Circular Economic Approach To Dharavi: Existing Self-Build Framework Intervention

by

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Dalhousie University is located in Mi'kmaq'i,
the ancestral and unceded territory of the Mi'kmaq.
We are all Treaty people.

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Abstract

Informal settlements are rapidly growing worldwide. This is the result of rural population migration moving into urban capitals like Mumbai leading to a scarcity of space. They establish slum communities within the cosmopolitan cities that provide new livelihood opportunities. Dharavi lacks adequate housing, infrastructure, and sanitation for its 1.6 million inhabitants.

Through a circular economic methodology, the thesis intervenes at the urban, dwelling, and component scale to improve the existing self-build framework to be feasible and sustainable while harnessing the social and economic networks to redevelop the settlement gradually. This bricolage assembly method depends on the evolving waste materials surrounding the site. The design allows for this adaptability at both the dwelling and material scales to develop community resilience.

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Last but not least, I want to thank my parents for supporting me while I follow my passion. Thank you for your ongoing support of my efforts; it has taught me the value of giving back. And to my closest friends for always supporting me and also helping me stay motivated and goal-focused.

Chapter 1: Introduction

India is growing at an unprecedented rate. In 2022, a developing nation took over the economic productivity of a developed country. This astronomical leap in development indicates that India is expanding at a rate it is not designed to withstand. Cities are clamouring for skilled labour; with those already in the city busy in the service sector, the rural populous are answering. Within the province of Maharashtra, there is a massive influx of workers pouring into metropolitan cities and setting up make-shift, unrecognized, and illegal settlements as they secure labour jobs that are sporadic and informally paid. These settlements are as haphazard and fragile as the mental state of the migrants that occupy them. The negatives of these settlements are lack of sanitation, sunlight, water infrastructure hastily built, and often unfit for safe inhabitation. Initially, the misconceptions and building practices are investigated to better understand how people live in these settlements. On the positive side, these settlements are thriving communities with social practices and residents contributing actively to the cities' rapidly growing economy. Despite their informality, the informal settlements in Mumbai are historical; for example, Dharavi has existed since the 18th century. It is interesting to consider the contemporary urgency of a neighbourhood that has had such a significant impact on the shaping of modern Mumbai. A constructive intervention that meets the needs of these communities is necessary to recognize their contributions to society.

The thesis focuses on preserving the settlement's economic and social practices, allowing it to supply solutions to an exponentially rising population. This thesis explores

the governmental projects that proposed separate redevelopment schemes to rectify the issues faced by the settlement. It uses these schemes to study the area demographic; as the voice of the inhabitants and determines a unit size as a design constraint (Patel 2021, 53)

This thesis uses the work of a series of authors to develop design ideas and understand the distinction between formal and informal. The kinetic vs static concepts shed light on the organizational living in these informal settlements (Mehrotra 2008, 206). The City is Not a Tree, describes the formalized hierarchical community as having social and economic secondary spaces of more value than a settlement's urban core (Alexander 1987, 132). Cityness designates Asian cities to prioritize the parts above the whole; hence on a deeper scale, the various space use habits that make and transform the dwelling into a home are vital compared to the finished formal building (Sassen 2002, 2). Finally, Urban Advantage portrays the architecture in slums as the result of a desire to meet fundamental needs like shelter and food and create a living through income-generating spaces (Brugmann 2009, 282). The concept states that everything is connected to the economy. This entire study also assisted in informing the location of the design proposal.

The thesis investigates the existing practises of self-build. The kinetic and cyclic nature of informal settlements will be converted into a circular economic technique and applied to address everyday housing conditions. This strategy will result in a lower environmental imprint that the government can fund. Through a more sustainable system, it will empower informal residents to maintain their self-build habits.

Given India's fast economic growth and large population, it faces unique resource and energy management challenges (Dey 2021, 5). A suggestion for assisting the country with this challenge is what Dey dubs a circular economy. In this economic model, recycling plays a vital role as the materialistic methodology present on-site is transformed to help the united efforts of the informal and formal sectors in recycling waste materials into building materials.

This thesis rethinks housing as a shelter and introduces bricolage as an infrastructural framework. The design proposal encompasses housing as a prototype for different social/labour spaces and water infrastructure. The project combines natural and industrial on-site waste materials to create building blocks. Housing precedents like the Pune incremental housing project and the Ahmedabad activity center are investigated to indicate that the project works under the self-build archetype while ensuring community inhabitation practises are sustained in the design.

The design is developed considering the constraints of the site, economy, material, social space preservation, infrastructure, and unit size. Furthermore, the site is near an existing industrial production group that produces waste and allows people to dwell nearby. The waste produced is an essential element for design, along with other natural materials. The thesis also advocates for improving sanitation, sunlight, and durability through the design proposal while maintaining the existing social and economic networks established by the people as a daily practice. This reduces the long construction timeline through the feasibility of waste material construction. The thesis proposes a formal self-build housing model that is durable because of materials, feasible due to waste reuse, and sustainable while

considering the inhabitant's input. The thesis proposes a project implemented at the urban, dwelling, and component scales.

