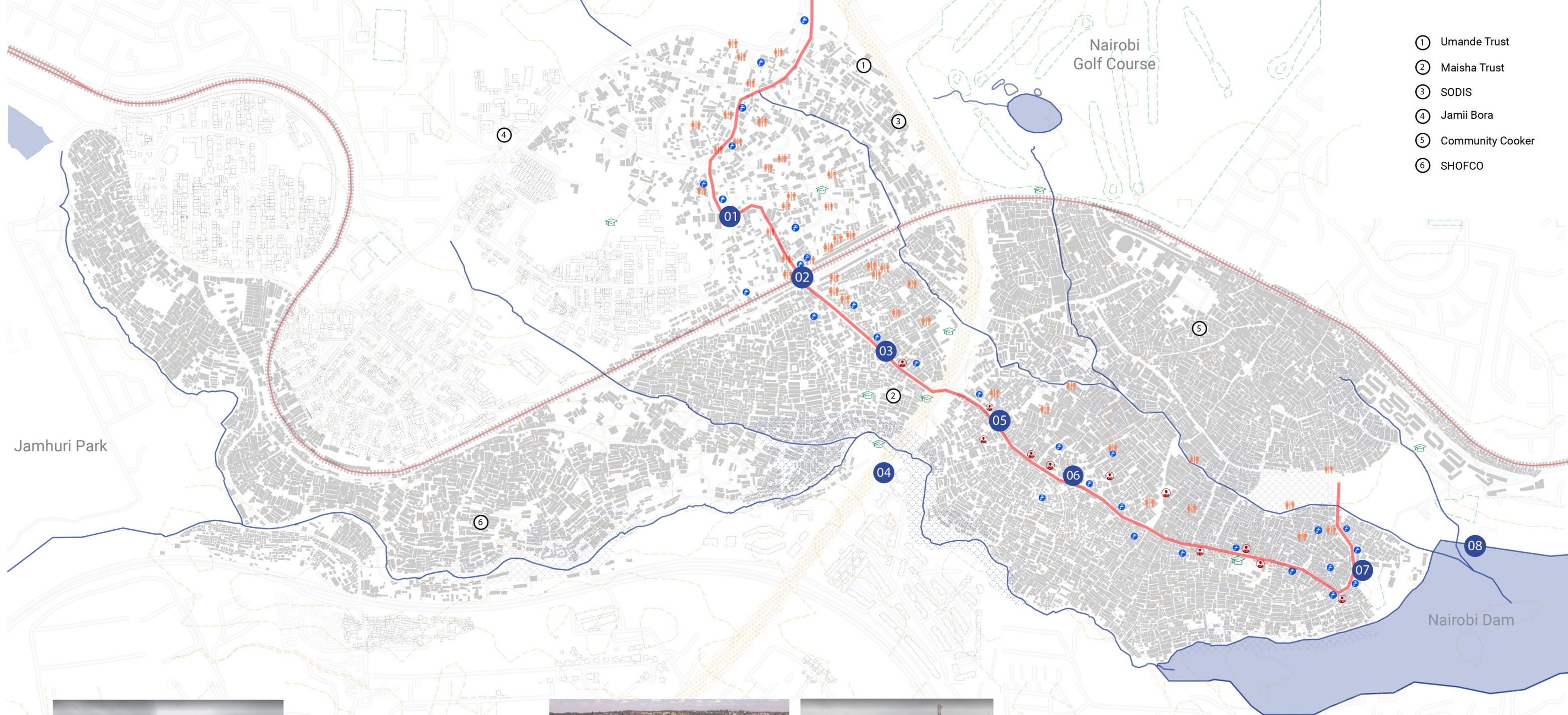
1. Umande Trust
2. Maisha Trust
3. SODIS
4. Jamii Bora
5. Community Cooker
6. SHOFCO

Nairobi Golf Course

Jamhuri Park

Nairobi Dam

Villages
Water Streams
Contours
Railway

Water Body
Flood Prone Area
Urban Changes

Education Facilities
Drinking Water Facilities
Medical Facilities
Sanitary Facilities

Actors

During the process of mapping Kibera, numerous initiatives were discovered, each contributing to the diverse systems that sustain the area. These partnerships and coordinators are engaged in several active projects, each adopting unique approaches, offering valuable perspectives and foresight from various architects and organizations. The array of agencies, some already present in the mapped areas of Kibera, and others actively involved in the settlement's development with distinct roles, are briefly examined below.

a) NGO's

Number of local organizations are involved in the betterment of Kibera in different disciplines. Some are involved in planning, landscape, and infrastructure. There are a few that are working with water and waste management, documentation, technology innovation, and education, amongst others.
Some main Non-government Organizations (NGOs) that are involved with the planning and structuring the circular economy are:

Kounkuey Design Intitiative (KDI)
Umande Trust [3]
Maisha Trust
Map Kibera trust
SODIS (Solar water disinfection)[4]
Jamii Bora - Microfinance[5]
They are focused on issues that are pertinent to this project and would be addressed in detail later in this chapter.

b) CBOs

Several community-based organizations are set up by the local residents of the settlement. They are deeply involved with smaller and more sensitive issues and problems at a daily scale, and people in the settlement come together to derive solutions. There are several CBOs that are initially set up by other organizations but are then handed over to a CBO to manage and maintain. Major CBO that are involved in Kibera are:

Community Cooker: Produces heat from burning garbage for heating water and cooking. Developed by a Kenyan furnace builder and a Kenyan Architect. Garbage collectors exchange time for cooking.[6]

Sack garden: Growing food in a sack requires less water and other resources.

Merry-Go-Round: A group of 15-30 women saves some money weekly and contributes to a mutually decided cause, like clothes for kids, house repair, other supplies.

c) Government Programs

Since Kibera is now the biggest informal settlement in Africa and the UN's headquarter is in close proximity the neighbourhood, it has become important to address the issues. Several government programs have been initiated and many bodies have been created to regulate the progress. Some initiatives are created and maintained by governmental bodies while some have 100% participation of residents in the community.

Some programs are:

Kenya slum Upgrading Program (KENSUP)
Kibera Soweto East Project
Kenya Informal Settlement Improvement Project (KISIP)
Sustainable Neighbourhood project (SNP)

d) International Agencies and Design Offices

The organizations or firms that come from other countries participate in the welfare of the settlements. They usually initiate a program for one time-installation or have a long-term program set for further development in any discipline. Due to not being local, it becomes very important to critically consider the context and then propose any strategy. Some projects do wonders but others often fail to showcase any results. Some main organizations that we will be looking into are:

Madrid based SelgasCano and Boston based Helloeverything
Genesis Architects
SHOFCO (Shining Hope Communities) [7] - Clean water Access, Educating girls, and sexual justice
NC Kibera [8]- Helping people create international networks and involving international agencies. Giving Micro-economy scenarios.

3.2 Design Initiatives

3.2.1   Kounkuey Design Initiative

The Harvard-based organization with infrastructure and landscape design expertise actively engages with the local community to undertake various projects aimed at revitalizing the area. Their primary objective is to stimulate economic growth within the settlement through their innovative design interventions. Their involvement in this process starts with their understanding of the multifaceted nature of Kibera and their access to the lives of its residents. Their comprehensive mapping efforts identify potential neighborhoods as well as land previously burdened by waste and garbage. Through a transformative approach, these spaces are reimagined into communally useful programs and spaces.[9]

Their design initiative encompasses programs like public squares, education centers, community centers, and basic services, among others. By involving the residents in the creation of these public spaces, they also create job opportunities for the local population. Additionally, they collaborate with current residents to upgrade their homes, working together towards improvement. KDI allows financial partnership with the residents, to enable them to become owners of their own structures, empowering them with a sense of ownership and stability.[10]

Fig 3.4: In progress project in
Kibera by KDI (Top)

Fig 3.5: Proposed development
plan by KDI (Bottom)

Fig 3.6: Renovated Exterior view
of Anwa school in Kibera (Top)

Fig 3.7: Community Engagement
in renovating process of Anwa
School. (Bottom)

3.2.1.1 Anwa Junior Academy

This is one of the school projects initiated by KDI that actively involved local women in the design and installation process. The aim of this project is to update the existing school structure with locally sourced materials like mud walls on the ground floor and recycled metal sheets locally called "mabati" on the first floor. To enhance the stability of these materials, certified timber framing was introduced, elevating the quality of the construction. Furthermore, the project provided opportunities for women to incorporate their skills in bamboo weaving, integrating their traditional craft into various aspects of the renovations.

Furthermore, KDI made efforts to bolster community engagement through training local laborers in mud and sand-based construction, fostering incremental improvements in Kibera. Addressing the cultural challenge of women feeling neglected and "not taken seriously," [11] this project empowered local women by involving them in the decision-making process, granting them a voice and authority.

The systematic approach of the project, starting with a thorough analysis of material-related challenges paved the way for the creation of prototypes, which served as models for subsequent projects like designing the school.[12] This approach by KDI not only utilized sustainable and locally available resources, but also fostered ownership and empowerment in the local residents.

3.2.2 Oasis Kindergarten

The Maisha Trust, an international foundation based in UK with an office in Nairobi, had undertaken a project to construct a school infrastructure in the heart of the community. Its primary objective is to enhance access to education for the children residing in the community. Several informal structures have been serving as educational facilities, but they are inadequate in providing the necessary infrastructure for the needs of children's education. As mentioned by one of the owners of the project Tom Vohya in his interview, this was their initial motive to develop this project.

Their vision focuses on creating a very basic and functional structure using local and cost-effective materials. To take a two-way approach to accommodate all the necessary activities while making the structurally stable on the loose and flooding ground conditions.[13] Given the challenges with the permanent construction in Kibera, the project architect opted for a simple and informal approach to materiality by using a shipping containers style of structure. By utilizing these strategies, the children coming in get full exposure to the formal education system along with fully designed activities in the vicinity.

Fig 3.8: Exterior view of Oasis Kindergarten (Top)

Fig 3.9: Under construction view of the school. (Bottom)

3.2.3 The Kibera School

This project is done in collaboration between Madrid-based SelgasCano and Boston-based helloeverything which has resulted in an interesting educational facility. The project embraces informal construction and design strategy, initially set for an architectural exhibition in Copenhagen. This was then relocated to Kibera which creates an outstanding design accepted well by the local residents in Kibera. The construction system employs a white polycarbonate roof and vibrant steel-pipe structure to create lively and playful spaces. Each room formed is used in a multi-functional way creating an informal connection between classes.

The intention behind this design approach is to celebrate the resourceful and adaptive nature of the settlement, which is often the materiality for any design in informal settings like Kibera.[14] By incorporating these interesting elements, the project embraces the spirit of repair and showcases the vibrant and creative character of the community.

3.2.4 Architect Kevin Kimwelle

Kevin Kimwelle is a practicing Architect currently based in South Africa, with a wealth of education and experience across various regions in Africa. His observations of the remarkable innovation within poor communities, where everything is utilized to its fullest, sparked a profound interest in recycling and reuse.[15] His urge to bring this lesson from this overlooked group of people to mainstream architecture made him do this experimental project in Kenya as his Ph.D. studies.

This house stands as a testament to his vision, constructed using 80% recycled materials, such as wooden pallets and glass bottles that create a captivating illuminating effect.[16] Throughout the process of collecting raw and salvaged materials, he successfully united two distinct communities to collaborate on a shared objective. Through this project, which he aimed to be equally aesthetically pleasing and functional, they collectively elevated the value of these materials with newfound appreciation. To accomplish this ambitious endeavor, he deeply engaged with the local community, involving waste pickers and local fabricators, who ultimately became key stakeholders in the project.[17]

Fig 3.11: Exterior of recycled house using glass bottles (Top)

Fig 3.12: Interiors proposing use of recycled pallette and structure (Bottom)

Endnotes

1   **Desgroppes, Amélie, and Sophie Taupin. 2011.** *"Kibera: The Biggest Slum in Africa?"* Les Cahiers d'Afrique de LEst, no. 44 (September): 23–33. Access Date: 03 March, 2023 https://doi.org/10.4000/eastafrica.521.

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10   **KDI. 2019.** *"Living Data Hubs."* 2019. Access Date: 10 May, 2023 https://www.kounkuey.org/projects/living_data_hubs.

11   **Bredhauer, Maryrose. 2016.** *"Transformative Adaptation in Informal Settlements: The Case of Kounkuey Design Initiative in Kibera, Nairobi."* Access Date: 25 July, 2023

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13   **Mutonga, Peninah. 2016.** *"Oasis Kindergarten Kibera."* 2016. Access Date: 03 March, 2023 https://www.archidatum.com/projects/oasis-kindergarten-kibera-maisha-trust/.

14   **Bittle, Jake. 2016.** *"The Kibera School by SelgasCano and Helloeverything."* 2016. Access date: 12 January, 2023 https://www.architecturalrecord.com/articles/11895-the-kibera-school-by-selgascano-and-helloeverything.

15   **Berger, Markus, and Kate Irvin, eds. 2023**. *Repair: Sustainable Design Futures.* 171-179 Abingdon, Oxon: Routledge.

16   **Chapman, Samora. 2019.** *'There Is Ingenuity in Africa': The Architect Who Builds with Trash."* 2019. Access Date: 03 March, 2023 https://www.theguardian.com/cities/2019/oct/22/ingenuity-south-africa-architect-kevin-kimwelle-builds-with-trash.

17   **Markus and Irvin,** *Repair, 171-179*

Chapter 04:
Local Construction Systems

Fig 4.1: Collecting Recycling
Materials from street
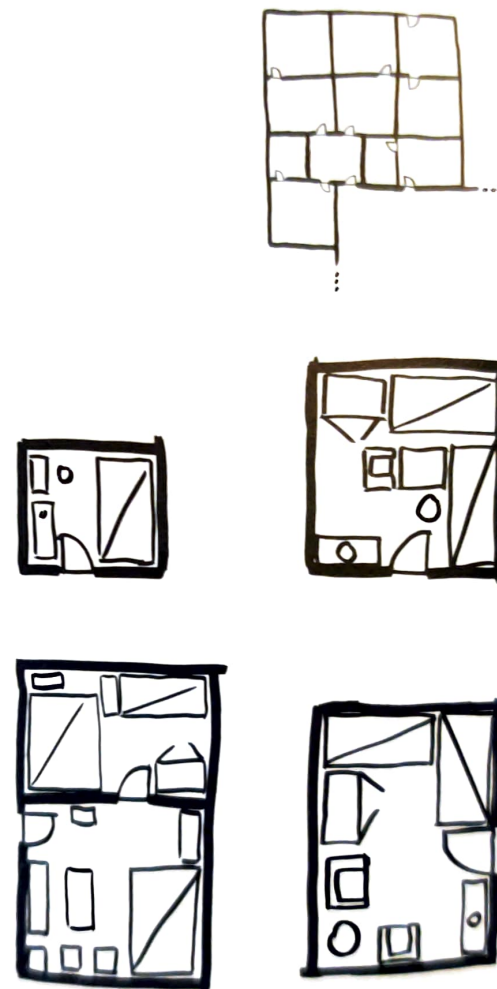
There is a broad range of construction systems in Kibera that provides opportunities for more study and exploration. The spatial analysis of the neighborhoods and dwelling reveals a high degree of density and clustering. With very minimal land available to expand with a continuously growing population, affords many opportunities to create different size shacks or dwellings. Over the years, many roads have gradually transformed into densely packed fabric as new dwellings emerge, leaving narrow alleyways for movement.

Owners also tend to expand their dwelling structures vertically, adding extra floors to the structures to achieve maximum profit and provide more rental spaces. The typical layout of the dwellings in Kibera consists of interconnected rooms shared by multiple families resulting in extremely high occupation statistics and densification. At a more detailed scale, individual rooms which can also be stand-alone structures typically vary in sizes ranging from 2m x 2m to 3m x 4m, accommodating various dimensions and layouts within this range. They are usually inhabited by single families with homes used as multi-purpose rooms[2] as seen in the drawings.

4.1 Existing Materials

In Kibera, the current state of material used for day-to-day purposes is limited due to economic constraints. The residents lack the financial means to acquire new and durable materials with a longer lifespan, resulting in a predominantly temporary state of construction. In order to respond to this gap, there have been attempts to document materials digitally in Kibera. As one of Africa's largest informal settlements, Kibera has a very vibrant community and dynamic culture that has been extensively covered in documentaries and articles, shedding light on various social issues. However, there has been a lack of documentation of material movements in Kibera including the informal inhabited architecture.

To bridge this gap, available data from several sources documenting other dimensions of Kibera have become the primary sources for identifying the existing use of materials in its construction. This approach aims to compile a comprehensive understanding of the materials used, leveraging existing information from various photographers and documentaries to fill the void in the material documentation.

Fig 4.2:   Floor plans of types of shacks for dwelling in Kibera

Disclaimer:
Please note that the research conducted here relies on photographs taken by other individuals. Much like the cutting-edge approach of Forensic Architects[1], who employ photographic and video images for architectural analysis, we acknowledge that these images are thoughtfully curated by the respective photographers, reflecting their specific intentions. Understanding these limitations, our sole focus lies in extracting information related to materials and their flows within the community.
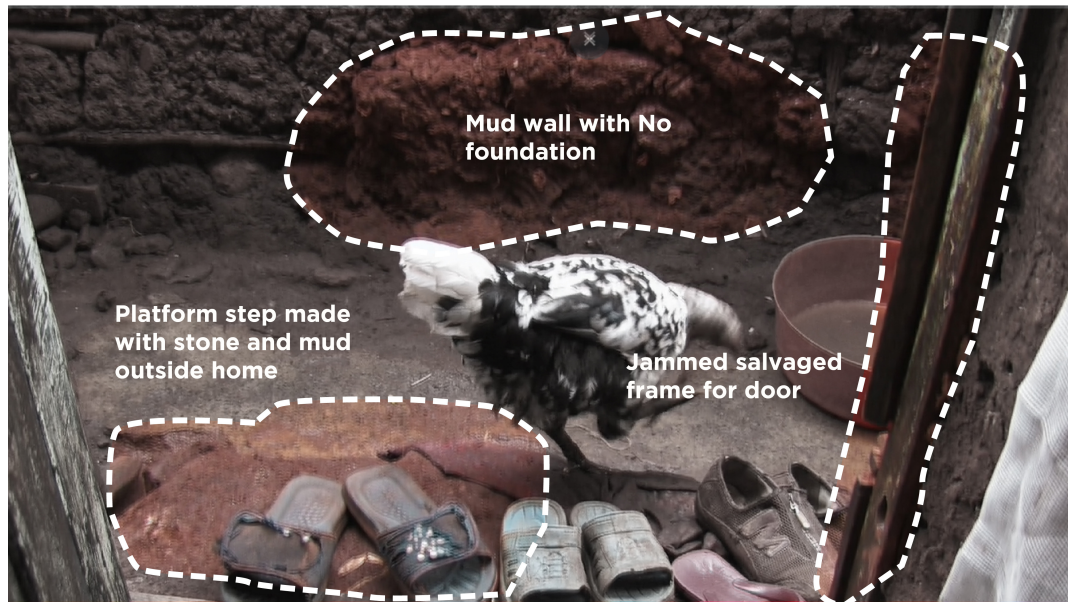
Fig 4.3:   Alley In Kibera Showing Mixture of materials used for walls. (Top)

Fig 4.4:   Doorstep at a dwelling in Kibera (Bottom)

Fig 4.5:   Into the daily life ina dwelling in Kibera (Right)

1) Assembly Structures

These pictures taken by various local photographers who document the local life in Kibera and screen captures from many features in documentaries such as Footprint, and Nairobi Half Life showcases the prevalent use of the specific material within the community. As the aerial pictures suggest the extensive use of metal sheets to cover the roofs and walls. In some cases, traditional construction systems like Manyattas or Luo homesteads inspired by Maasai are adapted.[3] Additionally, fabric imported from Western countries as waste is often used within the dwellings, serving as temporary partitions as well as for a dropped ceiling to store household items and fulfilling various other functional needs in daily life.[4] The materials used to construct the walls are usually mud with bamboo for some internal strength. Some residents managed to cover with metal sheets or plaster it with cement to protect it from rain or floods.[5] The exterior walls on the inner surface are covered with fabrics to avoid shedding mud from the wall due to constant touch.

The captured images showcase the resourcefulness of the residents, showcasing their ability to adapt and creatively utilize materials to shape intimate spaces. This implies that people in Kibera are very receptive to incorporating new materials and technologies into their regular construction system.

Fig 4.6:   Typical Toilet structures in Kibera (Top)

Fig 4.7:   Outside a structure protected by sandbags in Rainy season. (Bottom)

Fig 4.8:   Bio-Centres, Kibera (Right)

2) Basic Amenities

The lack of essential amenities such as toilets, drinking water, and electricity pose a daily challenge in Kibera.[6] The people of Kibera have a higher sharing rate for these facilities without any proper maintenance and the facilities are often constructed using temporary materials and inadequate construction technique, making them unusable shortly after their creation. The unstable timber frames holding the metal sheets as a cover together forming the wall are not very reliable as a design. These structures are further compromised by the overflowing rivers and garbage blockages around them.

To address these social issues in Kibera, several Non-Governmental Organizations and slum upgrading programs have initiated projects to provide the community with improved facilities. One such solution proposed by Umande Trust is Bio-Centres in various parts of Kibera.[7] These centers not only provide facilities to the residents but also have developed a bridge between the organizations and the community to provide more employment for the individuals involved in its maintenance and operation. The construction of these centers, in collaboration with the government's slum upgrading program, is permitted to have a proper underground foundation and concrete block structure above.

These efforts help to mitigate the challenges associated with sanitation and access to other amenities in Kibera, contributing directly to a better health and sustainable living environment for its residents.
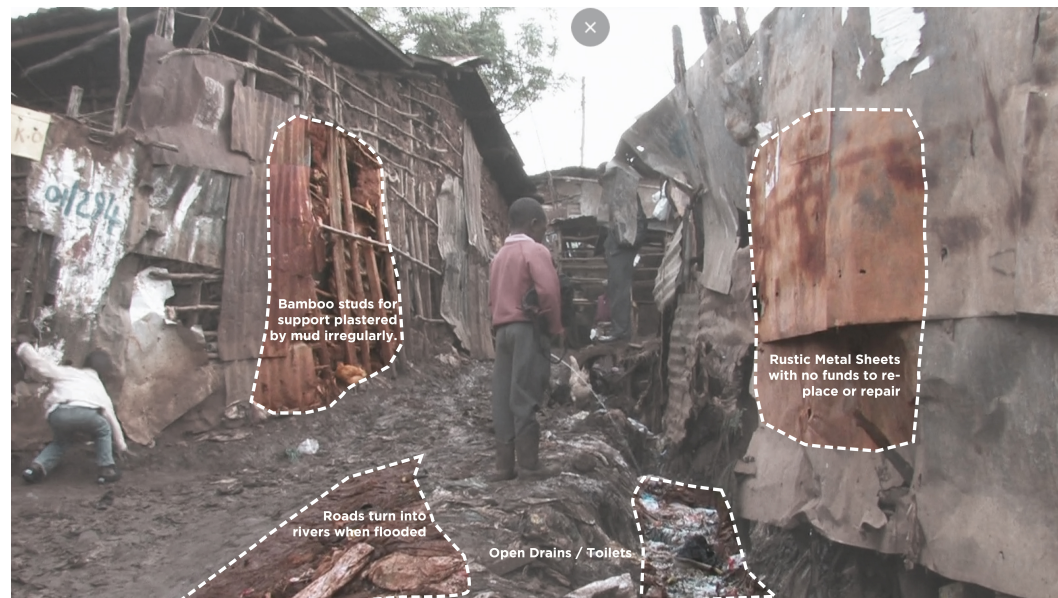
Fig 4.9: Business outside the dwelling (Top)

Fig 4.10: Alleyway with improvised structures on either side. (Bottom)

Fig 4.11: Daily chores outside a dwelling with neighbours (Right)

3) Extension Spaces

The dwelling sizes in Kibera are small and insufficient to accommodate the daily chores and a household of about 6-7 people. Consequently, many daily chores spill over to the exterior spaces along the outer wall of the dwelling. These spaces vary in width depending on the location and are often shared among neighbours. These extended spaces have evolved into multifunctional areas that are self-occupied and serve various purposes throughout the day. The accompanying pictures demonstrate some of the common activities taking place in these extension spaces.

Daily activities like cooking are often conducted outside due to the harmful smoke generated by open stoves and the coal cooking system. Some other common practices for these spaces include growing food using sacks based on local community organizations, washing dishes and clothes. These spaces besides serving the chores, have also transformed into micro-commercial spaces, used to sell vegetables, and for other home-based businesses. Some residents have managed to create small porches where two people can sit, fostering a healthy sense of community and providing communal gathering spaces for interacting with neighbours.

The constructions of these extensions are easily movable and dismantled, offering flexibility to adapt to the changing needs. They are constructed with convenience in mind, accommodating the multifunctional roles they serve throughout the day. The furniture used in these spaces is versatile, serving many purposes at the same time in a day. Individual members of the house have a different sense of contribution to the making and evolution of this space.

In addition to these ground-level extensions, some residents in Kibera expand their structures to include an additional floor above. This can involve replacing the ground floor with more durable and permanent material or constructing on top of an existing temporary structure. The latter situation comes with the risks involved. These extensions are typically carried out by the owners of the structures, as tenants do not have the right to make these permanent modifications. This investment by structure owners tends to increase rental income by offering separate floors for rent.

Sometimes, this practice can have negative repercussions for the tenants, including structural problems and higher rental expenses due to the extensions. As mentioned by Tom Vohya, in the interview, the owners of these structures prioritize maximizing their income and may lack empathy towards the tenants' concerns. Consequently, the tenants bear the burden of these issues, posing additional challenges for them.

Extended floors, recycled lighter material on floor above

Integration of innovative ideas and latest technology

The narrow ladders move vertical

Fig 4.12: A two storey structure with informal materials. (Top)

Fig 4.13: Ladder to the upper floors from between the houses. (Bottom)

Fig 4.14: Repair work in extended spaces (Right)

Exterior space for repair

**METAL SHEETS-
CORRUGATED TIN**

CONCRETE BLOCKS

STONE BLOCKS

MUD & STRAW BALE

WOOD ELEMENTS

Affordability

Suitability of Use

Local Production

Availability of Skills

Use in Formal Buildings

Material Availability

Fig 4.15: Material Feasibility in Kibera

4.2   Material Mapping

4.2.1   Feasibility

Based on the above documentation, the primary construction materials commonly used in Kibera are corrugated metal sheets, concrete blocks, stone, mud, and various wood elements.[8] These materials are utilized in different forms across different regions based on their availability and accessibility to individuals. The use of this diverse variety of materials can be understood better using certain factors, including price, availability, local manufacturing or harvesting methods, and the reusability of the salvaged materials from demolition sites and landfills in Nairobi. As also mentioned by Tom Vohya in the interview, local hardware stores in Kibera often serve as the source of these materials for the local residents. By analyzing the graphs featuring each factor in fig 4.15, it becomes possible to compare different materials in each color and gain valuable insights for selecting the most suitable one with the highest overall factors. This process would greatly aid in further comprehension and decision-making regarding material choices.

Besides these material considerations, the residents of Kibera must possess the necessary skills and knowledge to work with these selected materials. This includes understanding the properties of the material and having the skills to handle and process them in the construction process. The culture of Kibera fosters a sense of mutual assistance, leading residents to support one another in the construction of homes and repairing damages similar to Merry-go-round communities for neighbourhood values and financial support, as mentioned by Neuwirth in *Shadow Cities.*[9] This collaborative approach reflects the community's commitment to communal values and improvement.

Outsourced Materials
from outside Nairobi

Import of unused material
from western countries

Mathare

Kariobangi

Kawangware

Dandora

To recycling centres
of each slum

Gikomba Market

Plastic Recycler

Kibera

Mukuru

stone supply
for construction

Source of Bamboo

Source of Straw-bale

Stone Quarries

Recycled Market/
sorting hub

Recycling Centres

Nairobi County Boundary

Major Slums

Major River system

10 Km

N

4.2.2   Movement and Resources

The materials used in Kibera are sourced either through recycling within the community itself or imported from various other locations in the city or abroad such as demolition sites or the Dandora landfill, one of Nairobi's largest waste disposal sites. An array of materials discarded across numerous countries is transported to Kenya via ships and trains in containers. Within the city, this process kickstarts an informal waste reclamation system. Salvaged materials and daily garbage from all over the city are also brought to Dandora, where it is further sorted and distributed as needed. Subsequently, these items are transported to various second-hand markets or hardware stores utilizing small trucks, effectively establishing a connection between formal and informal sectors. The City of Nairobi performs a certain level of recycling as a strategy in its waste management system, and all the other unwanted or non-recyclable garbage is brought to landfills. However, there is only enough land for making new landfills as the existing landfills are getting full so fast. This has come to the attention of authorities and residents of the city, and the issue is beginning to be addressed.

In recent years, several industries have emerged in the capital city that specialize in recycling plastic waste into various products, including building materials. The management of Dandora has also taken a step forward to accommodate this changing future in their way of working, and has set up proper steps to sort waste to support these industries. These efforts allow for similar systems and strategies that can help in better waste management and distribution of recyclable materials to Kibera, as well as all surrounding settlements such as Mathare, Kawangware, and Mukuru, amongst others.

This movement of materials has the potential to not only enhance waste segregation and processing but also extend the benefit to the local residents to gain access to these materials more conveniently. However, effective implementation would require equal coorporation and support from the city management authorities and governmental regulations to ensure its success.

Materials are conveyed to the residents' dwellings through a variety of means, encompassing motorbikes, auto rickshaws, carts, and even manually on foot, often involving only a few pieces at a time. The limitations posed by transportation necessitate that the strategy focuses on ensuring access to the most confined areas within Kibera.

4.3   Scales

Kibera, as an urban fabric, presents a diverse range of construction strategies and material usage. The selection and use of individual material is highly influenced by the cultural context and the need to accommodate the dense fabric of the settlement within limited spaces. Despite the chaotic appearance of these settlements, the clusters of structures together in Kibera are arranged by the residents to maximize their comfort. In these compact living spaces, an average of eight people, including children, adapting them to serve multiple functions at a time as the need arises.

Besides the transformative nature of dwellings, each material undergoes various adaptations at different scales within each neighborhood. The same material could take different forms to serve as a recycled material at different scales. It's crucial to understand how materials transform as the scales shift, increasing the number of users and areas simultaneously. The three scales I am documenting for Kibera are the Interior Scale, Exterior Scale, and community scale to understand the scope of design that this project can adapt.

Interior Scale

Exterior Scale

Communal Scale
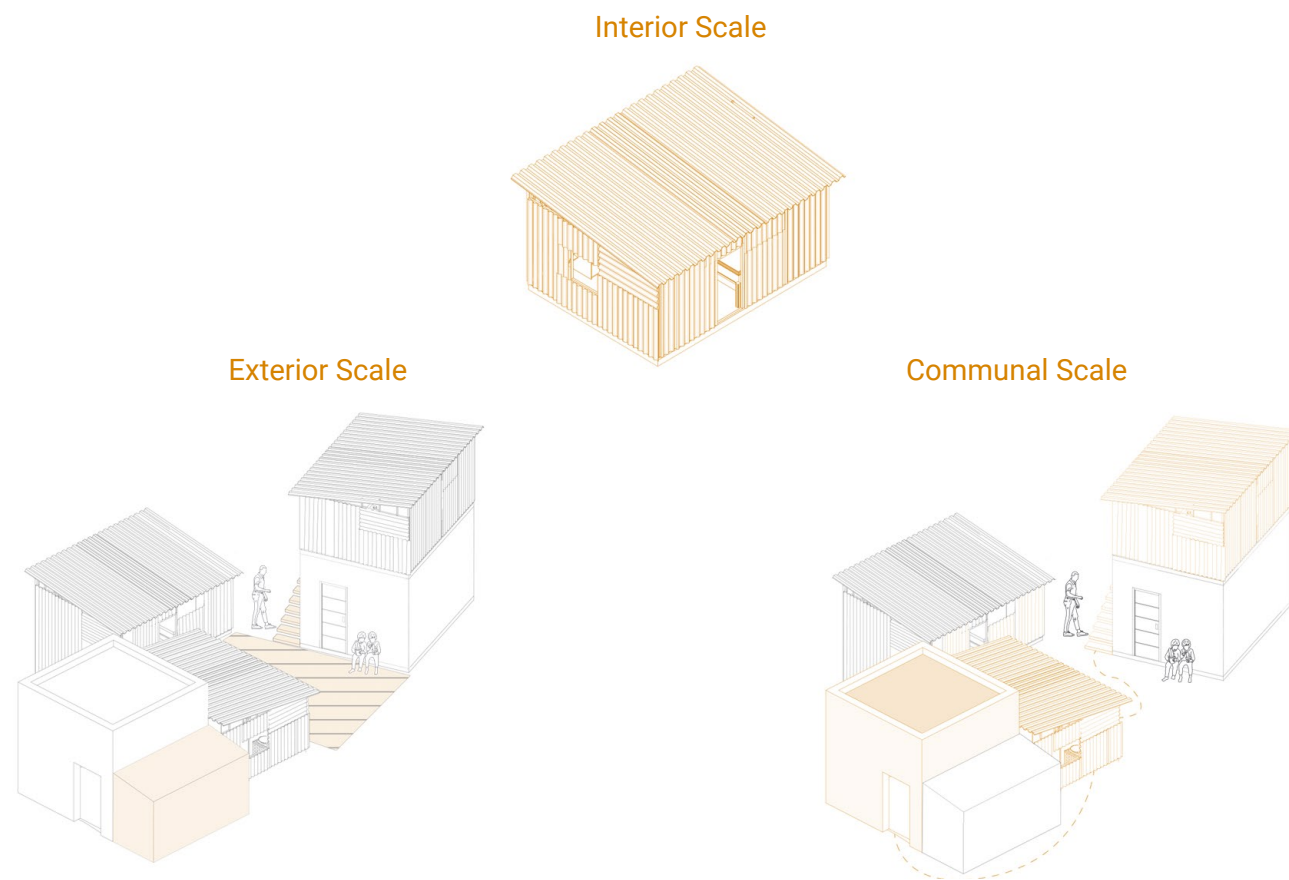
Fig 4.17: Scales of intervention (Top)

Fig 4.18: Interior Scale with elements for proposal (Right)

4.3.1 Interior Scale Documentation
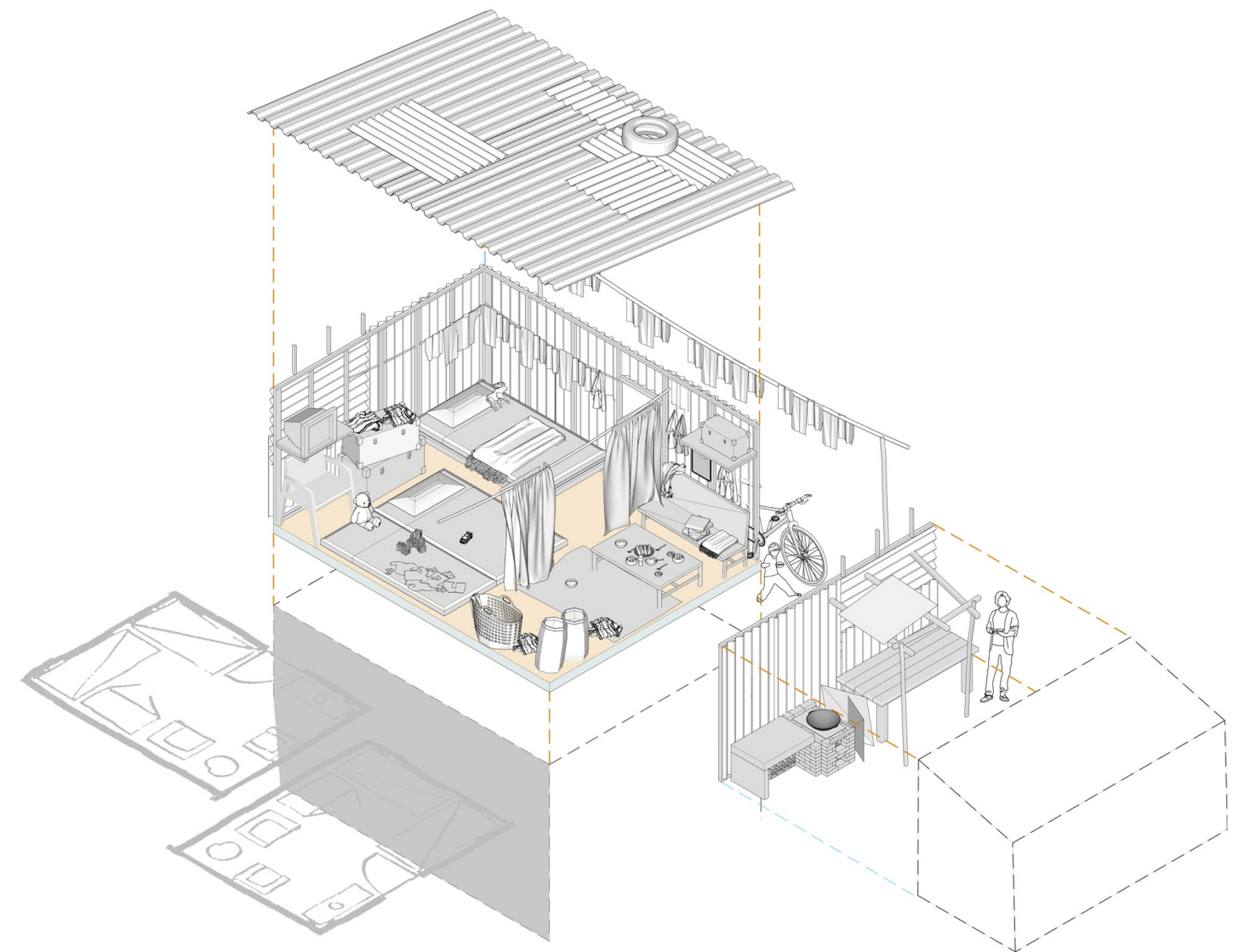
In Kibera, the house structures are remarkably straightforward, consisting of fundamental elements that serve multiple functions within a compact area. In this section, we will examine the four primary elements found in these structures and their respective adaptations in existing dwellings in Kibera. Some of these elements include:

Walls   **Floor**   **Roof**   **Extensions**
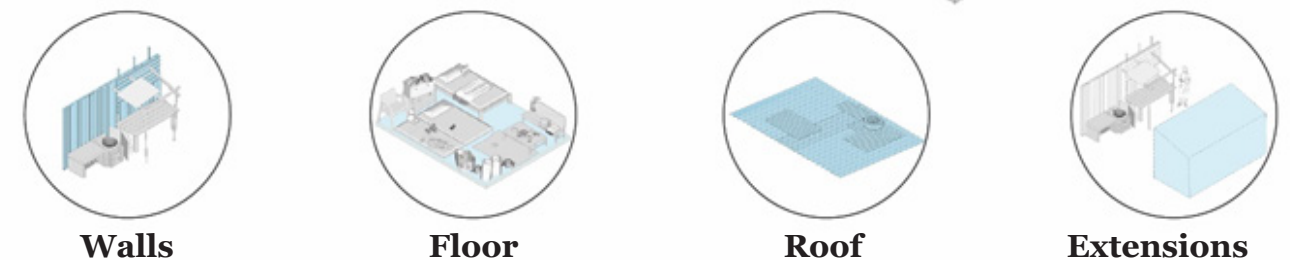
1) Wall

The wall element in a small-scale dwelling serves numerous roles indoors and outdoors. Apart from creating a physical barrier between the public space and the interior, it fulfills multiple functions within the living space. The dynamic use of the materials involved is to the best of the user's knowledge and their efforts to sustain the fixtures to the maximum of their ability. These can be constructed using various different materials as seen in the documentation section above. The use of it in the interiors would depend on the materials used and the level of flexibility it provides.
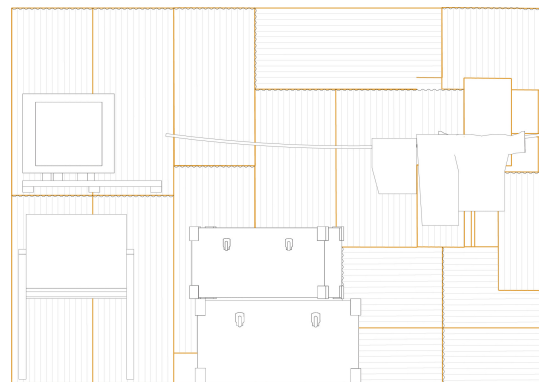
Fig. 4.19: Interior Wall Elevation

A significant surface area of a wall is utilized for hanging clothes and various other items. This is achieved by simply hammering a nail into the metal sheets or attaching extensions as platforms to store daily cosmetics, televisions, or mirrors. The residents make use of the limited wall surface to the maximum to store things and create functional solutions.
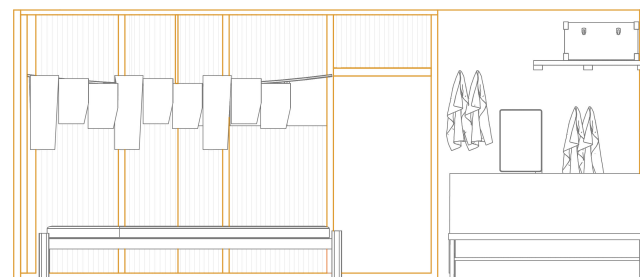
Fig. 4.20: Interior Entrance Wall Elevation

The interconnected nature of walls requires constant repairs. The addition of unplanned weight to these structures is through the attachment of sticks and ropes to hang clothes and make a transitional storage layer to the wall. It adds extra strain by the unconventional joinery to the corrugated metal sheets or cement plaster, leading to instability. These make-shift elements add extra responsibilities on the users to constantly repair to maintain the structural stability of the houses.
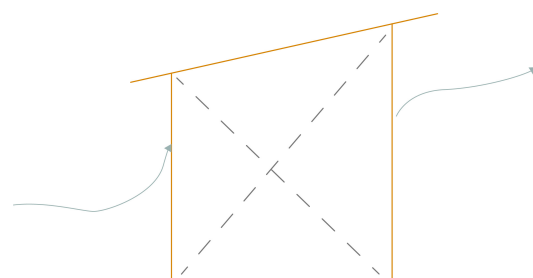
Fig. 4.21: Section of a dwelling

As mentioned by Neuwirth in the book "Shadow cities" the densely packed arrangement in Kibera often results in close proximity of the walls, leaving little space for ventilation.[10] Therefore, most of the houses do not have windows as there is not enough space to open them outside. In some instances, either there are shared walls or are positioned too close to one another, making it challenging to incorporate windows.

2) Floor

The floor has a very multifunctional use in a dwelling. Despite trying to keep the level raised from the exterior level, it has a very dynamic use throughout all day's activities. Different sections of it are used in different arrangements of movable furniture.

One major activity as documented in the documentary "Footprint" by Valentina[11] shows that the floors of the dwellings is often used for dining together. In Kibera's culture, people tend to eat together as a family on the floor and sometimes use a table as a platform to store food. They tend to use some floor cover to avoid direct contact with the irregular floor.
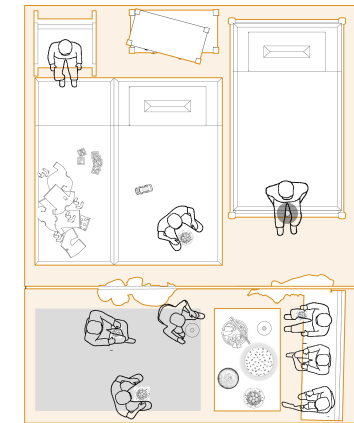
Fig. 4.22: Floor used for daily meals

Similarly, Footprint also shows that the dwellings have a semi-furnished sleeping system including low beds or just some thin mattresses on the floor the families also tend to sleep together and share their space uniformly. The irregular floor and other social issues do interrupt the usual pattern of their lives but the lifestyle of the residents finds some alternate methods.
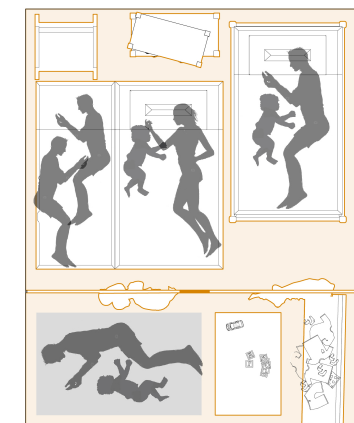
Fig. 4.23: Floor used for resting

Irregular urban infrastructures and unmaintained water streams all around Kibera causes the regular roads to turn into secondary streams for water to flow during floods. The irregular topography makes this change directly affect the dwellings in significant ways in some areas. The residents use sandbags on all the low-floor areas of their houses to try to prevent the water to seep in as shown in Fig 4.7. Despite all the efforts, many residents still cannot escape the situation.[12]
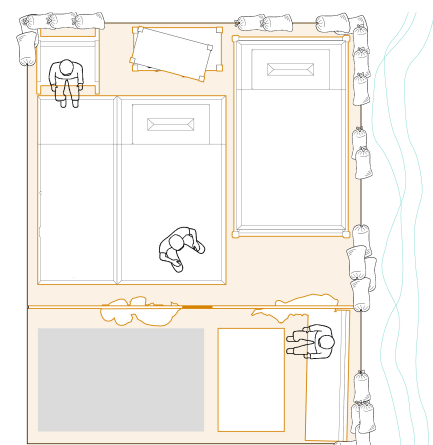
Fig. 4.24: Water leakages and sand bags used for floods

3) Roof

The roof structure is the most important but neglected element in a dwelling in settlements like Kibera. It is an essential part to keep the residents protected which also comes with a lot of other issues in it.

The irregular stitching of the top layer (mainly, corrugated metal sheets) on an unorganized bamboo or salvaged wood frame makes it easy to dislocate and sometimes even fly off. There needs to be additional weight to keep them in place or end up in a lot of dripping in the houses disturbing the entire interior setups.[13]
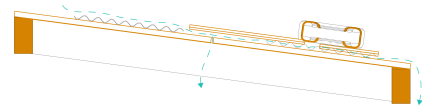
Fig. 4.25: Water leakage from roof in a dwelling

The roof's compact nature also doesn't leave any scope for any new element to allow ventilation in the interiors. Lack of any ventilation from either walls or roofs makes the dwellings very compact and suffocating.
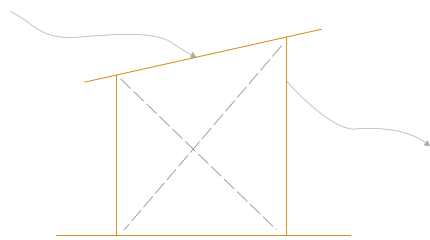
Fig. 4.26: No ventilation through roofs

4) Extensions

The extensions are a use of multifunctional public or common space outside the dwellings. They are well accommodated and tactical in nature that the spaces are happily shared amongst the neighbours. It serves as an extra space that allows for more movement and breathable space for many of their daily life activities outside their small 3m x 3m or 3m x 4m dwelling units.