Thesis Question

How can an intervention at the urban and dwelling scale improve the informal building system to be feasible and sustainable while preserving the craft's cultural, social, and economic spaces in the slum network?

Chapter 2: Informality

An overview of what informal settlements are and how they are perceived around the world. This section examines the present concept of informal settlements from the standpoint of the UN-Habitat slum problem. Although the report was performed a decade ago, the fight for existence was highlighted a decade ago, and people's perceptions of living in these villages have altered. The current living patterns will be examined to understand space use and dwelling practices that give an informal settlement its characteristics. The goal is to identify issues that residents confront within a community while researching aspects of a settlement that entice individuals to stay for decades.

What Is An Informal Settlement?

"Informal settlement" refers to various low-income settlements and inadequate human living conditions. These substandard dwelling situations demonstrate the many expressions of poverty. Dwellings in such settlements range from rudimentary shacks to more permanent constructions, and access to essential utilities and infrastructure is sometimes limited or in poor condition (UN-Habitat 2004, 337)

The definition of a formal versus informal settlement is constructed by the cultural and social expectations where such a phenomenon occurs. There is a range of informal settlements that are classified by various parameters. The United Nations Settlements Program characterizes a slum as of inhabitants with inadequate infrastructure, shelter, and sanitation. A community settlement is defined as informal if the residents living under one roof lack both adequate

living space, permanent structure, access to clean water, sanitation, and are overcrowded (UN-Habitat 2004, 337)

The uncontrolled element of overcrowding will be addressed in the design.

Glimpse At Urban Informality

In the 1820s, the term “slum” was used to describe the poorest quality dwellings and the most unhygienic circumstances; a haven for marginal activities such as crime, “vice,” and drug misuse; and a possible source of many illnesses that decimated metropolitan regions. However, during the nineteenth century, this was redefined as “a street, alley, or court located in a crowded section of a town or city and inhabited by individuals of a low class or the very poor.” (UN-Habitat 2004, 338). Today, “slum” is overused, derogatory, and highly racialized. It has numerous connotations and meanings and is forbidden in many more sensitive, politically correct, and academically rigorous lexicons. More recently, classifications defined in India in 1993 employ housing conditions and the availability of facilities as the primary foundation for classifying areas as slums - areas with dense, poorly built, or largely temporary housing with insufficient sanitary and drinking facilities (UN-Habitat 2004, 338).

Urban informality can be understood through the interwoven study of urban dynamics, such as lack of affordable housing programs, economics, vulnerability, over-population, government policies to provide aid, and forced displacement due to inadequate income. A report that studies the intersection of informal settlements and the informal economy states that about 30 percent of the world’s urban population lives in informal settlements, with 213 million settlements located globally. The UN-Habitat Global Report on Human Settlement 2009 states that an estimated 1 Billion

people live in slums. This amount is higher in South Asia at 43% and Africa, with 62% of the population living in slums (Lizarralde 2015, 3). The abovementioned growth will affect the urban context and expose a compelling challenge for architects, planners, and governmental legislators. Due to rapid urbanization, the urban metropolitan city structures will not be prepared. They will lack resources to accommodate the increasing population, leading to the fragmentation of urban spaces and the creation of informal settlements.

Global Views On Informality

Lack of essential services, substandard housing or illegal and inadequate building structures, overcrowding and high density; unhealthy living conditions and hazardous locations, insecure tenure, irregular or informal settlements; poverty, social exclusion, and minimum settlement size characterize the negative concepts of slums (UN-Habitat 2004, 338). Inner-city slums gave rise to the concept of informal settlements. The process by which central, prosperous residential sections of cities deteriorate as their original owners relocate to newer, more salubrious, and more fashionable places. They are manifested by an increase in central commercial and manufacturing sectors and an influx of migrants looking for work.

Informal Settlements In The World

A series of maps depict the population, percentage of people residing in slums, and some of the largest informal settlements in the world. Following this page, the maps show India as the most populated country in the world. 40 % of India’s population lives in informal settlements, thus calculating a more significant number of people than in Africa.