In these informal extensions, one of the primary activities is cooking. Although some households try to make space inside their houses, they prefer cooking outside due to health reasons. The furniture used for cooking is movable and flexible to allow for other activities as well.[14]
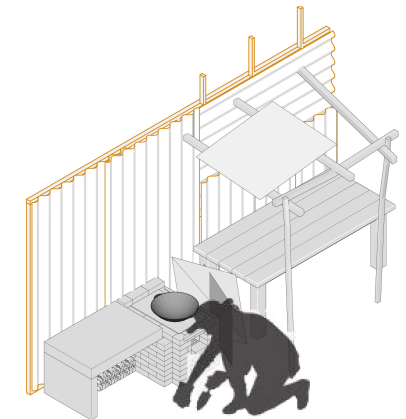
Fig. 4.27: Open Cooking platform outside houses

Since there is already a set of furniture that moves in and out of the dwelling daily the woman in the house also often prefers to run a small home-based business like selling vegetables or any other products to create a micro-economic income to benefit the household. These activities merge with cooking needs and run simultaneously.
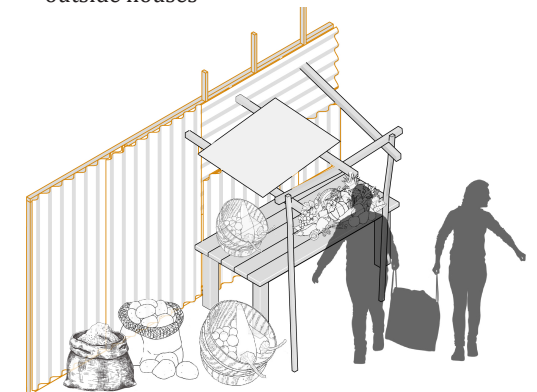
Fig. 4.28: Outside space of a dwelling used for home grown businesses

In some parts of Kibera, there is a community-based organization that promotes many female residents to participate in activities like sack gardens which they can just accommodate right outside their houses. Some of them do struggle with space and proper arrangement to keep the sacks safe and secure but they manage to create their small kitchen garden to participate in the community.
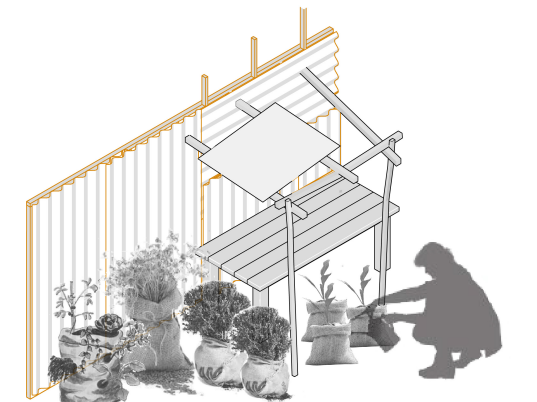
Fig. 4.29: Outside space used for communal activities like gardening

Fig. 4.30: Exterior Scale
Documentation (Top)

Fig 4.31: Businesses outside dwelling
on main street (Right)

4.3.2 Exterior Scale Documentation

In the context of an urban fabric highlighting marginalized communities, none of the issues can be seen in an isolated manner. All the issues are interlinked and have an implication on one another not just for one dwelling but also for a group of houses in a neighborhood. The living culture in Kibera is different from their traditional practices and is very much interdependent on the community. The materials are accommodated in a bigger and completely different way in a smaller fraction of urban space. The collective nature of repairing and supporting the culture is very integrated with the individual dwelling unit analysis.

A more effective implementation of materials and improved structural stability in the existing dwellings will create greater possibilities for the surrounding residents to adapt and support informal or formal systems. This intervention will also allocate space for communal engagement programs and essential infrastructural facilities, such as toilets, drinking water kiosks, and courtyard spaces. Many of these elements are already being utilized through various community-driven initiatives.

MATERIAL STORAGE

RECYCLING CENTRE

WORKSHOPS /
MATERIAL TRAINING

4.3.3   Communal Scale

To be able to initiate a process of recycling for the earlier stages a much more comprehensive process must be created which makes it easy for residents to adapt to and gain access to the materials more conveniently. An interconnected system of facilities can help improve the movement and circulation of materials for the entire community. It can start with a smaller scale and then can be adapted at a larger scale in phases over the years.
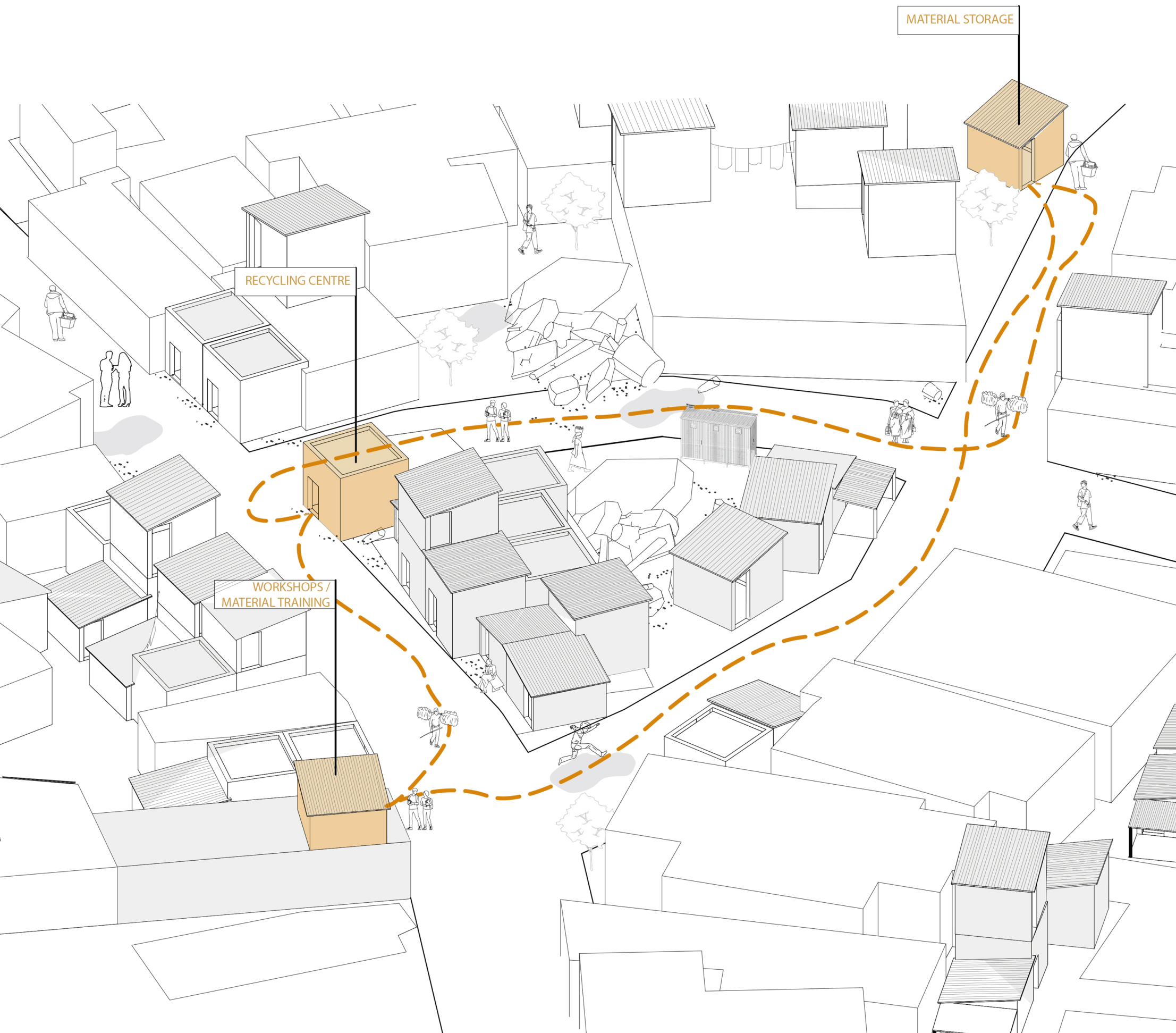
Fig. 4.32: Community Scale
Documentation

Endnotes:

1   **Forensic Architects. 2020**. *"Les Usage Du Monde - New Ways of the World."* 2020. https://forensic-architecture.org/programme/exhibitions/les-usages-du-monde-new-ways-of-the-world.

2   **Rahbaran, Shadi, and Manuel Herz. 2014.** *Nairobi, Kenya: Migration Shaping the City. 29,* Edited by Jacques Herzog and Pierre de Meuron. Zürich, Switzerland: Lars Müller Publishers.

3   **Tyman, John. n.d.** *"Cultures in Context Series African Habitats: Forest, grassland and slum* Studies of the Maasai, the Luhya, and Nairobi's Urban Fringe." Access Date: 10 May, 2023 http://www.johntyman.com/africa/11.html.

4   **Belanger, Jean-Francois. 2023.** *"Kenya, Une Historie Africaine: La Poubelle De La Mode."* 2023. Access date: 03 March, 2023 https://ici.radio-canada.ca/recit-numerique/4874/kenya-poubelle-mode.

5   **Saunders, Doug. 2010.** *Arrival City: How the Largest Migration in History Is Reshaping Our World.* 63. London: Heinemann.

6   **Shadi and Manual,** *Nairobi, Kenya: Migration Shaping the City. 33.*

7   **Ochieng, James. 2021.** *"Bio-Centers: Providing Better Sanitation, Income for Kibera Residents."* Journalism Initiative. 2021. Access Date: 10 May, 2023 https://healthsojo-africa.org/bio-centers-providing-better-sanitation-income-for-kibera-residents/.

8   **Doug,** *Arrival City, 63.*

9   **Neuwirth, Robert. 2016**. *Shadow Cities: A Billion Squatters, a New Urban World.* 90-91 London: Routledge

10   ibid, 72-74

11   **Canavesio, Valentina, dir. 2016**. *Footprint.* Women Make Movies.

12   **We are water. 2021**. *"Kibera, the Slum as a Sympton."* 2021. Access Date: 03 March, 2023 https://www.wearewater.org/en/kibera-the-slum-as-a-symptom_340571.

13   **Ondivow, dir. 2017.** *Raindrop.* Access Date: 03 March, 2023 https://filmfreeway.com/Raindrops269.

14   **Ondivow,** *Raindrops*

Chapter 05:
Design Intervention
An Unconventional
Approach

Fig 5.1: Conversations about
Materials

FLOOR

ROOF

INDIVIDUAL DWELLING

EXTENSION

WALL

INTERVENTIONS

WOOD WORKSHOP

RECYCLING CENTRE

METAL WORKSHOP

CASTING SHOP

COMMUNITY CENTRE
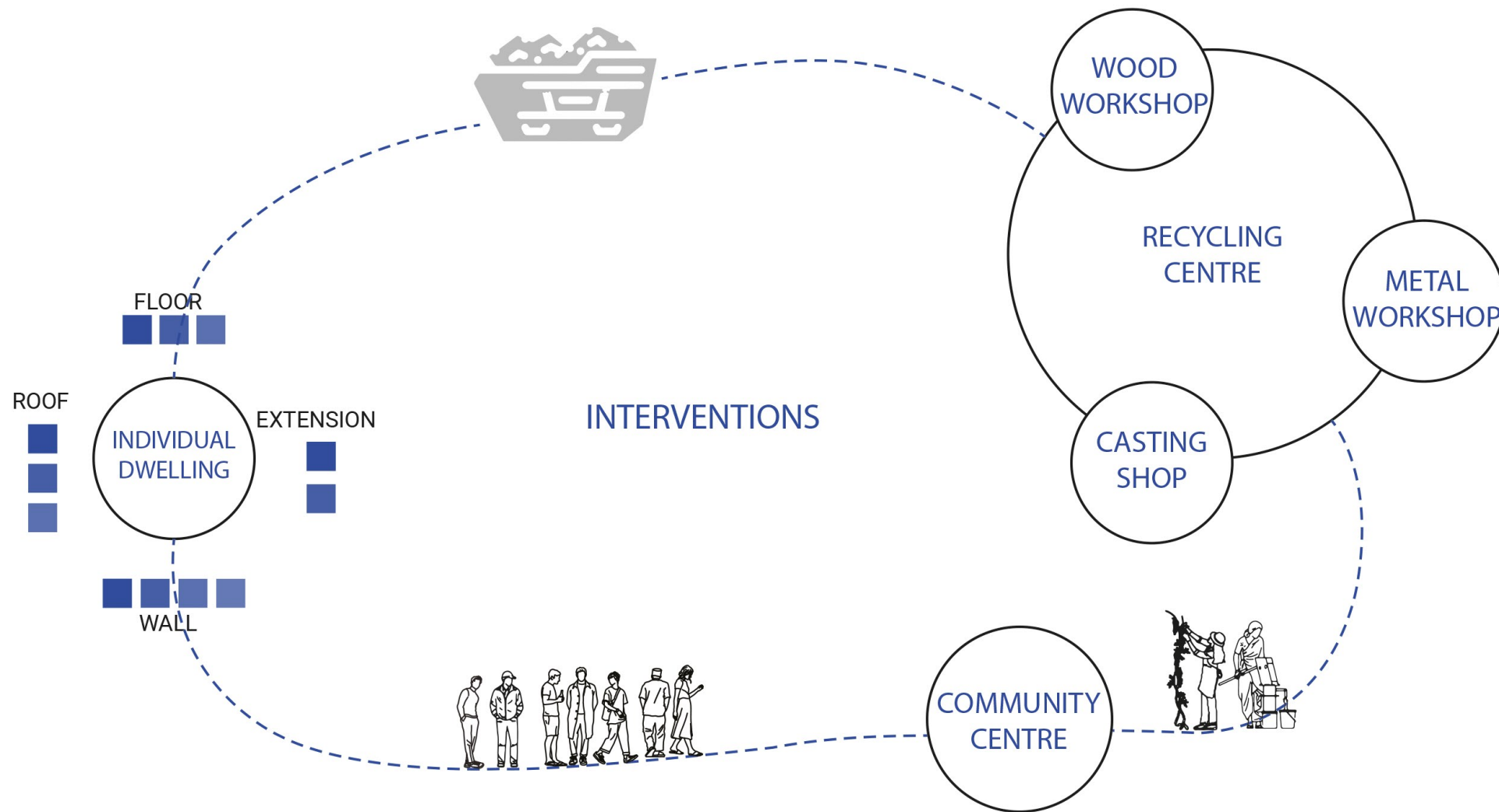
Fig. 5.2   Program Formulation

Program Formulation

The design for incorporating recycled material addresses multiple scales, including the collective urban, individual, semi-public, and semi-private, to provide people with access to materials and facilities for constructing these assemblies. These stages are closely interconnected, influencing each other throughout the process, with active participation from the residents in various aspects.

The strategic understanding of this process is drawn from various community-based organizations in Kibera, which facilitate material exchanges over time, allowing individuals to construct their own structures. This approach empowers people to take ownership of their existing structures and extends the benefit of assembling their future transitional housing without significant investment.

Within varying scales of design, specific objectives are prioritized, envisioning this design as a source of inspiration for the future development of the community. It incorporates various narratives that hold significance in the forthcoming years, ensuring a comprehensive and inclusive approach to meet the needs of the people.

Design Objectives

Quality Controlled Construction

Sustainable design

Local Employment

Better Material Availability
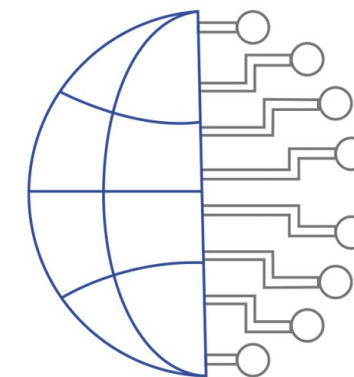
Technology Integration

Architecture as Education

Designing Assemblies

The first part of the design proposal focuses on the combinations of different stages of the new life of any material.

Assemblies:
The objective is to create a suitable assembly by combining different materials that can offer significant benefits and easy adaptability for the residents of Kibera. Each element presents multiple proposals following the same approach. The previous chapter extensively documents several proposals for each element found within a dwelling in the settlement.

Dwellings / Structures:
After finalizing the design with a specific set of assemblies, the subsequent task is to identify potential combinations of these assemblies that can converge to form a resilient design for a dwelling unit. As many of these assemblies are most suitable for such a space, the objective is to maintain open-ended possibilities that can be achieved using only a limited number of assemblies. The goal is to foster versatility and adaptability within the design, allowing for diverse configurations with just a small set of elements.

Community/neighborhood:
The replacement of even a single wall or any other structure in these dwellings can significantly alter not only the potential utility of that particular dwelling but also the overall environment of its surroundings. Introducing a green factor through one wall goes beyond mere structural changes; it fosters community engagement and serves as an inspiration for other residents to follow suit. This series of changes will cascade as the design intervention takes root and begins to adapt within the settlement.

Tagging system:

The analysis of each material involves studying its interactions at various scales and forms, including assemblies and structures, with the ultimate aim of enhancing the community's well-being. To effectively categorize and comprehend the materials' attributes and suitability, several tags or factors can be employed. These tags serve as valuable tools for users to understand their unique requirements and make informed decisions aligned with their budgets. Building upon the material documentation section, the following tags hold relevance:
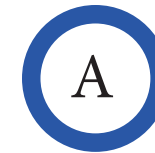
A — Affordability
This tag enables users to make financial decisions. By considering the materials used and their prices, it helps determine if a specific assembly or structure is generally affordable. However, affordability may vary based on the budget of individual households.

G — Green
This tag represents the incorporation of environmentally friendly elements or the potential to add a green factor to the design. Users have the flexibility and freedom to choose whether or not to include sustainable features in their design.

TE — Time Efficient
This tag identifies the most time-efficient assemblies that allow for quick replacement of elements. It relies on careful selection of materials and efficient joinery techniques to expedite the assembly process.
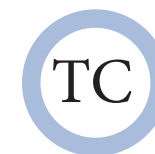
TC — Time Consuming
This tag represents the opposite of the previous one, indicating that the assembly requires a longer period of time for various reasons such as limited material availability or complex making processes.

MA — Material Availability
This tag is assigned to materials that are readily accessible, either locally or easily sourced from various locations without significant delays

SI — Skill Intensive
This tag is used for assemblies that require specific training or skill development before implementation. Users may need to acquire new skills or undergo training at a designated center to successfully utilize these assemblies.
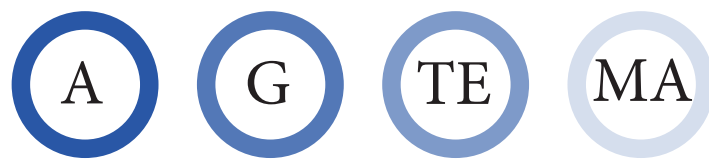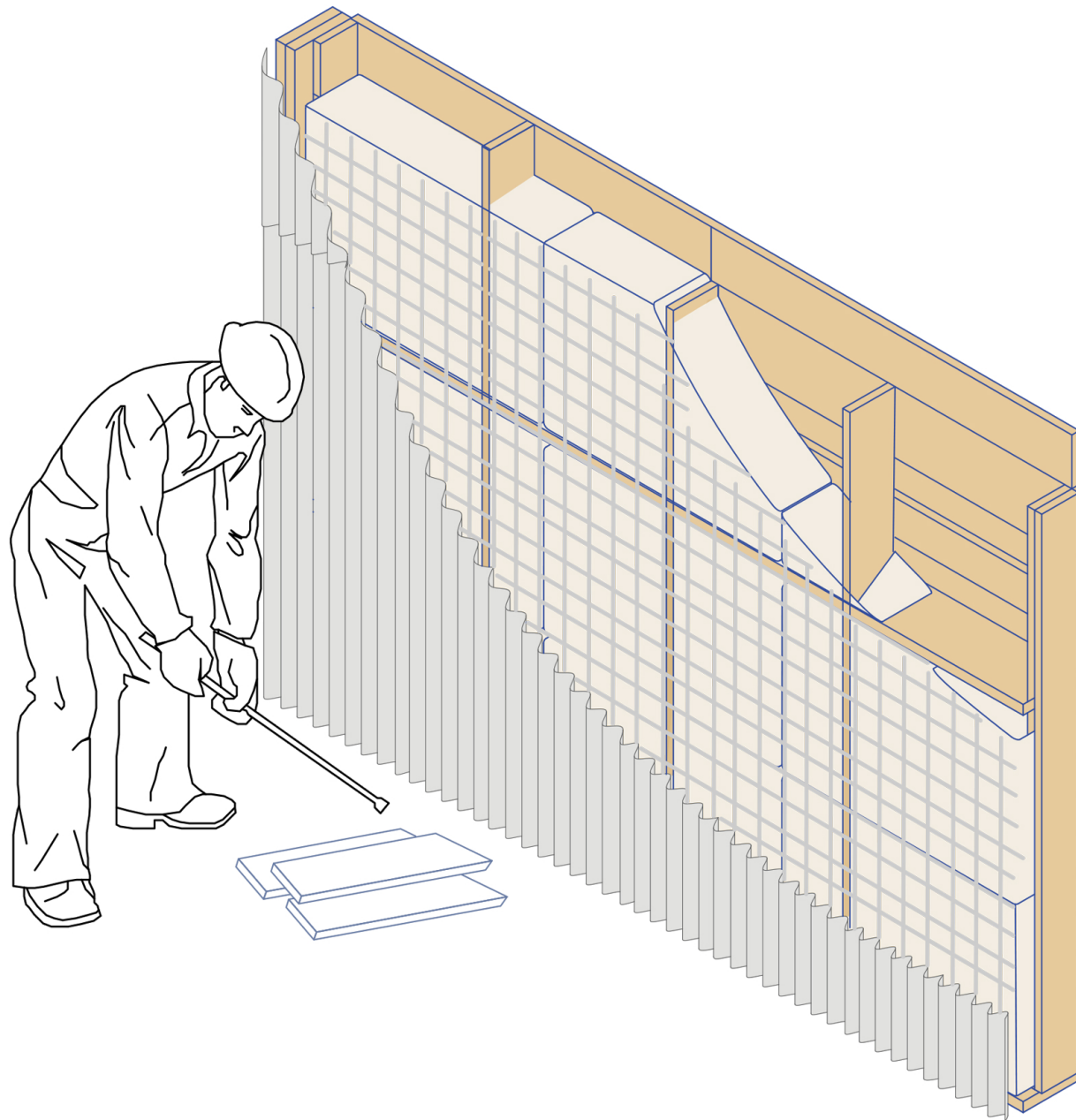
Fig. 5.3   Wall Assembly 01

W-01

Incorporating the most common waste materials found in the neighborhood, this assembly focuses on insulating the wall to improve its performance. The inspiration for this idea came from the interview with Tom Vohya and their project, while the assembly's concept draws from the Pallet House Project by I-Beam Designs[1] in India, which aimed to provide accommodation during natural disasters.

Layers:

- Wooden Palette (Interior Layer)
- Clay and straw Panel filling (Insulation)
- Chicken Wire - Protection
- Steel Sheets (Exterior Layer)

Advantages:

- Ease of modification to the layers individually. Exterior layers are easily dismantable to replace or repair the middle insulation layer.
- Insulation Layer : The middle straw bale layer, being a very cool and biochemical material helps in keeping the interior temperature moderated alongside absorbing water in case of leaks.
- One of the exterior layers being made out of wooden palettes , allows easy extensions to nail or add a platform for multiple purposes.

Disadvantages:

- Multiple materials to make different layers can result in longer waitlist in case materials goes out of stock
- The design of wooden frames can change, due to availability of different sizes of panels.

Restrictions:

- Require stable and planar base to fix this assembly. The floor needs to be solid.
- Longer time in case of a longer waitlist.
- Need certain air pockets on the pallet side of the aseembly for air movement to keep the straw dry.
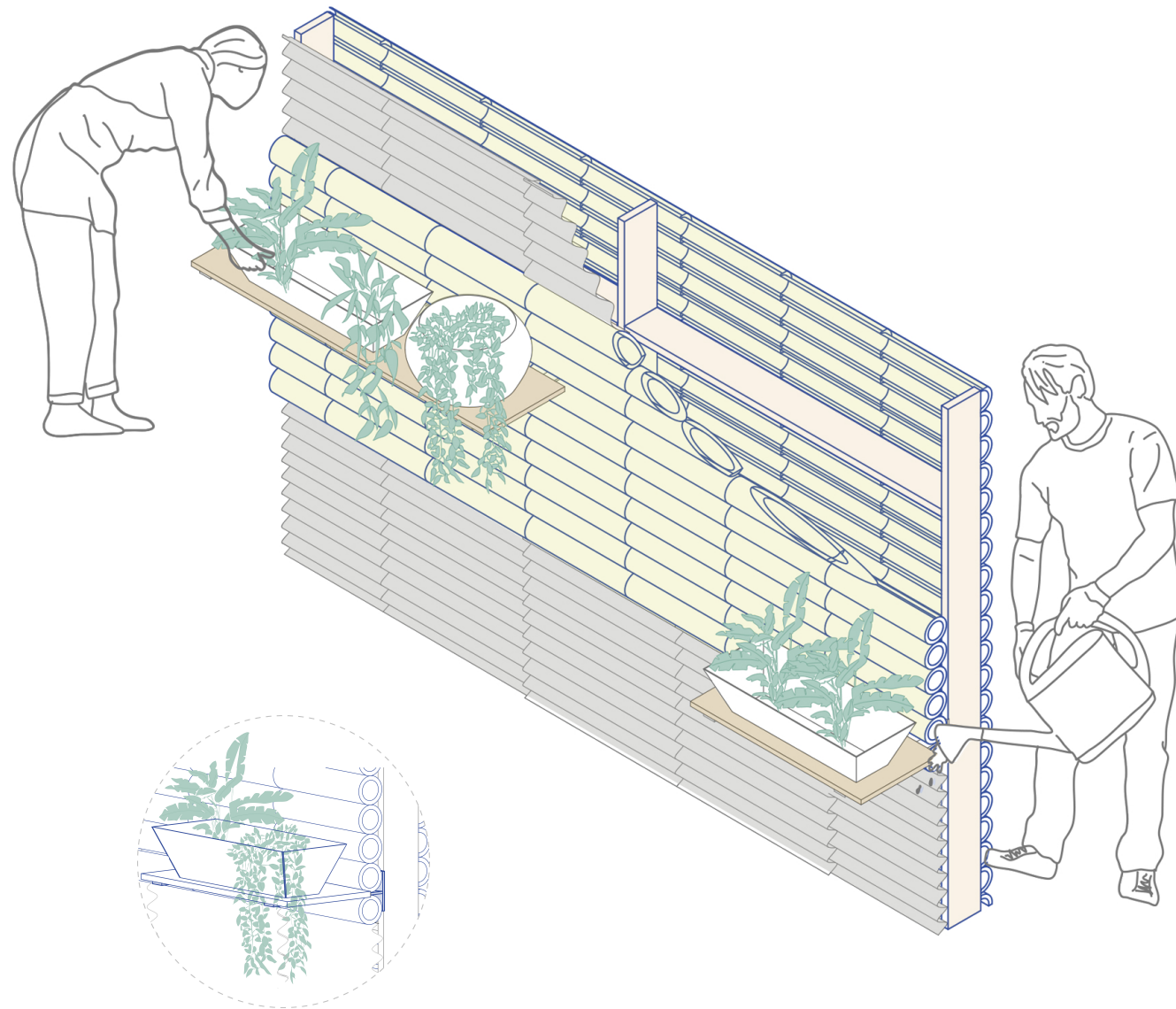
The clamp system to attach gardens.
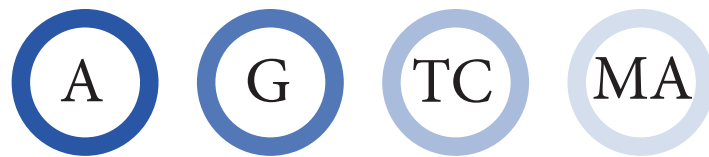
Fig. 5.4 Wall Assembly 02

W-02

To enhance the traditional timber and corrugated sheet wall design, this assembly introduces a sustainable element by incorporating half-cut bamboos. The inclusion of these bamboo pieces adds translucency to the wall and facilitates airflow. Through secure attachment to the timber frame, the bamboo can provide additional support. Moreover, the gaps between the bamboo elements can be utilized as platforms for various garden elements, further contributing to the environmentally friendly approach of the design. The intricate details realted to bamboo is referred to the book "Building with Bamboo" by Minke Gernot. [2]

Layers:

- Alternate Bamboo and metal sheets (interior and exterior layers)
- Wooden frames

Advantages:

- Provides opportunity to add sack gardens within the vertical assembly, saving space.
- A combination of half-cut bamboo and metal sheets provides flexibility and agency to the user and makes the assembly comparatively economical.
- The overall quantity of bamboo becomes less, with half-cut arrangement. It is also easy to replace and repair.
- The half cut bamboo has inbuilt gaps to allow for systematic extensions.

Disadvantages:

- Needs to be mounted well on ground, for proper structural stability.
- Hollow space around the frame can add to animal /insect habitation, chicken wire can prevent some.

Restrictions:

- Need a stable platform or plain to place the assembly structurally stable.
- The location should take into account prevailing wind and rain conditions for proper drainage and to avoid excess overloading of soil and assembly.
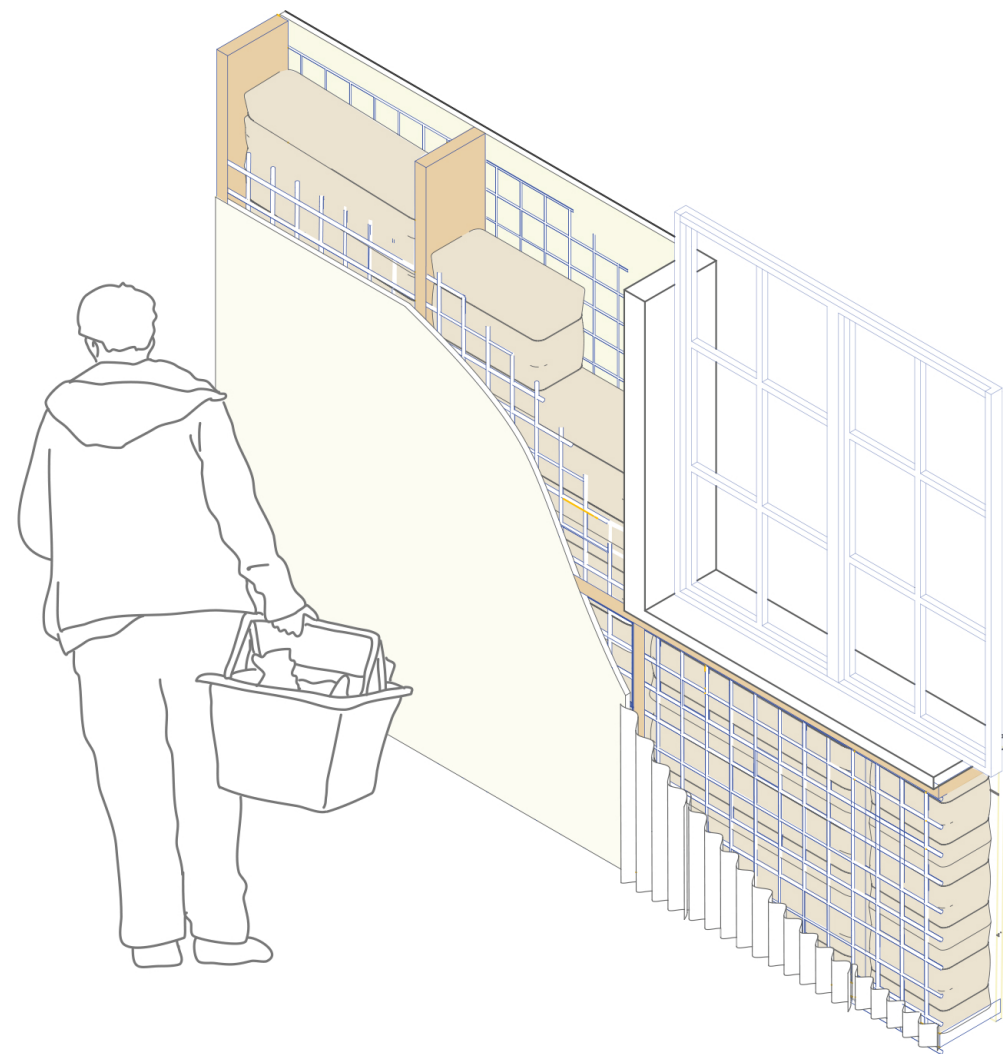
W-03

This assembly employs the practice of using pre-fabricated panels filled with straw-bale, which enhances moisture control and construction precision. The concept draws inspiration from the experimentation conducted by architect Sverre Fehn in the Mauritzberg Test house project[3], where the design proved to be easily movable. The exceptionally well-insulated panels perform admirably in the house and can be adapted to suit different climates with minimal modifications.

Layers

- Lime plaster and metal sheets (exterior layer)
- Straw-bale (insulation)
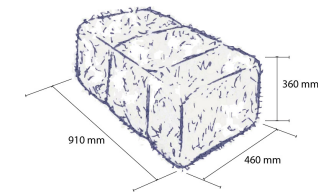
Advantages:

- Alternate lime plaster and metal sheets provide flexibility to replace or refill straw. Opens like a straw window to the assembly.
- Lime plaster coated with a waterproof agent provides prevention to water absorption.
- Metal sheets provide flexibility and agency to use most available material and make the assemblies cheaper.
- Straw is locally available in Kenya and easily prepared and reused into a new bales.

Disadvantages:

- If used in extreme rain orientation, it could require repair of plaster.
- Timber frame and chicken wire mesh needed to provide frame for installing of straw-bale.

Restrictions:

- Require a solid platform to install. Could also be a metal or concrete screed on the floor.
- Careful application with extreme condition sites.

Fig. 5.5   Wall Assembly 03

TC   MA

G   TC   SI

A   G   TE   MA
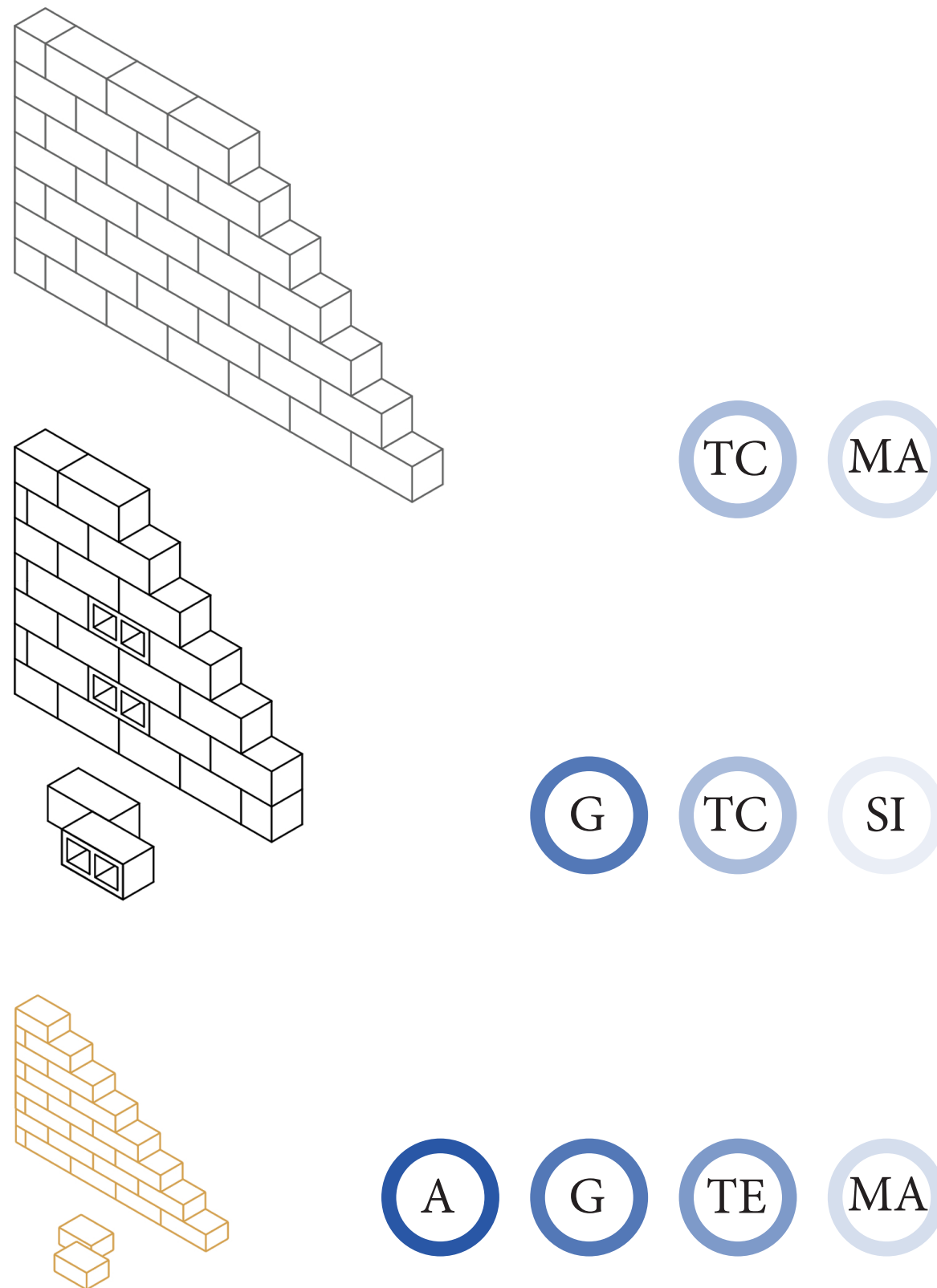
Fig. 5.6   Wall Assembly 04

W-04

The approach to using three materials in constructing the blocks demonstrates an advancement compared to the locally accepted materials. Although concrete blocks are easily accessible, the ones employed here are made from crushed concrete and recast into molds, enhancing their properties. [4]

The use of Compressed Stabilized Earthen blocks (CSEB)[5] is another innovative choice, and they can be conveniently produced locally with just one compressing machine.

Introducing hempcrete blocks represents a particularly progressive step, as hemp is not a readily available material in the neighborhood. However, considering the numerous advantages of hemp, such as its biogenic nature and potential for the future, there is hope that it will gain acceptance in the community.

Layers:

- 01- cast crushed concrete
- 02- Compressed mixture of hempCrete and binding materials like clay or lime.
- 03- Compressed mud blocks, or Compressed stabilized earthen block (CSEB)

Advantages:

- This variety of products these mixtures can create expands the variety of assemblies and options for local construction.
- Recycled concrete can help reduce the carbon footprint of the material and provide stable blocks for construction.
- HempCrete blocks can be locally pressed into blocks, and also compacted on site if needed.
- Mud, the most used material can be prefabricated into blocks to increase lifespan and stability.

Disadvantages:

- Hemp pre-processing needs a different facility before it comes to the recycling center.
- Concrete blocks are the most time consuming factor, due to their curing requirements.

Restrictions:

- All these blocks require more physical labor as compared to other materials, and have stages to produce the final product.
- Requires more equipment and facilities.

R-01

The design of this assembly, aimed at maximizing ventilation within the structures, utilizes simple and easily accessible materials in Kibera. The inspiration for this design comes from the collaborative efforts of Jason Anderson and Alan Wright of Relief International, who worked on tsunami shelters for a school in Sri Lanka[6] with the involvement of local communities and parents.

Layers:

- Bamboo (framing)
- Metal sheets (exterior finish)
- Fastening Materials (screws, nuts, bolts, and washers) for joinery

Advantages:

- The raised framing system allows more daylight to structures along with better ventilation.
- A decent slope design could provide better drainage of rainwater to one side of the structure and easy water collection.
- The content of the design allows to be lightweight, making it feasible for different types of wall assemblies.
- Easy repair and replacement

Disadvantages:

- Needs extra arrangement of metal sheets or bamboo sheets to cover the sides, to prevent water.
- Larger space would require complex truss design. It could mean more bamboo.

Restrictions:

- Needs regular and level wall structure to sit on.

Fig. 5.7   Roof Assembly 01
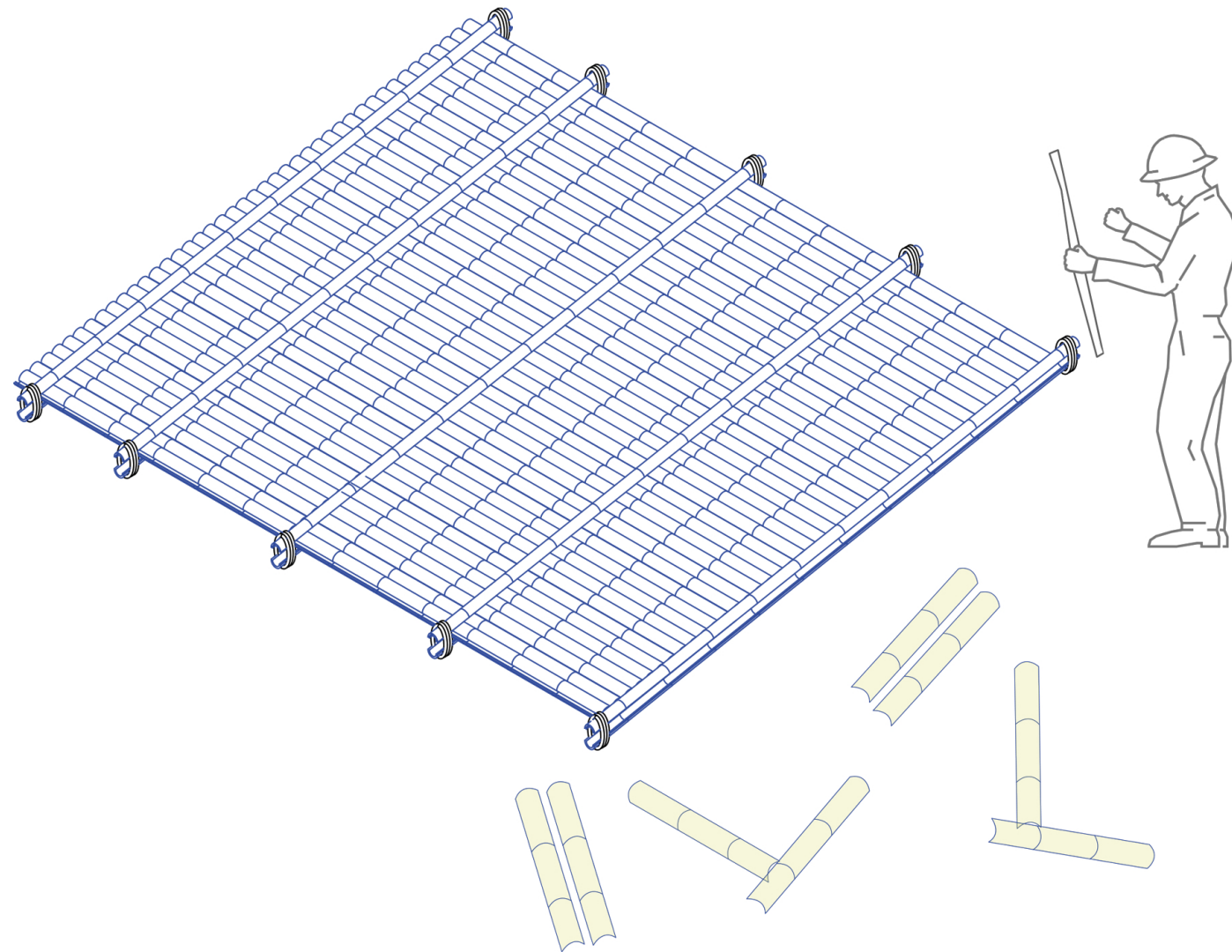
R-02

This assembly takes inspiration from the time-honored bamboo construction practices observed in various Asian countries. The technique has been extensively explored and applied in a project at the Green School in Bali, Indonesia[7], showcasing its suitability for local construction. With ample bamboo supply, this approach holds great potential for adaptation in other regions across the world.

Layers:

- Half-cut bamboo (framing)
- Timber side frame

Advantages:

- The interlocking bamboo frame allows easy assembly and draining of water. It can have an inner layer of bamboo woven sheet to provide an extra layer to interiors.
- Easy fixing in the initial stage.
- Single material gives more flexibility to adapt.
- Under layer provides extra dripping protection.

Disadvantages:

- More wait time, if material is not available.
- Replacement is a challenge, as at least half of the roof will need opening up to replace some parts.

Restrictions:

- Restricted slope for proper rainwater draining. Extra slope can work results in need of inner layers for more protection from joinery leaks.

Fig. 5.8   Roof Assembly 02
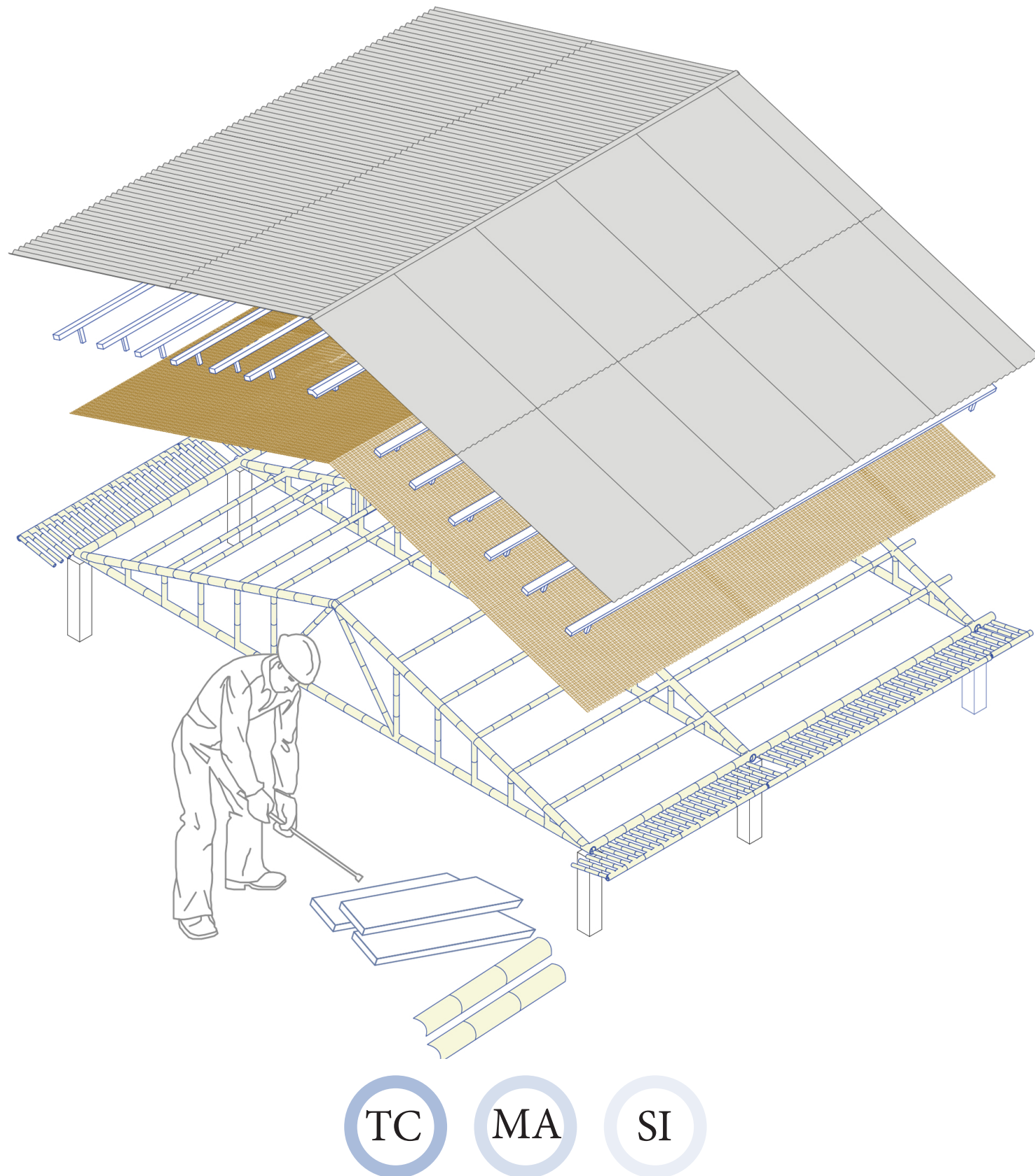
Fig. 5.9   Roof Assembly 0

R-03

The proposed assembly suggests a double-roof system, which includes a ventilation gap between two screens, the external and internal layers. This innovative design, as outlined in the housing unit project for the Opera Village Remdoogo in Burkina Faso by Francis Kere[8], proves to be a well-suited combination to effectively mitigate overheating within the structure.