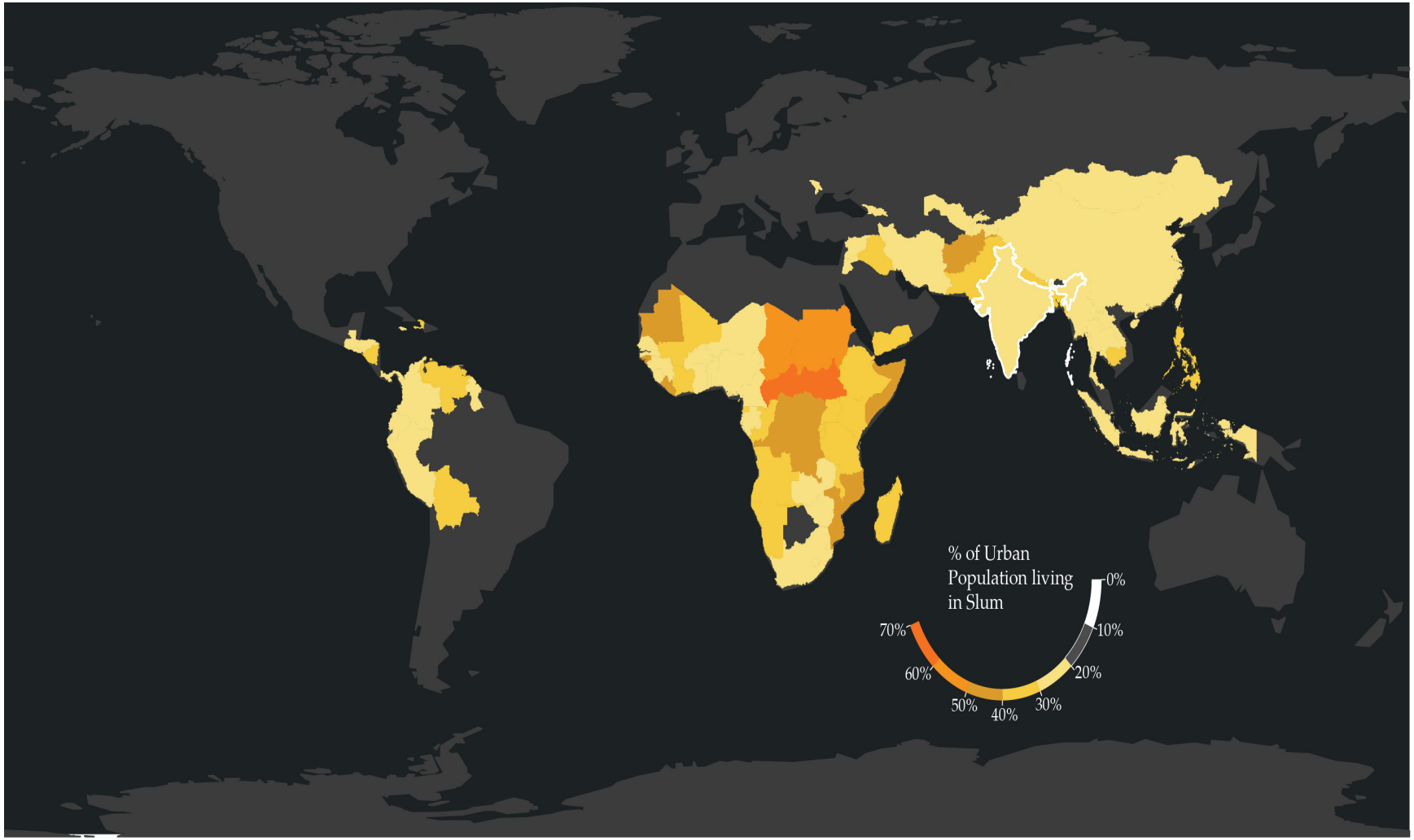
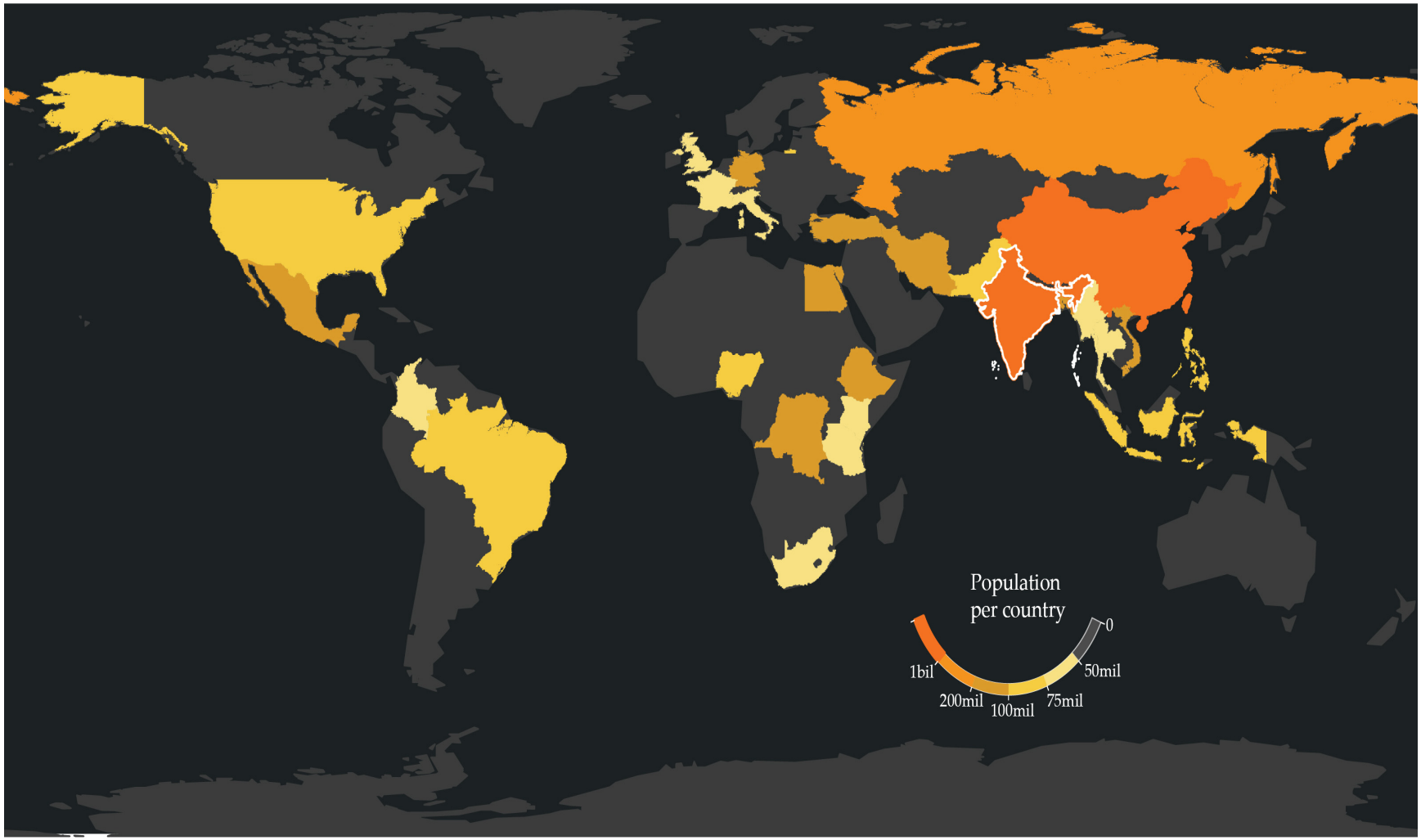