Layers:

- Bamboo truss structure (inner framing)
- Wooven bamboo sheet (inner lining)
- Metal running frame (outer frame)
- Metal sheet (outer layer)

Advantages:

- The double roof provides more ventilation within the structure, best suitable for more compact spaces.
- The layer is material, allowing more stability and protection from weather conditions.

Disadvantages:

- Multiple materials could lead to more wait time, for all the materials to become available.
- Needs more hands and time to assemble.

Restrictions:

- Could require certain knowledge or skill to attach all the layers efficiently.
- Time consuming assembly.
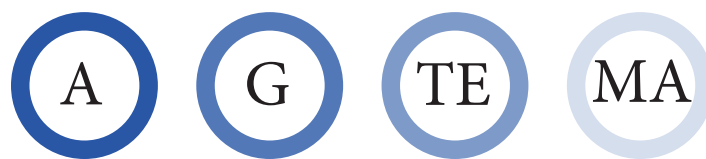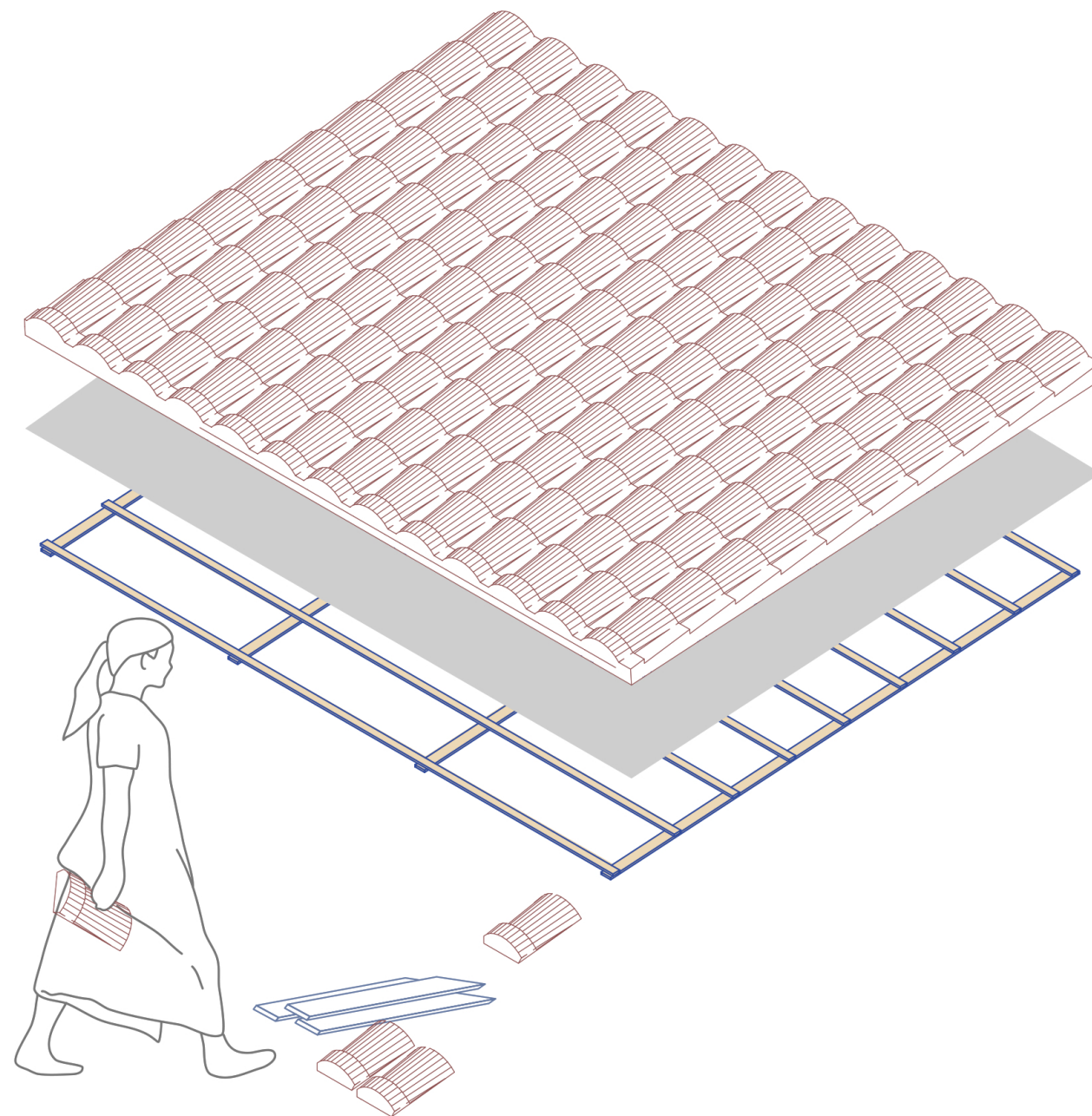
Fig. 5.10 Roof Assembly 04

R-04

The proposed assembly draws inspiration from early childhood development centre in Rwanda.[9] The use of tiles proves highly effective, especially in climate like Africa, as they provide excellent interior cooling and protection against rain. Crafting these tiles is a meticulous process involving careful heating to achieve stability. When combined with a timber frame and appropriate sheathing, this assembly results in a durable and sustainable roofing solution.

Layers:

- Timber frame
- Sheathing layer (Waterproof boards or Carton based ReWall)
- Terracotta tiles (outer cover)

Advantages:

- Terracotta tiles naturally cool the space and is a very eco-conscious material.
- Require less materials, and less time to assemble.
- Can design the slope as needed, provides flexibility to combine with other assembly designs.
- Naturally waterproof material.
- Easy repair and replacement

Disadvantages:

- High slope design might require a side wall to prevent water dripping.
- Material availability: the tiles are prepared artisinally, not self built.
- Outsourcing can make it a bit expensive.
- if not attached down well, they get liable to blow off in high wind.

Restrictions:

- Availability and supply of material as and when needed.
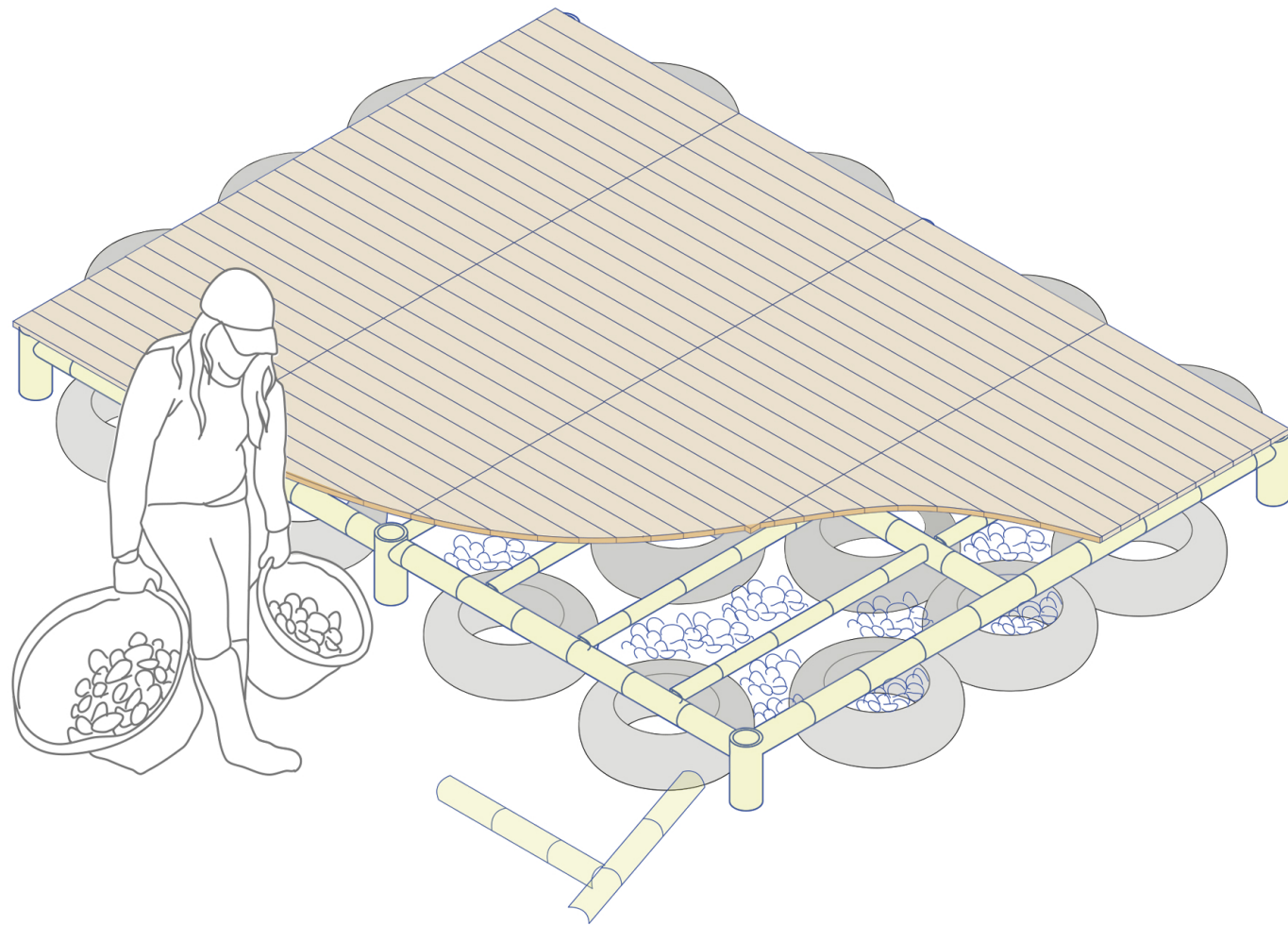
F-01

In this assembly, an innovative approach incorporates the use of tires as fillings within a bamboo frame foundation, which rests on a concrete base. The inspiration for using tires comes from the work of earthships[10], where tires are ingeniously employed as building materials in construction systems alongside compacted earth for walls, foundations, and retaining structures, effectively repurposing waste materials.

Layers:

- Bamboo Frames
- Tires with Pebbles and mud (filling)
- Bamboo wooven sheet/wood boards (top finish)

Advantages:

- Easy to repair and replacement
- Require less materials, and less time to assemble.
- Easy for small and movable extensions.
- More sustainable and locally available materials.
- Accomodates flooding and prevents damage to the core of the foundation.

Disadvantages:

- Top layer needs more repair
- Doesnt have a very deep in-ground foundation
- Weathering of filling

Restrictions:

- Continuous repair of top layer and filling.
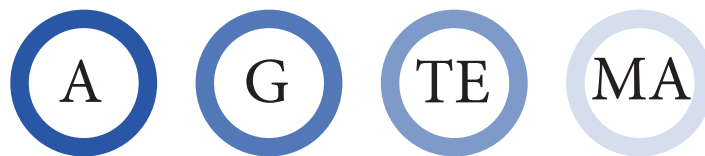
Fig. 5.11 Floor Assembly 01

F-02

Recycled concrete plays a significant role in construction waste. By recycling, it lowers carbon footprint and improves cost-effectiveness. The process involves crushing existing concrete into smaller portions, making it suitable for recasting with an addition of admixtures to increase adhesiveness, thus contributing to sustainable construction practices.

Layers:

- Cast recycled concrete (top coat)
- Gravel (under layer)
- Concrete strip Footing

Advantages:

- Stable and allows plane platform for above assemblies.
- Holds more deeper and stronger on the loose soil.
- Less maintenance
- In some cases, only the Concrete screed is used as a single layer, for quick fix situations.

Disadvantages:

- Could be expensive for bigger space, or even smaller spaces for some households.
- Can break if hammered or drilled in too much.
- Needs other expensive materials to cast, like binders and adhesives.
- More permanent and less flexible to movement and replace.

Restrictions:

- Require involvement of the structure owner and could be used to provide a better space to tenants but maybe with a raised rent.

TC   MA   SI

Fig. 5.12 Floor Assembly 02
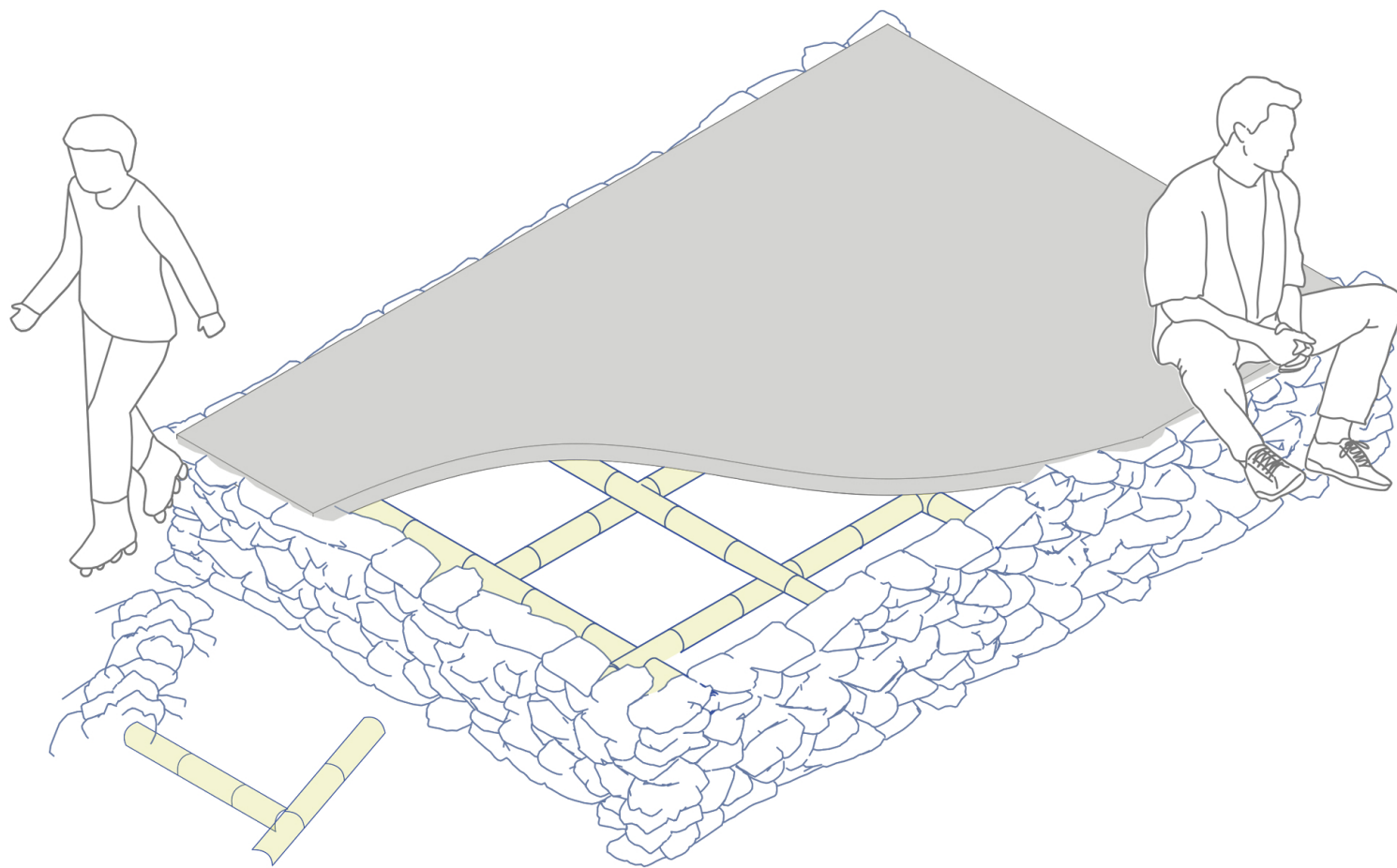
F-03

This assembly relies on stone as the main foundation wall, which can be sourced locally from quarries in Nairobi or imported from nearby quarries. The process of shaping the stones allows for the creation of a solid foundation and community participation. Drawing inspiration from various flood preventive construction systems, this assembly proves suitable for use in Kibera, effectively managing local floods and overflowing water.

Layers:

- Stone strip masonry
- Sand and mud (infill)
- Concrete screed (top finish)

Advantages:

- Much stronger and resistant assembly
- Involves local materials and easy to obtain these materials.
- More protection from flood or flowing water
- Easy to modify or adjust heights as per need.

Disadvantages:

- It is a more permanent structure, difficult to dismantle and replace.
- Top coat is concrete screed which requires periodic maintenance

Restrictions:

- Involvement of structure owner to execute this assembly.

G   TC   SI

Fig. 5.13 Floor Assembly 03
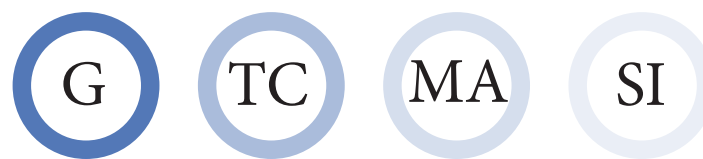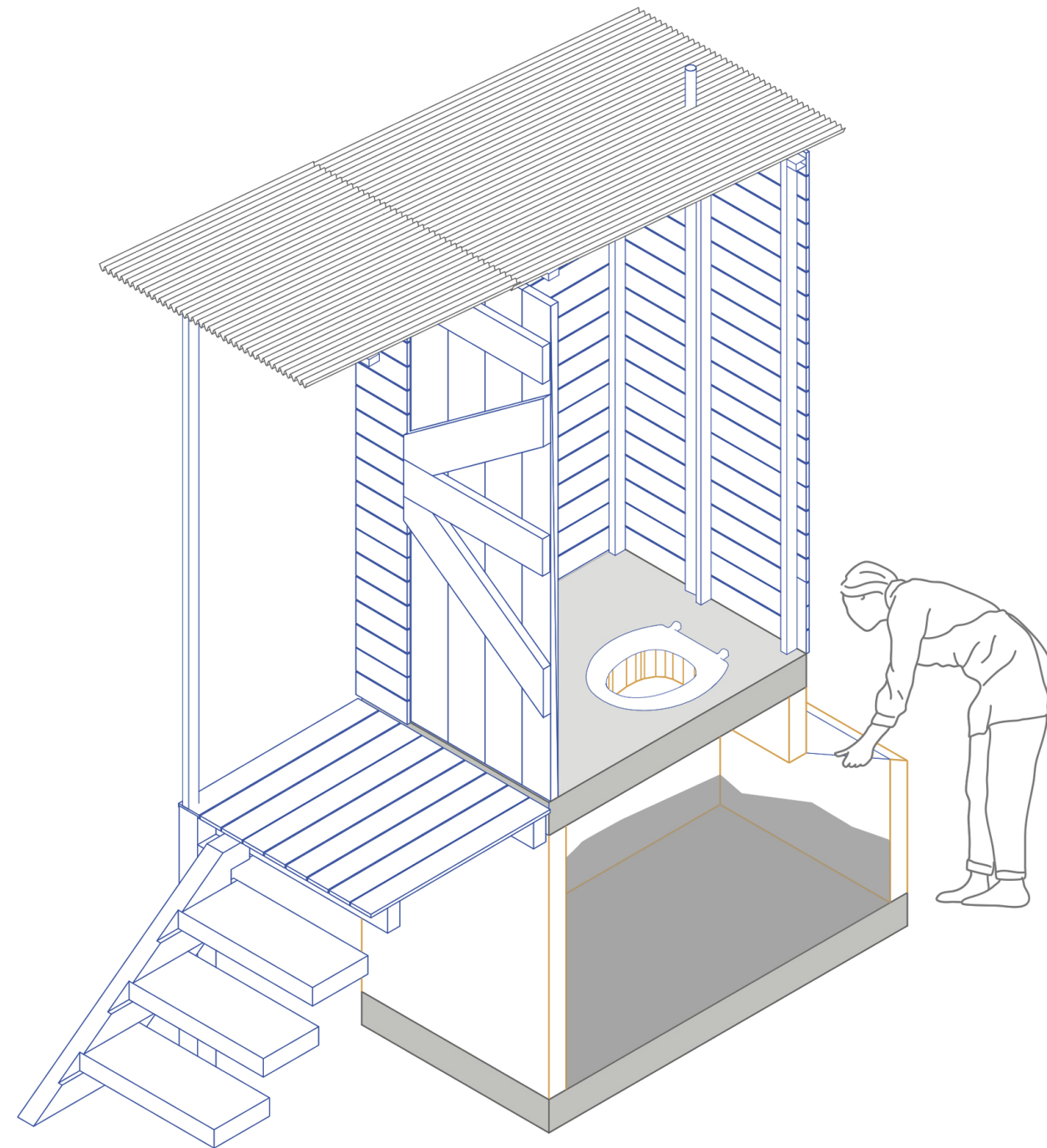
Fig. 5.14 Extension Assembly 01

E-01

This extension functions as a dry toilet very commonly found in temporary fabrics and even in Kibera. This involves a more permanent construction than the portable ones. As described by Marjetica Potrc in the paper "Temporary territories"[11], where they experimented with a dry toilet in Caracas to rethink the relationship between infrastructure and architeture in real-life practices, this type of toilet best suits the climate like Kibera.

Layers:

- Metal frames (super structure framing)
- Wooden planks / metal sheets (super structure cover)
- Bricks (substructure walls)
- Concrete casted floor (base and floor)
- Metal or wooden lid to compost

Advantages:

- Dry Toilet: suitable for dry climate and uses a fan to dry the waste material
- Allows Quick and easy access to facility
- Procedure tested in experiment and very well accepted
- Easy removable of the compost from the lid, allows reusability of the pit
- Light structure and flexibility to adapt to other assemblies for different elements

Disadvantages:

- More of a permanent placement design, the pit is cast in the ground, around 2m deep.
- Becomes unusable, if not maintained.
- Expensive to construct, as requires multiple materials and skilled labor.

Restrictions:

- Requires proper maintenance and hygiene
- Expensive assembly, so could be a community effort instead of a personal investment.
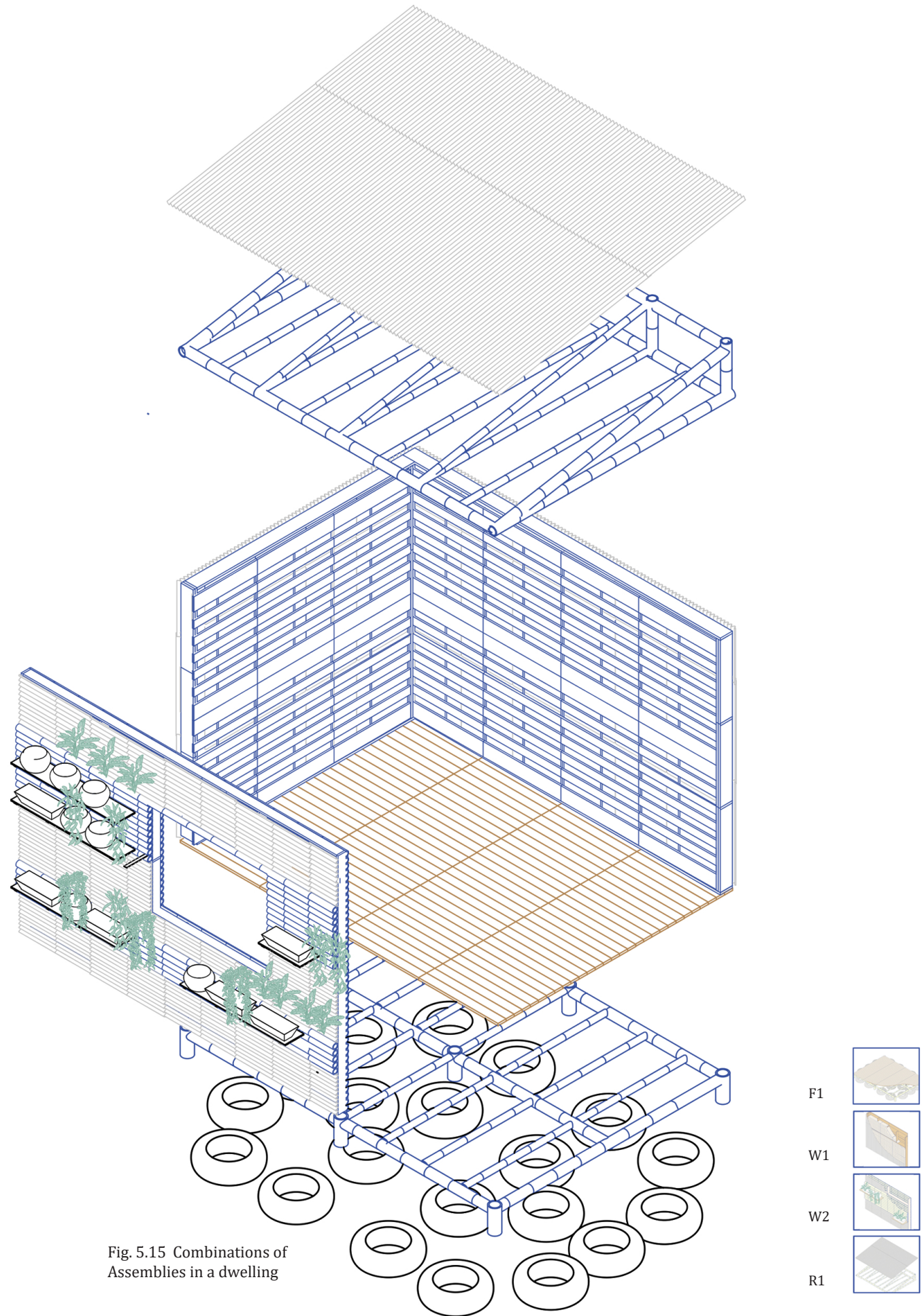
Fig. 5.15 Combinations of
Assemblies in a dwelling

F1
W1
W2
R1

A G TE TC MA

F3
W3
W4c
R3

A G TE TC MA SI

F2
W4c
W4b
R4

A G TE TC MA SI

F1
W4a
W2
R2

A G TE TC MA

F1
W2
W3
R3

A G TE TC MA

F2
W4c
R4
W1

A G TE TC MA SI

F1
F4c
W3
E1
R1

A G TE TC MA SI
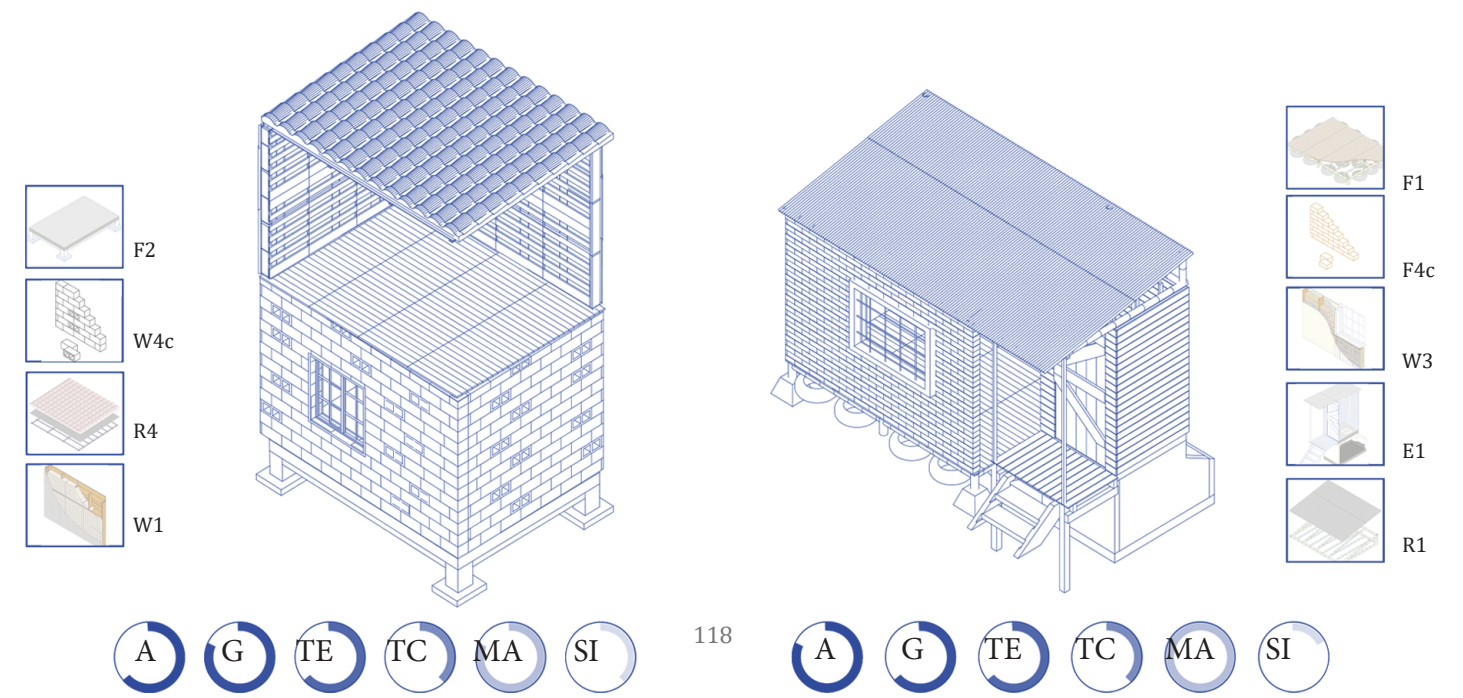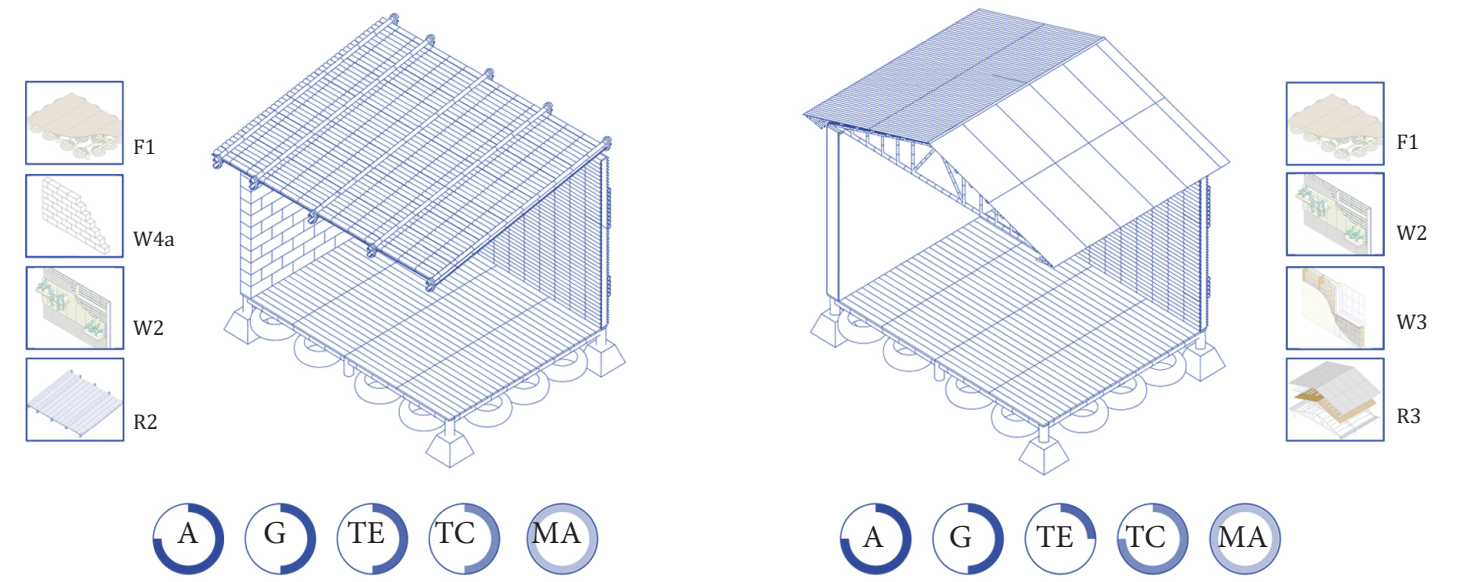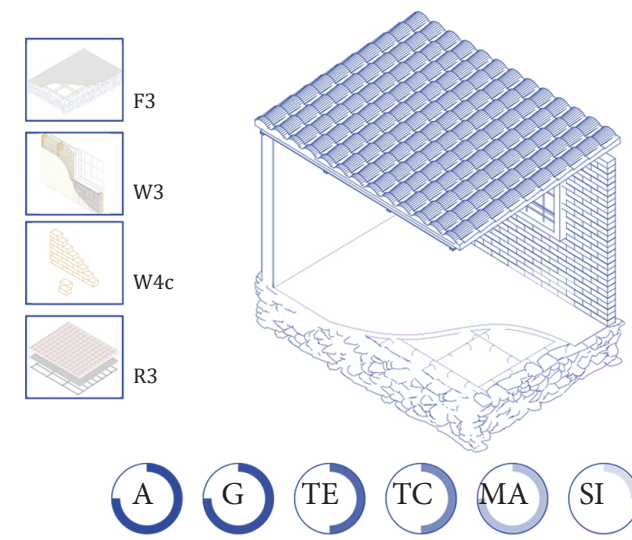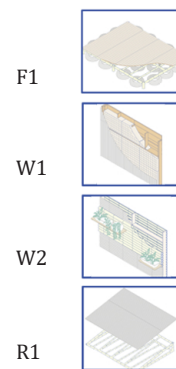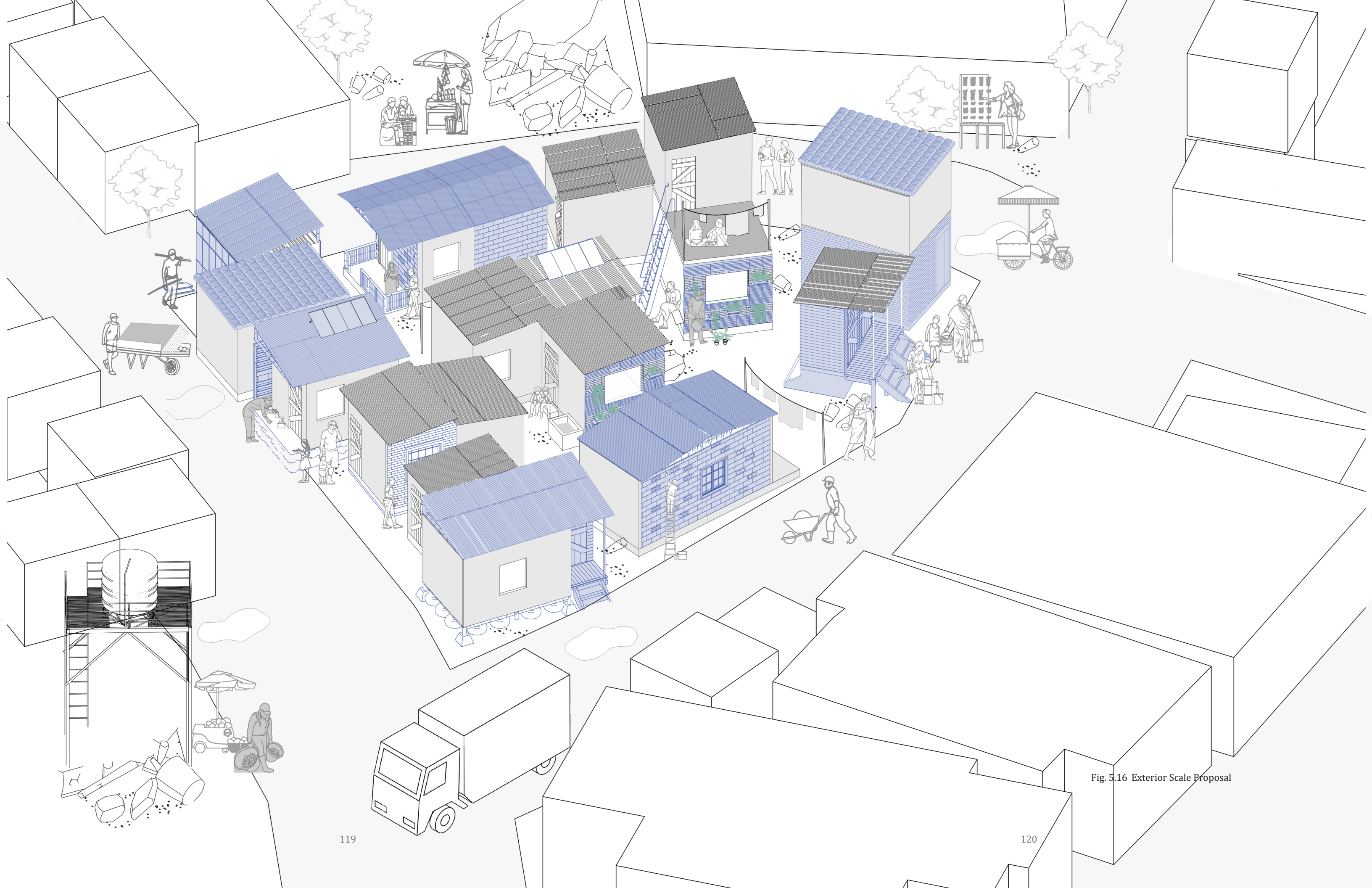
Fig. 5.16 Exterior Scale Proposal

Making the Assembly

This section delves into the later stage of the urban-scale design in Kibera, which presents several challenges when integrating the proposed assemblies into the existing urban context. To tackle these challenges, the project draws inspiration from the Mexicali project by Christopher Alexander in Baja, which emphasizes the fusion of the architect's design power and the builder's construction expertise into a unified process.[12]

In line with this experimental approach, the project focuses on creating a pattern language for the families of the houses being designed, tailored to their specific needs. The heart of this endeavor lies in the builder's yard, where not only experimental manufacturing takes place, but it also serves as a hub for generating innovative test models for actual construction.[13] A primary goal of the project is to increase user involvement and foster a more balanced power dynamic among architects, builders, and other stakeholders.

Addressing the issue of materiality in Kibera is of paramount importance, given the lack of facilities for creating structures and the inefficiencies in accessing materials. To tackle this challenge and foster communal engagement, a crucial solution is proposed: the establishment of a recycling center.

The envisioned recycling center will serve as a hub equipped with essential tools, machinery, and workspace, encouraging local residents to actively participate in constructing this innovative architecture. The profound impact of such a center cannot be underestimated, as it holds the potential to revolutionize self-built construction practices in similar settlements. By promoting greater community empowerment and sustainability, this initiative will bring about positive and transformative change in the context of Kibera.

Design for people, designed by people, built by people

Architecture as Education

The envisioned project goes beyond merely providing space; it seeks to offer valuable training and learning opportunities for the residents to deepen their understanding of architectural details and construction techniques. This educational aspect aims to empower them to build more efficiently, resulting in more stable and quality-controlled assemblies and structures. Given the frequent mishaps in Kibera, it becomes vital for those involved in the construction to comprehend the significance of materials and joinery.

In a project led by Sarah Wigglesworth, the "Straw House" in London[14], she exemplified sustainable design and innovative architectural representation of construction techniques. Her approach emphasized that architecture can be comprehended and appreciated

through building aesthetics and community engagement. By adopting a similar approach to showcasing architecture and the previously proposed assemblies, along with a comprehensive analysis of various factors in a more vernacular manner, the project can achieve its objectives.

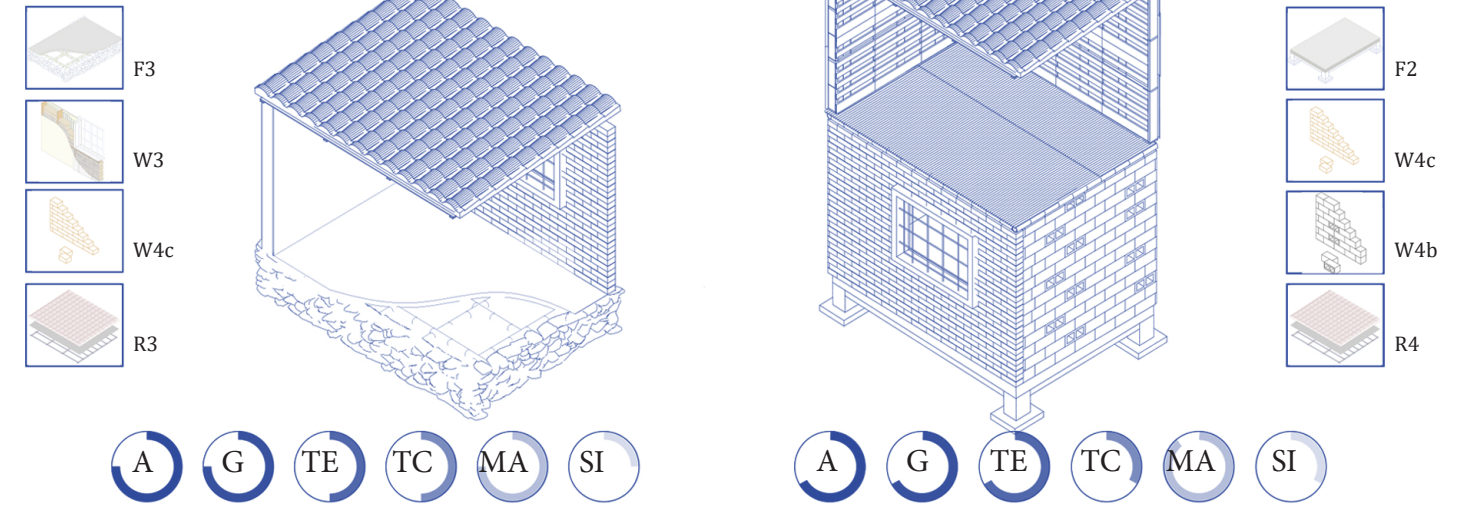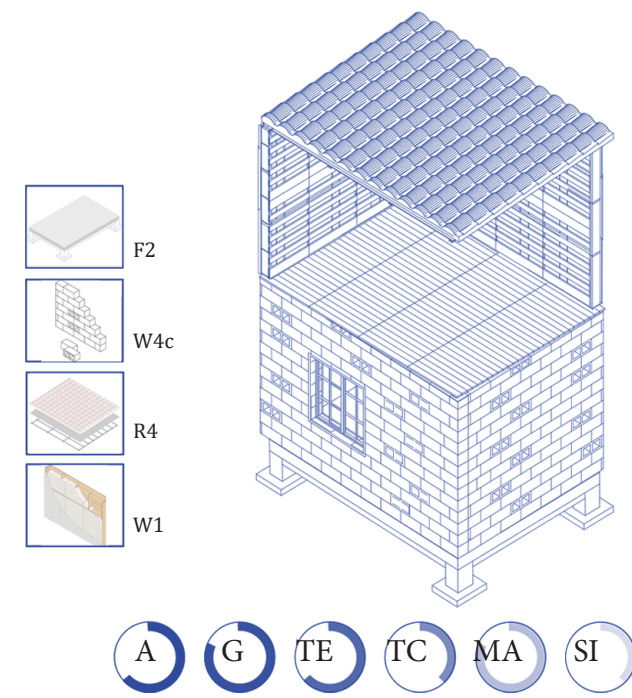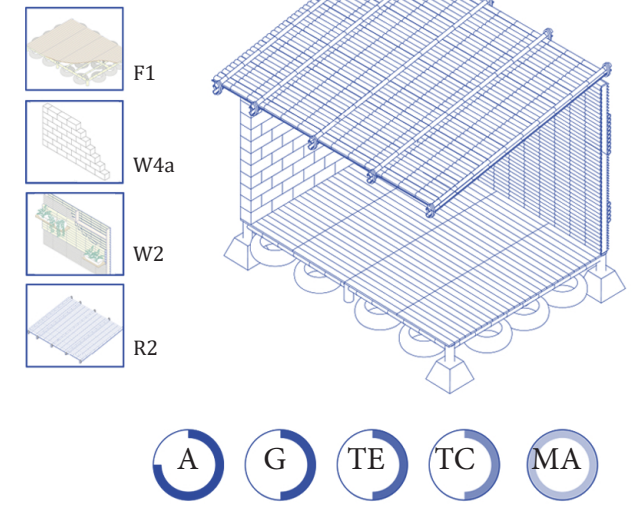The recycling center facility, at the heart of the proposal, holds the potential to become a transformative educational process in itself. Through its design, the materiality of the construction will be expressed, allowing people to grasp the proposed assemblies, thereby motivating and engaging them to embrace these innovative approaches before adopting them in their own construction endeavors. This integrated approach not only provides physical structures but also cultivates a deeper understanding and appreciation of architecture and construction within the community.

Material Flow and Community engagement at recycling centre

The project's core objective is to engage the community at every stage, from design to the creation of all assemblies. The center receives materials from local residents, who collect garbage from the surrounding area, fostering better waste management in Kibera. In return for their efforts, they gain access to materials by contributing working hours. Another source of materials comes from the Dandora landfill in the main city, helping dispose of unusable materials effectively.

The community involvement goes beyond just skill development for locals; it also involves existing contractors who can support and promote the creation of assemblies through recycling. Participants learn and understand the process of making proposed assemblies, encouraging innovative research and custom assemblies based on specific needs. The aim is to empower the community to actively contribute to the project, creating a collaborative and sustainable approach to address local challenges

Site search for the recycling centre

The process of searching for the ideal site and developing site selection criteria is a defining step in the design process. As Kibera is an informal settlement, many sources suggested that the building would require displacing a certain number of people with similar structure owners. The project did not choose such an approach and instead sought out unique and empty land that would provide multifaceted scenarios. After examining GIS maps, four distinctive sites were selected, each presenting a different intervention. While the project would only focus on one site, the other sites offer the potential for further development in subsequent phases.

Site Selection
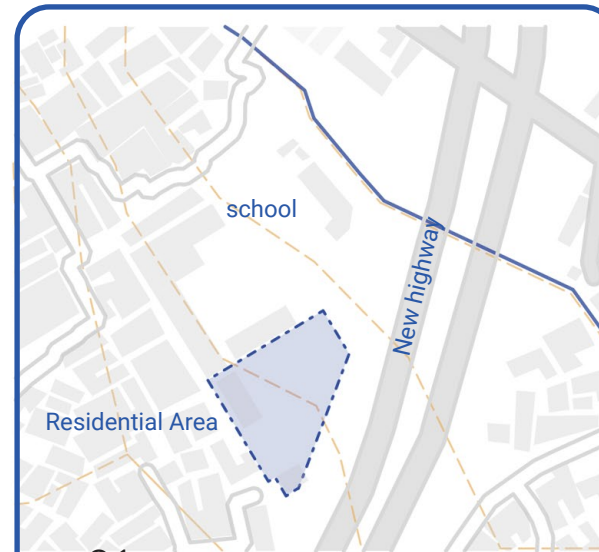
01

Village: Mashimoni
Area: 700 sqm

Layers:
- high pedestrian and vehicular flow

Unique?
- communally and educationally connected

Pros:
- Easy pedestriand and vehicular access
- In the centre of Informal residential
- Border location can help extend project more
- Supporting school can help make it a better educational facility.