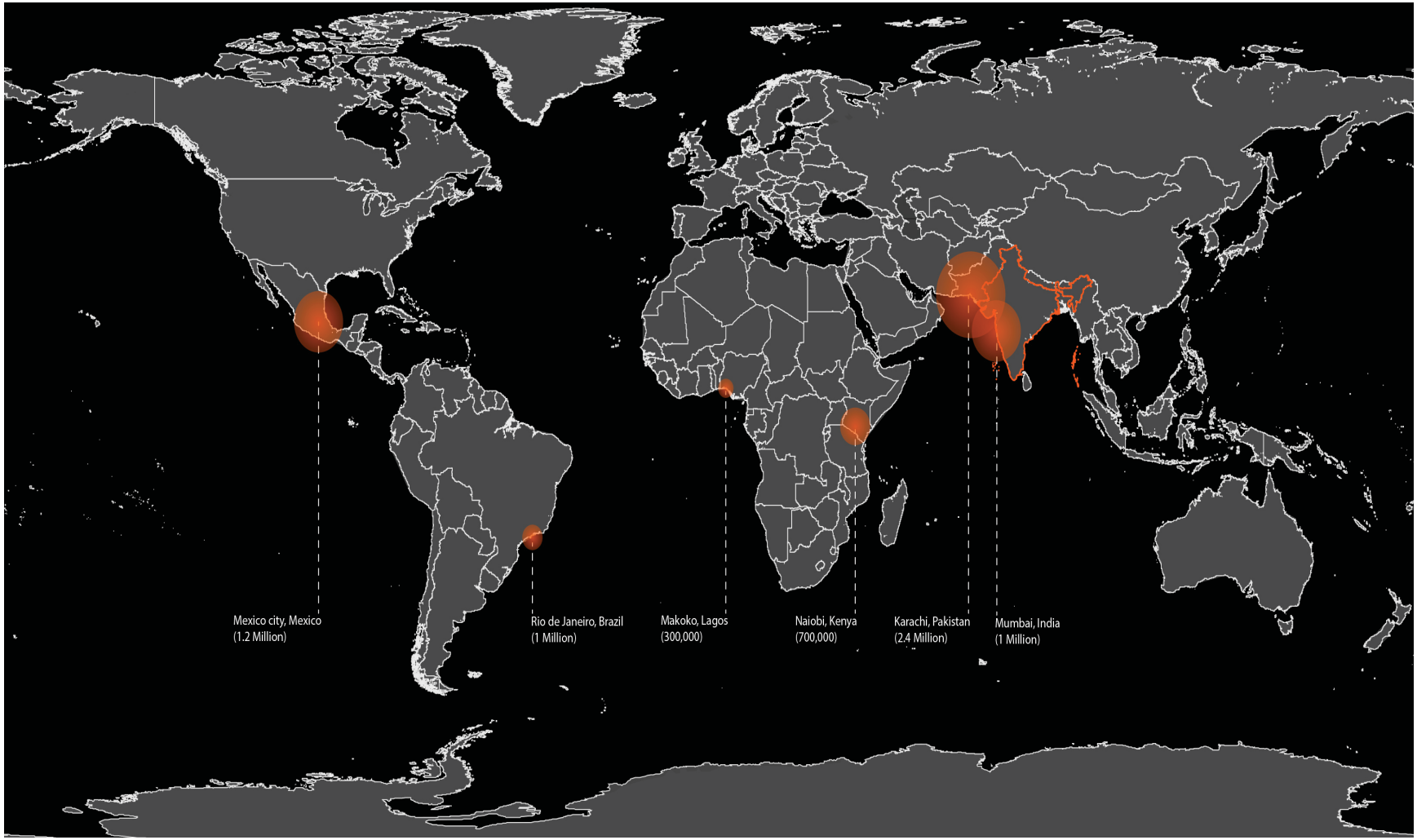