Cons:
- Restrict School functioning and vision
- Merger of informal program with a formal school can be a problem?
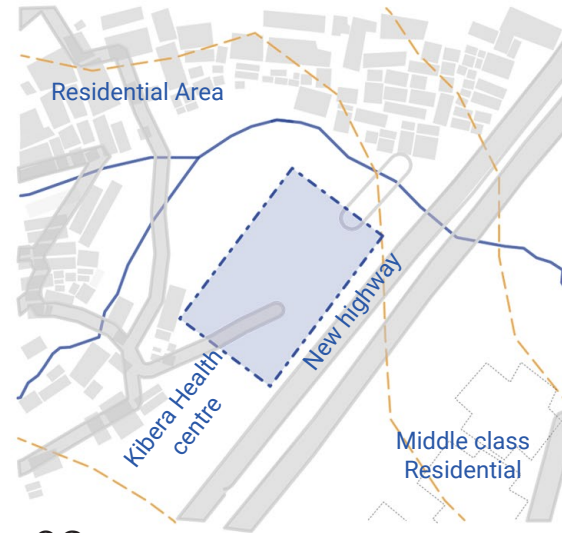
02

Village: Kisumu Ndogo
Area: 1500 sqm

Layers:
Flood-zone

Unique?
Has a big area and a wide spread site.

Pros:
better accessibility.
serve three villages that it surrounds
Possibility of a more resilient design

Cons:
Extreme flooding area
Hygiene issues to adajacent health centre
Since not in any villages, land rights not owned by government.
Not surrounded by existing informal Residential as compared to others.
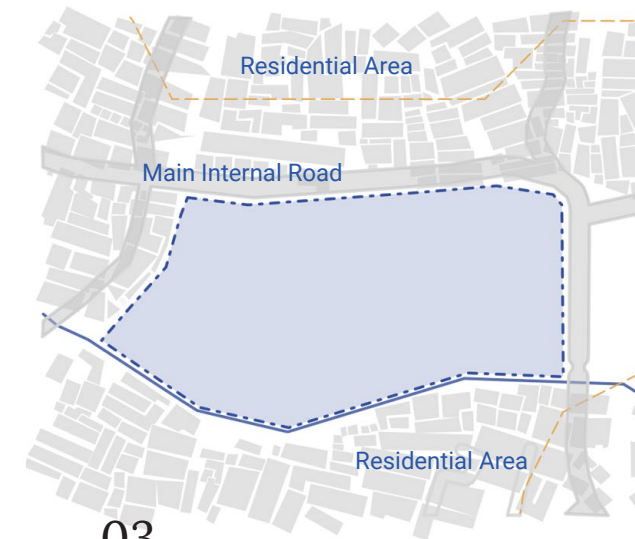
03

Village: Soweto East
Area: 11000 sqm

Layers:
Proposed Land for future development
Flat and less affected by floods

Unique?
Big and appropriately unoccupied land
At the merger to the formal fabric

Pros:
Easy Transportation and access
Appropriate dwellig target in the surrounding
Connected to formal fabric
very accessible for people making their way back into Kibera from KENSUP houses

Cons:
too far from the main Kibera Centre
Limited Target Market
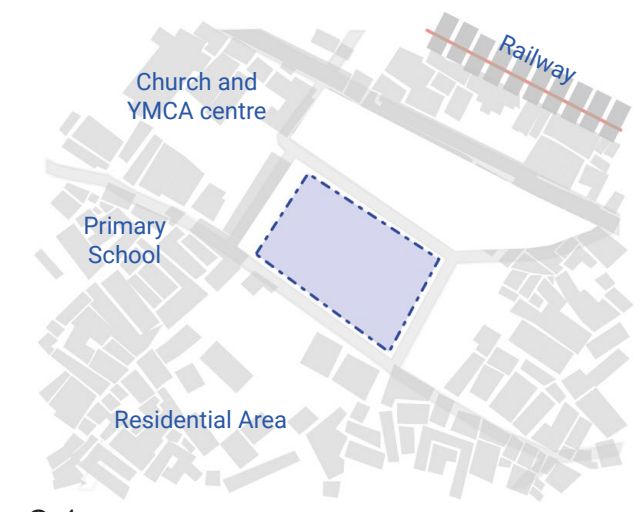
04

Village: Laini Saba
Area: 3600 sqm

Layers:
multi-functional public ground
Commercial and recreational value

Unique?
The site has a specific use, but is still very much shared for many daily activities including transport.

Pros:
Multitypology approach
easy and direct access
multi-functional dynamic for a new program

Cons:
could intervene with existing football ground
alloting bigger spaces for permanent buildings.

Fig. 5.17 Site Selection

Site Plan

The chosen location for the recycling and community center is on the premises of an established school in the village of Mashimoni. The school, known as "Mashimoni Squatter Secondary School", established in 1986 is highly active and attracts a large number of people from the surrounding area.

Criteria:

Education Facility Collaboration: Partnering with existing educational facilities to incorporate daily life skill training would enhance the program's impact.

Existing Proposal: The current school has proposed a life skill school within the existing buildings on the site. Addressing this proposal aligns well with the community's needs.

Existing Flow: Leveraging the existing flow of parents, vendors, vehicles, and the proximity to nearby highways, the recycling center can attract more visitors and raise awareness about the recycling process.

Fig. 5.18 Site Plan

Landfill Recycle Material
The waste can be brought from Dandora Landfill that is recyclable.

Resident collected Waste
Residents of Kibera can participate by contributing the waste from their surroundings. The collected waste can be exchanged with time to work in the centre.

Sub-Contractors
Existing skilled individuals that deals with repairing process in Kibera could become part of the process to expand the reach and benefits of the recycling centre.

New Residents
New residents from Kibera that becomes a part of the centre, either with a job opportunity or learning process.

Tagging Technology

Sorting

Drop off

Recycling Centre

Maker's Space

Proposed Assemblies

New Research & Assemblies

Community and Training Centre

Assemblies Designs

Walls

Roof

Floor

Extensions

Incremental Housing
These elements can be used by the residents to contribute to their incremental housing in the far off place.

Dwellings in Kibera
These assemblies can slowly be used to renovate the houses in Kibera

— Material Flow
— Community Involvement

Fig. 5.19 Design Systems and Working

Assembly Integration

1. Drop Off/Pick up Area
2. Sorting Area
3. Stairs to Community Centre
4. Common Space and kids area
5. Assembly Storage
6. Community Centre
7. Toilet
8. Test & Trial Porch
9. Common Space
10. Outdoor Makers Space
11. Indoor Makers Space
12. Commercial Kiosks
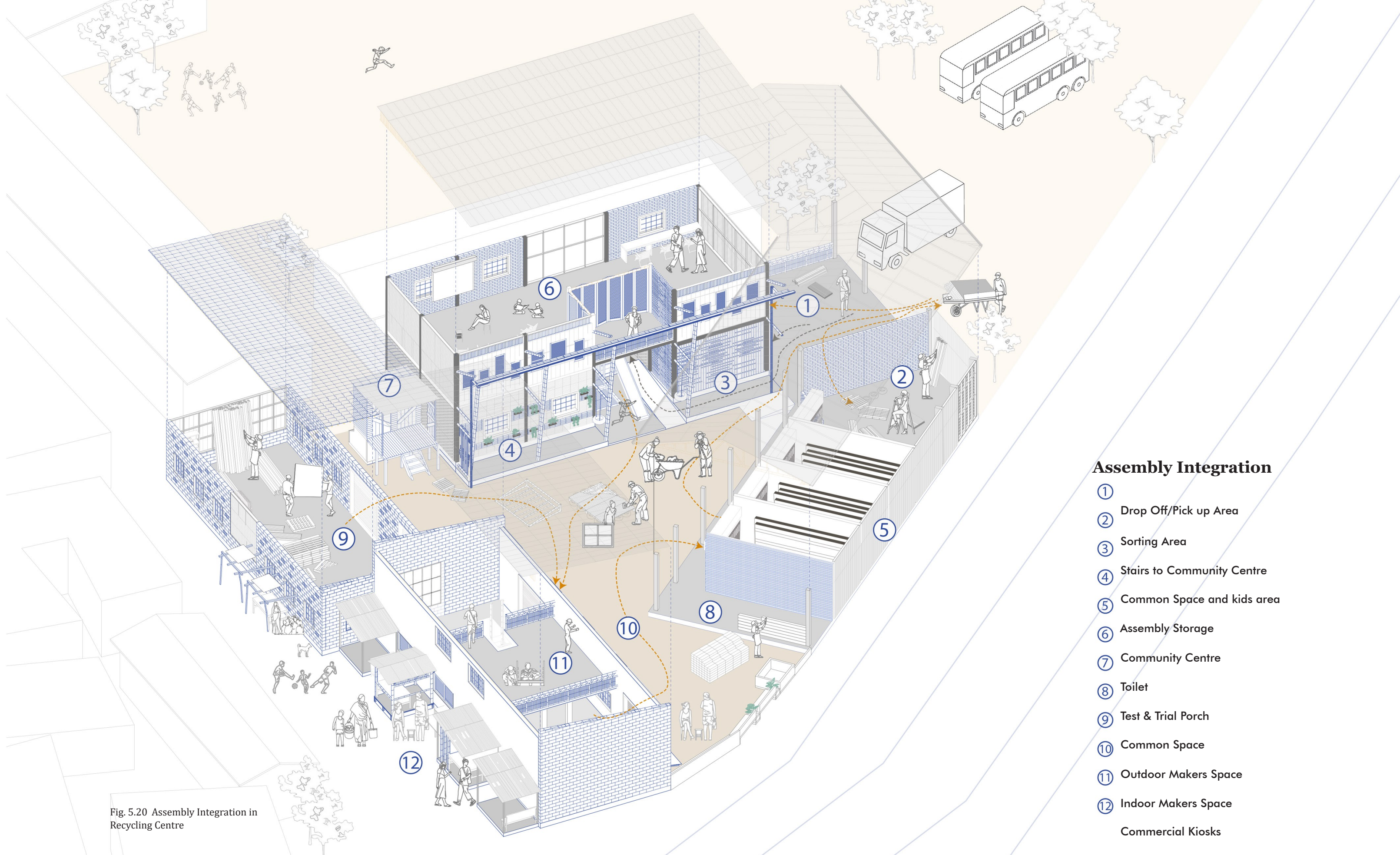
Fig. 5.20 Assembly Integration in Recycling Centre

Section 01 - Community Centre

This section emphasizes the learning process within the center, showcasing spaces like the resting area and the multi-dimensional community center above. This community center serves dual purposes, as it can be utilized by local communities while also providing equipment for engaging in learning or teaching activities. The interconnectedness of these diverse activities within the design is crucial to foster a space where people can actively engage and participate beyond merely constructing architecture.

COMMUNITY CENTRE

The community center serves as a versatile space designed to facilitate the communal engagement of local residents beyond their involvement in the recycling process. It plays a crucial role in exposing the project to residents through various means, such as daily meetings, learning sessions, and access to the internet and digital media for diverse purposes.

ASSEMBLY STORAGE

The material storage is of utmost importance in the design, as it provides a secure and weather-protected space for all assembled or semi-assembled structures. It is thoughtfully connected to the exit, facilitating easy movement of materials. Moreover, the design incorporates an experimental wall, serving as a testing ground for users to explore and experiment with various brick and bamboo designs for innovative research and development purposes. This interactive feature encourages creativity and fosters continuous exploration of new construction possibilities.
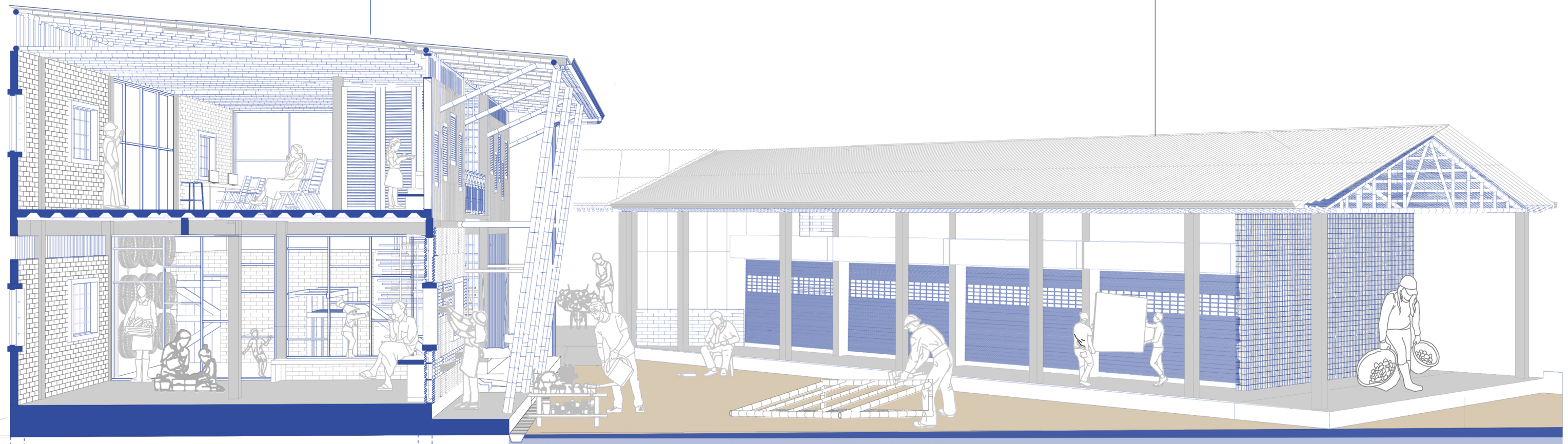
Fig. 5.21 Section 01

Section 02 - Through the courtyard

This section examines the relationship between the area where materials are initially dropped and their subsequent journey to storage, which involves crossing the main courtyard along the way. It highlights the interconnectedness between the architectural design of the community center in the back and the courtyard, showcasing how these spaces interact at various levels.

MATERIAL STORAGE

This building has been readapted into the new design while retaining its existing footprint. The spatial arrangement has undergone minimal adjustments, preserving its original layout as much as possible. The structure has incorporated some new materials, seamlessly blending them with the traditional existing wall structure to maintain its essence. The roof has been entirely replaced to ensure the preservation and proper maintenance of the materials within.

DROP OFF/PICK UP

This is the initial building proposed to welcome users into the facility. It offers an open space for residents to bring in any amount of materials for recycling, while also extending an invitation to gather materials from nearby landfills and recycling sites. This space is directly connected to the administrative area, where each material brought in is carefully marked and registered before proceeding further into the spatial facility.
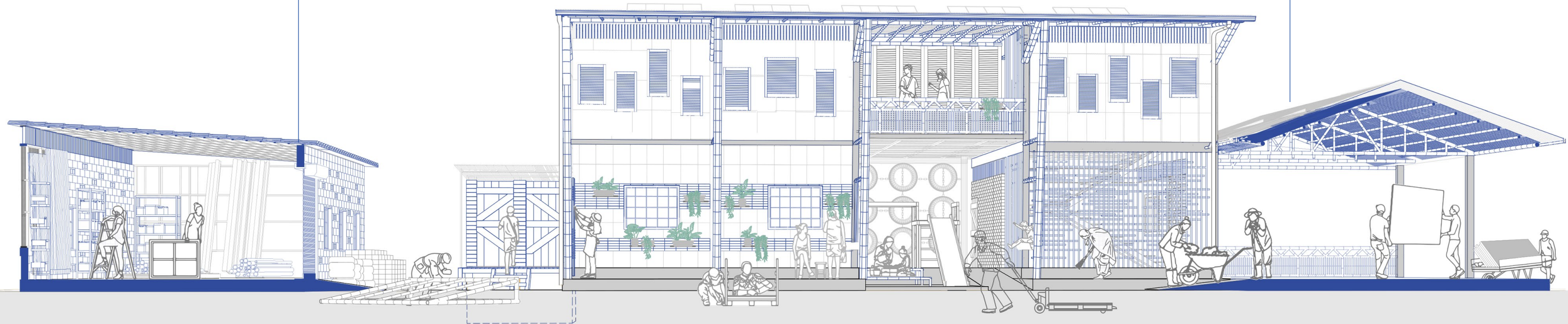
Fig. 5.22 Section 02

Section 03 - Relationship to street

This section establishes a connection between the workspace and surroundings, which overlooks a small commercial hub constructed from recycled materials. This new environment brings vibrancy to the surrounding roads. The previously blank and unoccupied walls of the center are transformed into commercial spaces, inviting more people to engage with and around the project. This revitalization also breathes life into some spaces that were otherwise underutilized.

This structure serves as the indoor workshop, equipped with all the necessary machinery and tools for assembling the components. A proposed mezzanine level demonstrates the stability to introduce intermediate floors, and a minimal ladder design allows for vertical movement within limited spaces. Concrete, chosen for its robustness, has been utilized in this structure to withstand the strong vibrations generated by the wood workshop machinery like CNC Machine, sanders, hand and table saws.
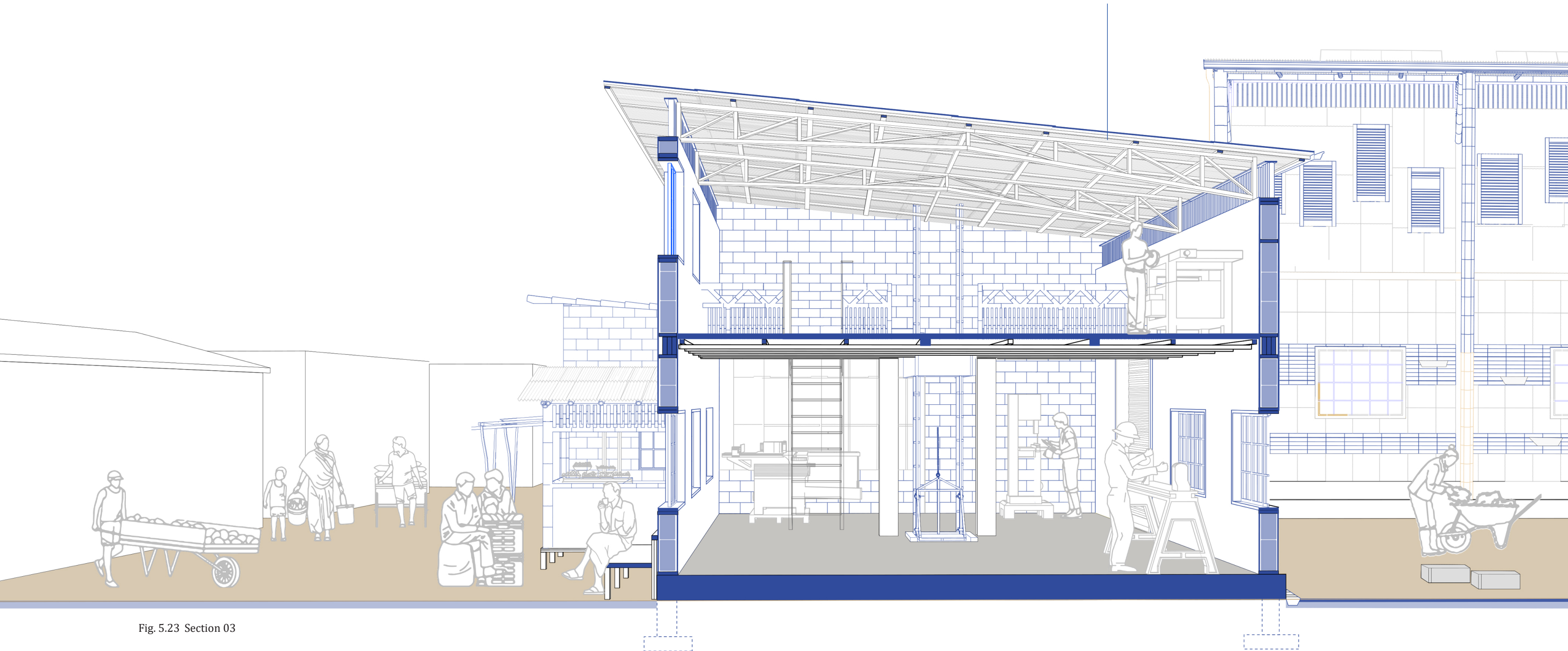
Fig. 5.23 Section 03

Rainwater Harvesting and Drainage System

Given Kibera's challenging conditions during rains, the incorporation of rainwater harvesting and a well-designed surface drainage runoff system is of paramount importance. By effectively managing on-site water flow, we can collect and recycle a substantial amount of water for irrigation and block curing, effectively controlling the water quantity.

Recognizing that a significant portion of the gathered water might not meet the necessary cleanliness criteria for everyday use in kitchens or toilets is crucial. Consequently, while direct consumption may not be advisable, the harvested rainwater retains its importance as a valuable resource for numerous non-potable applications, supporting sustainable water management practices. One such application is utilizing it for cleaning purposes in kitchens and washrooms. Moreover, this collected water can be extended for use in areas beyond the immediate vicinity, promoting community sharing and cooperation.

Solar Panel

The integration of technology such as solar panels enhances the project's sustainability, ensuring self-sufficiency. Considering the informal nature of electricity consumption due to expensive and lower legal supply[15], it is important for them to have a supply of their own. These panels are primarily installed on the workshop building and community center, targeting areas with the highest electricity consumption, fulfilling approximately 80% of the energy needs. By reducing dependence on the local grid, the project's operations can run smoothly and efficiently.

Ventilation

Throughout the design, bamboo screened ventilators have been consistently incorporated to ensure proper air circulation in all areas. This not only promotes fresh air inside the buildings but also allows the materials to breathe effectively. Such consideration is essential, taking into account the climate and material response. Moreover, integrating these features is a delightful experience for the residents, making it something they would appreciate having in their spaces.

Fig. 5.24 Site Service Plan

80%
of consumption through solar panel

20%
of consumption from local grid
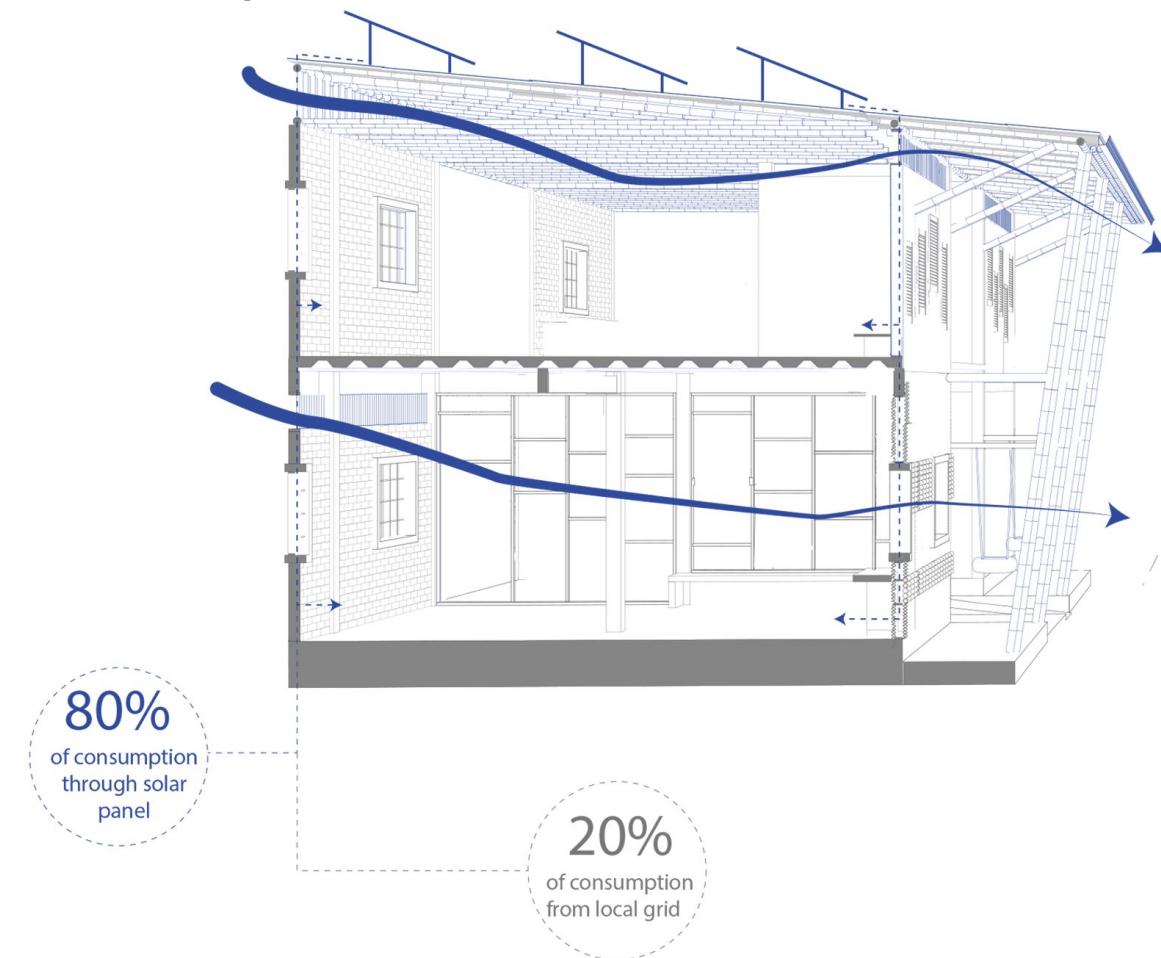
Fig. 5.25 Section for site services

Phase System

The ultimate goal of this project is to extend the reach of this facility and its operations beyond a single village to encompass 11 other villages within Kibera. Close collaboration with municipalities and landfill associations will be maintained throughout the expansion process. The vision is to establish a network of recycling and training centers, with each village having

- A prominent facility

- And an additional two centers, based on population needs, dedicated to material collection and drop-off.

By working in sync, this system aims to efficiently recycle construction waste and breathe new life into salvaged materials, fostering an effective and sustainable recycling ecosystem.

PHASE 01
now - 1 year

Scale:
1 single dwelling unit in the most appropriate area where stage 02 would be sett.

PHASE 02
1 year - 3 years

Scale:
One single entre catering a small community of about 50-100 dwelling units.

PHASE 03
3 years - 8 years

Scale:
multiple of phrase 02 structures catering a village.

PHASE 04
8 years - 15 years

Scale:
Settlement level, it hosts similar patterns like Phrase 03 that becomes a bigger network system.

Fig. 5.26 Phase System

Project Timeline

The implementation of the project must be attuned to Kibera's climatic conditions. Kibera experiences two distinct rainy seasons, characterized by a heavy downpour with an approximate rainfall of 8 inch during one and a lighter, sporadic rainfall of about 4 inch during the other. These climatic patterns impose limitations on the viable timeframe for the project's actual construction. Particularly challenging is the period between mid-March and May, marked by intense rainfall, rendering it unsuitable for construction. Consequently, this phase tends to shift towards indoor or research-oriented developmental processes.

It's worth noting that these climatic patterns also mirror the approach taken by Kibera's residents in constructing their own dwellings. In the face of these weather-related challenges, residents adopt a step-by-step construction approach. This measured progression is due to the difficulties they encounter in transporting construction materials and overcoming the obstacles associated with the building process itself.

The outlined table delineates the construction process for the initial seven years of a 15-year plan aimed at expanding a recycling center (UNIT 01) and associated pick-up/drop-off center (UNIT 02) within each village. The project's pilot phase, spanning the first two years, focuses on amplifying the capacities of the center and is intended to serve as a blueprint for subsequent UNIT 01 construction in later years across other villages. Progression through the third year culminates in the completion of one UNIT 01 and two UNIT 02 facilities in Mashimoni village, as per the proposal. Year 04 is designated for evaluating success and adapting the program to accommodate the evolving needs of Kibera's residents.
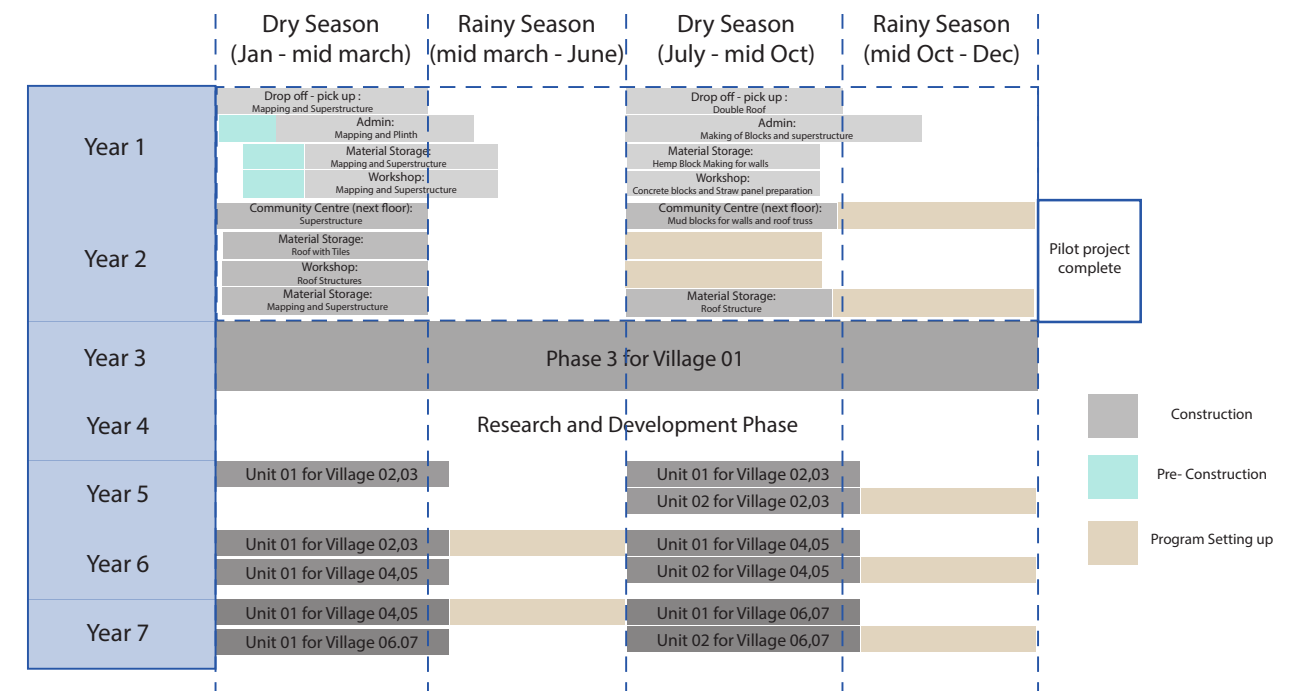
Fig. 5.27 Project Timeline

Technology Integration

1.   Material Tagging

At the facility, every material brought by residents or external sources undergoes analysis and receives a specific tag based on its conditions. It can be categorized as reusable, in need of processing, or rejected if it is unsuitable for constructing any assemblies. Materials that are rejected are ultimately sent to the Dandora site for disposal in landfills.
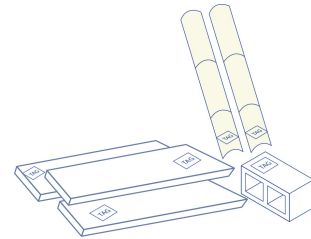
2.   Digital Platform

Considering the rapid digitalization of our world, it is crucial to ensure that this facility is accessible to everyone through a mobile application. This application would enable residents and potential users to explore various assembly designs available at the facility, along with their corresponding prices. Additionally, users could track the availability of tagged materials, empowering them to create new assemblies according to their needs. With the help of platforms like iBuild Global in Kenya that help to initiate a digital tool like this so that[16] accessing information becomes more convenient, eliminating the need for individuals to physically visit the center for every query or requirement.

3.   Training and Education purposes

The application of technology extends beyond just the mobile app. It involves training initiatives that go beyond materials and involve utilizing community centers to provide education on life skills and the fundamentals of assembly architecture. Moreover, the facility would offer access to essential electronics such as computers for learning and systemization, as well as projectors to customize the space for various purposes based on specific needs. By integrating technology in these ways, the facility aims to enhance learning opportunities and create a versatile and adaptable environment.

Fig. 5.28 Technology Integration

Endnotes

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13   **Christopher, Davis, Martinez, and Corner. 1985.** *The Production of Houses.* 97

14   **Jones, Barbara. 2015.** *Building with Straw Bales: A Practical Manual for Self-Builders and Architects.* Third edition. Cambridge: Green Books

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16   **iBuild Global. 2017**. *"IBuild- Empowering the World to Build."* 2017. Access Date: 10 May, 2023 https://www.ibuild.global/about/about-ibuild.

Conclusion

Informal settlements have long faced significant challenges, including low income, inaccessible housing strategies, and unaffordability, making it difficult for residents to access liveable spaces. In my perspective, these settlements represent a profoundly saddening condition that arises from the exploitation of labor and materials, benefiting the wealthy while disadvantaging the poor. The impact of climate change only exacerbates these problems. To tackle these issues, a comprehensive and economical strategy is proposed, requiring low investment while harnessing waste as a catalyst for sustainable development.

This thesis endeavors to analyze how the materiality and construction in these settlements can be rewired in a systemic manner to better serve the needs, health, and prosperity of the people living there. Empowering them to build spaces that cater to their requirements is essential. To achieve this, the introduction of recycling centres as vital spatial programs in places like Kibera provides more opportunities for locals to actively engage in the improvement of self-built dwellings and other structures. This initiative could serve as a stepping stone towards better housing strategies with the cooperation of government bodies, leading to positive advancements in the living conditions of these communities.

Role of an Architect:
The urban challenge evident in the slums involves multiple societal actors coming together to address the economic disparity that allows the privileged to build with unlimited resources, while others must resort to recycling their waste just to survive. This situation has resulted in a disconnect between architectural design and construction, failing to accommodate the diverse needs of different communities. As Christopher Alexander mentions in his book "The Production of Houses," the current control over housing production is misoriented due to the separation of design and construction, and the centralization of authority that typically follows.

The influence of international agencies has limited the people's empowerment to build and thrive efficiently. As Architects and designers, it is crucial for us to recognize and address this gap in the construction system, especially in localized and marginalized contexts like Kibera. We need to devise innovative proposals to bridge the divide between design and construction processes. It's important to acknowledge that not every problem can be solved solely through a designer's perspective in this modern world; in some cases, we must analyze the user's experiences and needs to propose a more involved and effective design approach.

In conclusion, the process of understanding the settlement and the design formulation uncovered some layers to approach better planning and housing strategies that would better suit sensitive areas like Kibera. These approaches could be as follows:

The role of self-help strategies as a temporary substitutes for government initiatives:
By empowering residents to actively participate in improving their living conditions, the self-help approach addresses immediate housing needs. Residents, who often lack access to affordable housing, can use the strategy to build simple yet functional shelters that serve as a stepping stone to a better future. This approach reduces their dependency on the government and creates a sense of ownership, at least over the assemblies if not the land within the community.

Integrating Grassroot strategies
An essential aspect of this thesis and its proposed design is its integration as a grassroots initiative in the urban fabric of Kibera. Community involvement and engagement play a vital role in the success of any housing project. By working closely with local residents, architects, and other professionals, the project can be tailored to the unique needs and culture of the community. Such an approach ensures that the solution is both sustainable and socially inclusive, fostering a sense of collaboration among the residents.

The importance of detailed and updated documentation for improved implementation
Accurate and updated documentation is critical for the effective implementation of any project like this. By meticulously recording the project's progress, challenges faced, and successful outcomes, future projects can benefit from the lessons learned. Regular updates and evaluations allow for adjustments in the approach and contribute to the continuous improvement of the strategy. Furthermore, transparent documentation facilitates knowledge sharing and inspires other communities to adopt similar innovative approaches.

In the inclusive program of the proposal, digital mediums and technology hold immense potential in revolutionizing housing projects. Digital platforms can facilitate community engagement, ensuring that accurate and instant information is accessible for the residents to make the recycling process more transparent and reliable. Advanced data analytics, artificial intelligence, and virtual reality can aid in the design process, making it more efficient and precise. It could also ensure that the voices of all residents are heard and considered in the decision-making process to update the strategy as per evolving needs.

Future research possibilities: Advancing the strategy
To continuously improve this strategy, several additional research could be conducted in the future. Firstly, integrating an additional layer of analysis related to behavioral and living patterns of the residents will enable a deeper understanding of their needs beyond mere dwelling structures. This holistic approach will lead to more personalized and sustainable solutions.

Secondly, considering the concept of material aging and implementing a system analysis dynamics will ensure that the constructed dwellings remain durable and resilient over time, reducing maintenance costs and waste generation.
Lastly, conducting a deeper analysis of assemblies and translating the findings into spatial planning, considering micro-climate and carbon footprint, will further enhance the strategy's ecological sustainability.

The recycling program empowers Kibera's informal settlement through self-help approaches and grassroots initiatives, fostering sustainability and a habitable environment. Detailed documentation supports its success. This thesis aims to experiment with the community, laying a strong groundwork for transformation in this dense urban fabric

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Subject:	Re: Folder shared with you: "Share with Deepkashi"

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This is to confirm my permission for you to use four images taken by me between 2017 and 2023 in your academic thesis. Please ensure that these images are used only for the intended purpose.

Best regards,
Brian.

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Hi Deepakshi,

Thanks for reaching out. Sorry for getting back to you late.

You're most welcome, go ahead and use them, I'm glad you felt their authenticity.

I'll love to read your thesis too when available.

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No problem,

Do you know that the ghetto I have been working on is Mathare and not Kibera? If is ok for you I have no problem about it

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Hello Deepakshi,

I grant you permission to use the photographs for the Garbage City documentation.

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Yara Tawfik

Deepakshi V. Mittal

From:	Frederic Levrat <levrat@uttdesign.com>
Sent:	02 September 2023 03:00
To:	Deepakshi V. Mittal
Subject:	Re: FW: Copyright Permission for Empower Shack Project Images

Deepakshi,
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Visual Content

Photgraphy

Photographer: Pascal James
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Photographer: Brian Otieno
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Photographer: Filippo Romano
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Videography

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Appendix

Interview

Interview with : Tom Vohya, Maisha Trust
Date: March 13, 2023
Medium: Virtually, Zoom Call

Introduction to the project
I will give you a brief about my project first so that you get in a sense of what I'm working with.
I'm looking at Kibera in the sense of architecture construction materials, trying to document how people use materials and where these materials come from. It's like a process of recycling material all together in informal settlements and so I think it's important to document that and then try to create architecture systems that help them build efficiently to add more space and value to the houses that they already have already. So combining recycling materials with documentation and how it can create another economy for them. I was looking at different case studies with proper formal systems of architecture and I came across a few projects including yours.

Can you tell me something about how it al started? Can you tell me a bit about it?
We started the construction in 2014 as also mentioned on our website. The intent was to build a kindergarten school because access to education at a particular level is very much available in Kibera. It either have to be private or public, where private is very expensive. We aimed to create a different environment, that's why we call it Oasis Kindergarten. We tried to create an environment of the school that also resembles the name by planting trees and making it very interactive.
So one of the challenges in Kibera is that the land is owned by the government, so very few people own their buildings. Therefore, there are regulations as to what you can put up in terms of building materials. On paper, it is required to put up semi-permanent structures, as the land does not belong to you. Facilities like hospitals and schools are flexible or corrupt. It took us a long time for us to settle with the materials we were going to use. Looking at the challenges, we knew we had to build semi-permanent structures and came up with the idea of containers similar to other schools. For us, the challenge was accessibility, as the site was in the middle of other houses.
Initially, there were about 28 small houses built out of mud and bamboo with cement screeds and iron sheet roofs, where we built. Timber is expensive in comparison to iron sheet structures and structural stability without any foundations.

Do we have a foundation for Oasis?
Yes, we do, have a foundation. We ended up using a very high-grade iron sheet, they are strong. And because the contractor wanted another story on the top, we used high gauge steel beams. From the outside, it is just iron sheets, but inside we covered it with gypsum boards. We tried to engage professional architects but were above the budget of the project.
So basically, I and another partner we were working with came up with the design of the school and prepared a layout. We had a vision, we had a contractor, who could help us and make iterations. We

used steel bars to hold the structure together with insulations in the walls.

Did the insulation help keep the interiors cool?
Yes, it does help, especially on the ground floor as it gets very hot in Kibera. All the classrooms on the ground floor keep a cool space and the upper floors have entertainment rooms for painting and TV sessions. The design is L-shaped, as we enter, on one side we have a security guard house and Asian toilets for boys and girls with a septic tank. In the main building, we have reception and 3 classes in a row. Then we have a library/music room and a kitchen at the end for cooking food for students. It uses an energy-saving tool that saves about 70% of the fuel. On the first floor, we have a multi-purpose hall.

As you mentioned, you have a septic tank, won't dig for the tank to make it a permanent structure?
Toilets are permanent structures and others are semi-permanent.
Also, on your website, it mentions you have bought the land. Even after that, you cannot build permanent structures.
There are many regulations to it. The government gave us some rightful deeds, as a political agenda. So to do a project in Kibera like us, there is no free space in Kibera to build or even kids to play. We were fortunate enough to get a landlord who owned 28 structures and therefore he sold them to us but with the involvement of the local government. They transfer the properties and aware the municipality about the new owner. The process is to buy structures, put them down, and then you can construct whatever you like. There are some other people, who have put permanent structures who got away due to corruption and bribes.

The other landlord from whom you bought the land is a structure owner?
Yes, they are the structure owners. There are several people in Kibera making money like that. They have built these structures everywhere and they are the landlords. They get tenants who pay the rent to them and not care about the maintenance and structure.
Structures built by structural owners are permanent or semi-permanent?
They are all semi-permanent. Most of them are.

Was there involvement in the slum Upgrading program while you were constructing Oasis?
No, not at all. There were quite a number of obstacles on the way. In Kenya, they attract a lot of international people that are interested in having these projects built in the slums. The local government takes advantage of that and has to pay on the table to do anything. Even we were not allowed initially as we refused to give money and tried to frustrate us in every possible way. It took us about 4-5 years before we were able to build. Firstly, finding the right people to work with is a challenge, the right team. We got an architect who disappeared with our money. And secondly, the right choice of material. We wanted something that could last for a while being semi-permanent. There is one particular one that happened a few years ago, they came in and got one portion in Kibera. They built flats and displaced people with an agreement to live in the flats. But what happens is, once they are relocated, they have to pay rent for the houses with running water, and electricity. The new owners

saw an opportunity and rented the flats out and moved back to Kibera. That project was not really a success.

You mentioned about construction systems you adopted, was flooding an issue that you had to deal with?

The flood was inevitable. Initially, we dint consider it, but later we did. Before we enter the plot, there is a drainage that was existing. But when we constructed it, we replaced it with a proper and bigger drain. So that when the water comes in, it can get directed properly. But in Kibera, there is a massive problem of waste handling, that lets people dump waste anywhere there was government involvement earlier where they would allow people to earn some money but collect garbage but now that project is bulled out. The drainage that we have now gets blocked by all the waste. The only thing that helps is when it rains. When water flows, it takes away garbage but sometimes even fills it even more. The water overflows, and enters the houses. Now we had to cover the drain, with just a hole below and not let it overflow.

The property is on a slight slope and the trench is right outside. It runs from the main road all the way to the end of the property and runs about 30m. So the water just flows down and we have raised the entrance to avoid overflow in the property.

Also, where you are located, the new highway was built. Did it have any impact on the project?

So when we were acquiring the land, we were assisted by one local person, who has a number of schools in Kibera. He had the knowledge and was able to get us a development plan of the road and were fortunate enough to see that it was not going to affect us. Once we began constructing, we were not affected but there were several schools that were near the highway.

Is the highway project completed, or still under construction?

It is completed and in fact very convenient. Earlier, we had to go all the way around, but now it is a shorter distance.

But to do that they displaced a lot of people right? I think that's when the upgrading program came into the picture too, right?

No, that was way before that.

So what happened to people who were evacuated?

So they just had to find another place. They were mostly tenants and were given short notice to move. But Kibera is very hot in terms of politics. If a politician comes and says guys don't move, the people trust so easily. Until the last minute when there is no help, the bulldozers come and residents are caught off guard.

That was all about the project, but I do have a few questions about how people live in Kibera or the daily systems in Kibera. As you mentioned, they use mud as a major material, and metal sheets or plasters on it. But have you noticed any change in materiality? Are there any other materials that you think they use sometimes?

Not any new material, but I do see more people going towards brick and mortar. Even just next to us, they are making a new building with brick and mortar. When you enter the places where there are better houses, they use them.

Is it clay brick or cement brick?

It is mostly cement brick.

But that must be expensive.

But for some reason, I don't think that clay bricks are very much available. Or the fact that people are so used to cement bricks, they don't want to adapt to clay bricks. There are some companies that are producing interlocking clay bricks now though. But they have not really penetrated the market even if they reduce the construction prices. Maybe it is because of the transportation cost and availability. But concrete bricks, it is easily available at hardware shops.

So cement bricks are locally available, how?

So there are a number of hardware shops that outsource and people just purchase it.

Are there any materials that people have to outsource?

No, most of the materials used are available locally.

There was an article that mentioned, "The people in Kibera are adapting new systems, as mud for construction is getting over", is that the case?

Most definitely, there isn't any open space in Kibera unless there is a government school with a playground. Everything is covered by structure or road. I am saying, people are adapting to more brick and mortar as mud is not there.

So in the construction process, like mud walls, are more females involved in regular maintenance, or it's still males?

Not at all, it is predominantly male, but we do have females who could do that. But they do that as a job. But in a traditional culture like Maasai culture, it is mostly female who does that.

While you were setting up an education facility, did you come across any restrictions on the encouragement of education for kids? Are there any other restrictions other than financials?

Not at all, there was a big initiative by the government in 2008, where other former presidents introduced free primary education. It then became illegal to not send your child to school. We have not had any cases where children are not sent to school. If they do not go to school, then they will just get bored. But now it is expected of children like any other daily activity. On that job, the government has done a good job to encourage kids.

I also looked at your website, and you are looking to expand Oasis into a life skill school in the future. What are the goals for that?

Interestingly enough, we have started it on a small scale. When in Kibera, during holidays, it is very discouraging to see kids just go around alone or meet with accidents. Being restricted to one room is difficult for them and due to holidays, they just go out on the roads. They ask for money on the road,

and it is not a very good thing. And we thought about what we could do about it in our facility in the holidays. They engage in unhealthy behaviours, so we started a Chaluka skills hub as an initiative. So during the holidays, we will be able to empower young people with variable skills apart from their regular school education. They come in, we engage in different activities like photography, filming, cooking, computing, and mentorships. We had our first session in February of 2022. We are planning the next one next month now. We want them to be exposed to skills that they might not be able to otherwise. We plan it slowly right before the holidays, and we are willing to expand it in the future. We are trying to prepare them for all the fields offered outside the book-related education in Formal Kenya or outside Kenya. We are just testing the water for now, but it is for a good cause.

In my project as well, I am planning to look up to a recycling facility that can help regulate the availability of the materials better to the residents. A workshop is an essential program in it, which is based on life skills but different than yours. It's more hands-on and becomes a skill for the future. Have you seen any similar programs or facilities in Kibera?
There is only one, it is like a landmark but I wonder why they never expanded on the idea. They used bottles and concrete to make an entire structure. That's the only one that I have seen o far but in my opinion, if something can be built out of plastic or garbage. Even I think about how garbage can be managed and turned into something precious in our facility as well. We can recycle something for plants or something else and help the environment and affordable systems. I have seen some company that converts plastic into something useful.