Illustration of the percentage of urban population living in slums, in the word. This does not account for rural population (World population review 2022).



An illustrated of the population per country showing India to have the second highest population but combined with the world map of population living in slums above, India has a large population residing in informal settlements (World bank 2022).



A depiction of the top informal settlements in the world. Dharavi, in Mumbai, India is the second largest in the world (Phillip 2022).

This suggests that India is important to study as a potential destination for a project that counters the harsh conditions in slums. Finally, a map displaying the largest slums shows Dharavi, Mumbai, as the second largest informal settlement, an ideal study site for this thesis.

Common Misconceptions About Informal Settlements

To find the best solution for informal settlements, we must understand the misinterpretations about informal settlements. In the book “Invisible Houses,” Gonzalo Lizarralde dictates the idea of developing informal settlements and creating a framework for them. However, initially, the author addresses the misconceptions about them (Lizarralde 2015, 6).

This project and its design are for the people who reside there. It is essential to consider the point of view of the inhabitants dwelling within such areas and understand their needs. So as to not impose our intentions and ideas into their neighbourhood.

Slums And Informal Settlements In Developing Countries Are Decaying Environments

The first misconception is that the slums and informal settlements of Mumbai are decaying environments (Lizarralde 2015, 6). Although some slums may contribute to the degradation of their surroundings, it is not always true that these spaces constantly need improvement. These spaces are only classified as decaying compared to the modern standards of living found in western developed nations. “Freedom to Build: Dweller Control of the Housing Process” by John Turner states that living standards only classify a physical component that generalizes people suffering from rent or mortgage affordability (Turner and

Fichter 1992, 145). Once observed from another perspective, the chaos is controlled and adaptable. Informal settlements can be seen as vibrant and dynamic neighbourhoods on the path of improvement. They are often carefully planned using innovative construction techniques in urban areas considered unsuitable for construction.

All The Urban Poor Live In Informal Settlements

The truth is that rural areas have more poor people compared to urban areas. Some people living in slum dwellings are not poor. Instead, the inhabitants are a cohesive clan that practices professions or are merchants, employees, entrepreneurs, gangsters, and university students. Cities with slum dwellings are associated with the inability to absorb migrating urban population. (Lizarralde 2015, 6)

Nothing Is Worse Than Living In A Slum

Besides what the media showcases about slums, these settlements are not sites of the worst living conditions in developing countries. They do not permanently house the poorest unhabitats of a city. Contrary to common belief, the poorest citizens are found to be those living in villages or rural areas of third-world countries. This has led to an extraordinary amount of people migrating from rural settlements to urban areas. The low-incomed poor living in urban areas has a better lifestyle than their rural counterparts, emphasizing informal settlements as an escape from the poverty faced in rural areas.

Slums And Informal Settlements Are Places Of Misery And Despair

This is not true because, initially, the residents are busy with activities, working, or doing chores. However, they also fight for money, status, food, or their children. In Mumbai, this was seen in the cleanliness of school children's uniforms. In India, men meet and gather to watch a cricket match, and families prepare for a celebration. This shows the social spaces within the slum as a positive characteristic that needs to be preserved.

Residents Are Waiting For The First Opportunity To Escape From Slums And Other Informal Settlements

Residents of a settlement attempt to improve their lives; from an outside perspective, this can be viewed as an escape from slums. Most people living in these settlements would like their living conditions to improve; the belief that slum dwellers dislike residing in slums and that they would escape from these areas has led to poor housing solutions and policies (Lizarralde 2015, 7). Slum characteristics state that inhabitants prefer to live in their existing settlements because of the solid economic and social network. The residents build bonds and relations with friends, family, clients, and service providers because these networks play a significant role in the people's lives as they gain a form of social and economic safety net.

Inhabitant Designers

An emphasis is placed on engaging the construction sector within the process and giving agency to slum dwellers. Private and governmental stakeholders will all play a role in the upgrading process; however, we can only achieve a

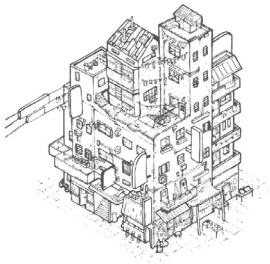
sustainable and innovative solution by realizing individual agency and comprehensive interactions between the inhabitants and the stakeholders (Lizarralde 2015, 180). Without considering the inhabitant's opinions, it would not be easy to understand the unique dynamics and individual needs to survive. Viewing informality through these various lenses allows architects to interpret the needs and wants of these capable and intelligent inhabitants.

Building Practices In Informal Settlement

Informal structures are called vernacular architecture because they are generally based on local needs, materials, and traditions. Hasgül expresses that ''Vernacular architecture does not go through fashion cycles'' (Hasgül 2016, 19). Squatter colonies have a self-build process, influencing residents' motives for tenure and expression of constructed form. Houses are only one or two stories high due to the primitive building techniques and materials employed in self-built dwellings. Aside from problematic locations, informal settlements rarely meet sustainability standards. Due to the low-quality materials utilized in this sort of low-income construction and the informal builders' lack of technical training, self-construction poses several obstacles (Caballero 2018, 198). Ordinary families in urbanizing countries prefer living in large unfinished houses or shacks rather than small finished ones (Turner 1977, 87).

The economic circumstances in an informal settlement forbid them from purchasing or renting a home; they are compelled to occupy private or public land to self-build their homes in hazardous conditions. Families usually start with temporary materials like plastic, wood, or cardboard before progressing to more permanent buildings made of bricks,

blocks, cement, asbestos, or zinc tiles (Caballero 2018, 199). By definition, informal housing units are built with less expensive materials, such as mud bricks, bamboo, and plain wood. Furthermore, these materials have a shorter lifespan. Hasgül provides three reasons behind the importance of people's participation in developing their homes. First, program results are more successful if the intended beneficiaries participate in their design and implementation. The second benefit is building the community's self-enabling character and cooperative spirit. Facing common problems with solidarity and finding solutions collectively leads to greater self-assurance and pride over the group's ability to act productively. (Hasgül 2016, 22). This indicates the importance of the self-build system of constructing homes. Based on the materials used, the condition of living, and the timeline of self-build construction, this process is a negative element of the slum that needs to be improved.



The negative element of unsanitary dwelling that will be improved through the design.

Conclusion

The United Nations defines a slum as a community of people with inadequate infrastructure, shelter, and sanitation. The UN's definition is almost a decade old; this thesis investigates the contemporary understanding of these informal settlements from the occupant's perspective. The study demonstrates that all settlements are not rotting wastelands inhabited only by the poor but rather lively communities with a network of improving social and economic spaces.

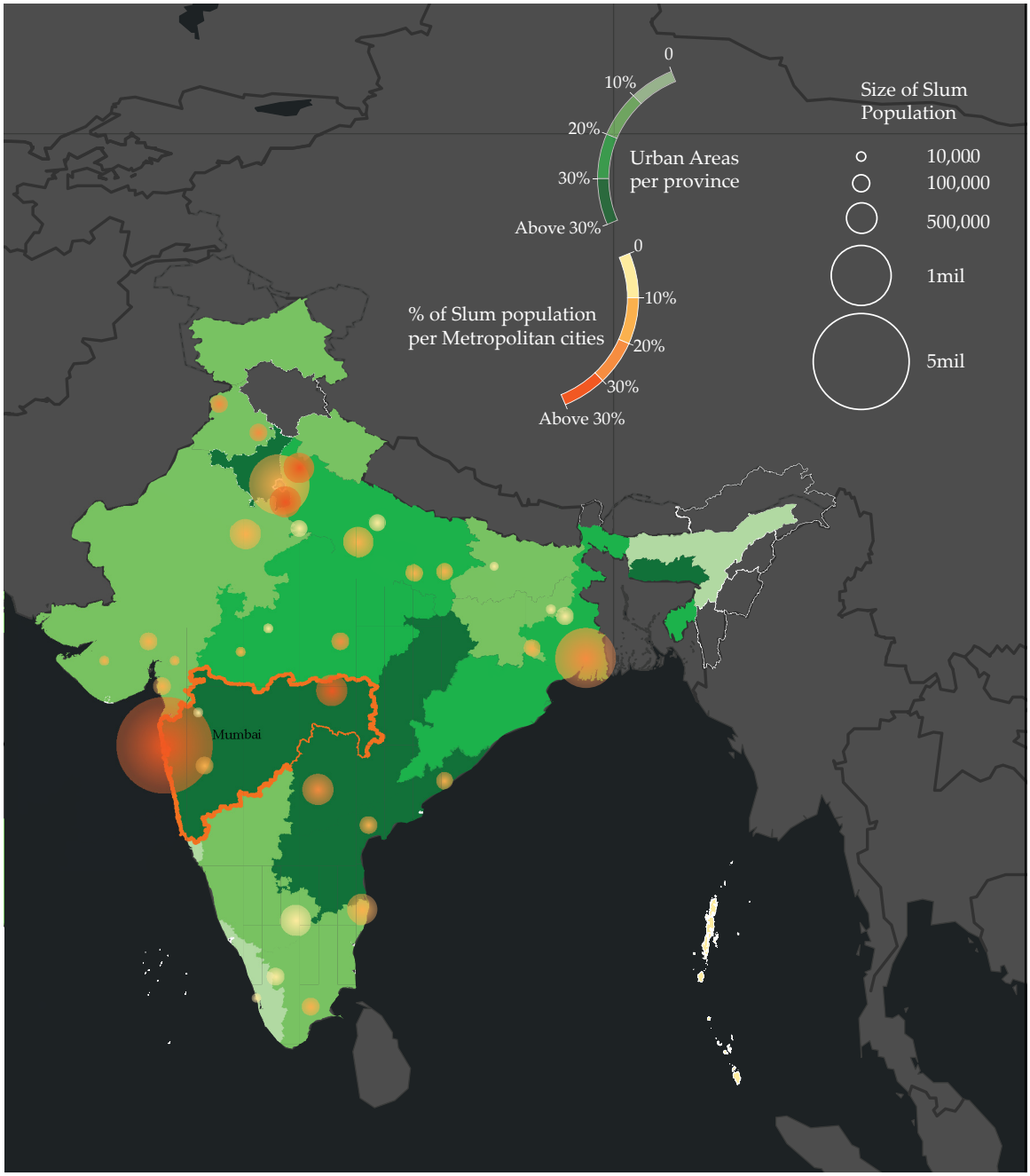
Chapter 3: Borough In A City

This chapter studies informal settlements in the country to establish a specific location for the thesis. It also investigates the migration of people from rural to urban areas as they seek job opportunities. Many come to Mumbai for economic opportunities in India's economic and business center. This study will emphasize Dharavi as the city's largest slum, requiring additional housing. The Dharavi neighbourhood will be further researched for its economic capabilities, social network, and redevelopment rules to establish the issues and define design limits.

Informal Settlements In India

These slums proliferated due to the post-British independence partition and the industrial revolution. Before the 1950s, the slum population was labourers working in mills and factories. The density of the slums did not stretch to rural areas but instead began to concentrate in and around the cities. By 1968, slum dwellings had increased by 18%. By 1980, slums accounted for half of the population (Bandyopadhyay 2013, 56).

Urbanization drives economic growth that draws people to seek increasing economic opportunities; a poor urban infrastructure fails to meet the needs of these migrants. Slums proliferate for demographic, social, economic, and political reasons. Common causes for slums to grow to include poor planning, economic stagnation, depression, poverty, high unemployment rates, an informal economy, colonization, segregation, politics, natural disasters, and social conflicts (Ganguly 2019, 20).



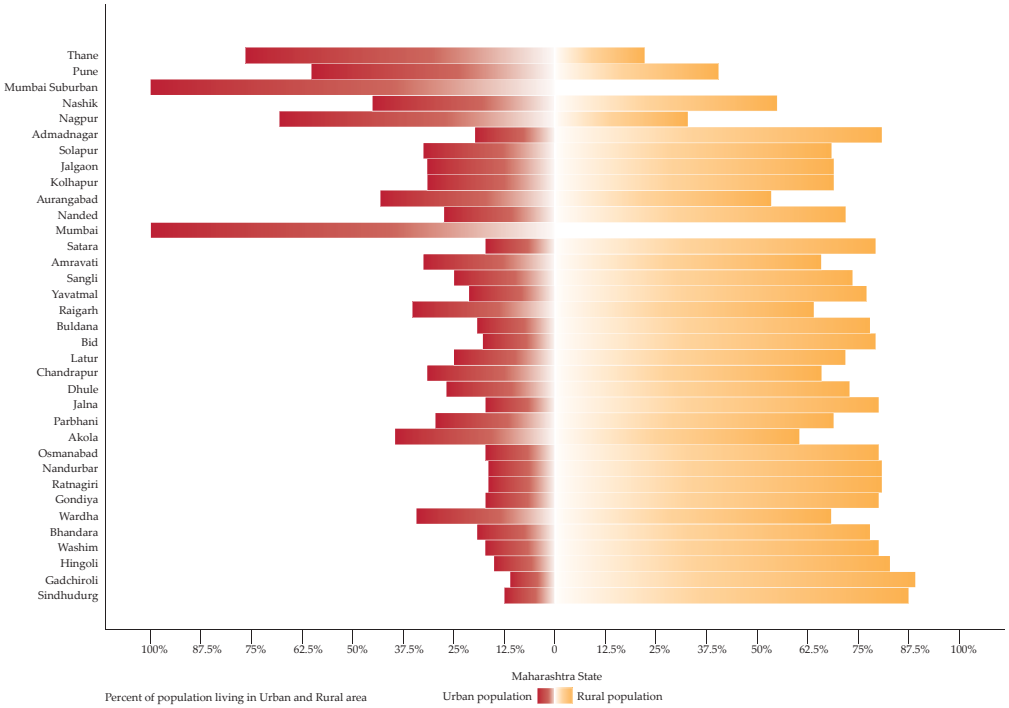
This is an illustration showing the slums in India and highlights Mumbai with the largest informal settlement (World population review 2022).

Whenever there is a significant gap between the demand for housing and an insufficient supply of affordable housing, this gap is typically met in part by slums (Ganguly 2019, 22). Many slums keep developing because of their growing informal economy, which drives the demand for more migrant workers. An informal economy grows faster than a

formal economy when government laws and regulations are opaque. Slums thus create an informal alternate economic ecosystem that demands low-paid flexible workers, something impoverished residents of slums can deliver (Ganguly 2019, 24).

Migration Of Residence Into Urban Cities

The phenomenon of labour migration is based on Ravenstein's migration laws, in which he highlighted the concept of 'search of opportunity' as the primary motive for migration (Ravenstein 1885, 198). Another primary factor promoting informal urban settlements is the influence of pushing and pulling. Pushing is described through the environmental degradation and declining productivity of cropland; low rural incomes from agriculture; lack of new lands for farming; move to export rather than subsistence farming; enclosure and consolidation of farm holdings; limited off-farm employment. By comparison, pulling is



A graph of where the population residents in the province of Maharashtra. An emphasis on Mumbai as the population resides in urban areas (Borhade 2020).

characterized by higher incomes in urban areas; more significant employment opportunities; economic safety nets; availability of social services, education, and health care; improved water supply, and other environmental services and infrastructure. The push and pull factors attract and cause the migration of people from rural to urban areas (UN-Habitat 2004, 338). For these reasons, Mumbai is the economic attraction to labour workers. The informal settlements in Mumbai will inform a neighbourhood and site for the thesis.

Architecture

Dharavi settlement near Mahim Junction in Mumbai, India. (Savin 2016)

The urban landscape of Mumbai is defined by an architectural pluralism that contrasts vastly different needs and benefits, all interdependent on one another. Formality and informality are not defined using western parameters. Formality constitutes long-term and static architecture constructed in a planned and orderly manner. Rules also govern Mumbai's informal architecture, yet these are different from the formal rules and instead function to offset the inequality prevalent in society (Degaetano 2012). Thus one will find over 4414 police officers and 81 inspectors residing in these illegal slums despite being enforcers of the law themselves. Despite its wealth, the prevalence of slums in Mumbai results from unstable economic cycles and irregular income distribution. The wealthiest 10% of the population are rarely seen on the street, moving through them like a corridor that connects people between two locations. The middle class (30%) sees the streets as an extension of their homes. For them, the streets function as gathering spaces to socialize and rest. The remaining 60% of the poorest population take to the streets out of dire necessity as provision, work, living, and surviving all occur on the streets. Thus the public realm

functions differently for each class of society. Unfortunately, most architects design with only the top 10% of the city's residents in mind (Degaetano 2012).

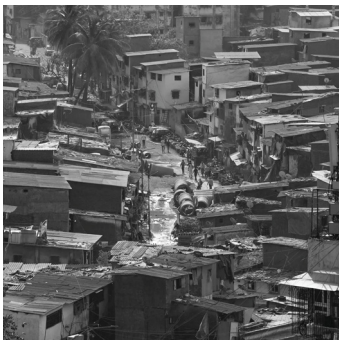
Building Practices In Mumbai

Slum housing in Dharavi and the different kinds of materials they use. (Simpson 2018)

Mumbai has traditionally been a migrant city of Gujarati migrants, industrialists, dealers, and migrant labourers, initially from the countryside. The migrants settled in various parts of the city, according to their income status, extending from the famous Malabar Hill, Gurgaon's middle-class cultural center, the bustling chawls of working-class Girangaon, to the destitute slums of Dharavi and the homeless in remote corners and pavements (Neera 2003, 4729). The architectural style used in Mumbai is gothic, which was introduced for public structures symbolizing powerful legal, political, and educational institutions like the high court (Neera 2003, 4728). The architects of Mumbai's prominent public buildings were all non-Indians, predominantly British (Neera 2003, 4730). These enormous public buildings, meticulously surrounded by rich green grounds, increased the monumentality while emphasizing the physical and metaphorical distance between ordinary indigenous and colonial rulers.

Dwellers go about their daily routine in the Dharavi slum in Mumbai (Berehulak 2009)

The textile industry contributed to Mumbai's prestige. The textile mills were located on the southern tip of the island of Mumbai, past the Gothic and art deco architecture. Even today, the high walls surrounding the mill structures, the rising chimney, the box-like unpainted three- or four-story chawls, and streams of employees streaming to and from the mill gates all contribute to the appearance of a time warp. Housing for textile mill workers was built in the shape of four to five-storeyed chawls in 1920. These were one-



Parts of Dharavi have been sealed off during a government-imposed nationwide lockdown. (Mukherjee 2020)

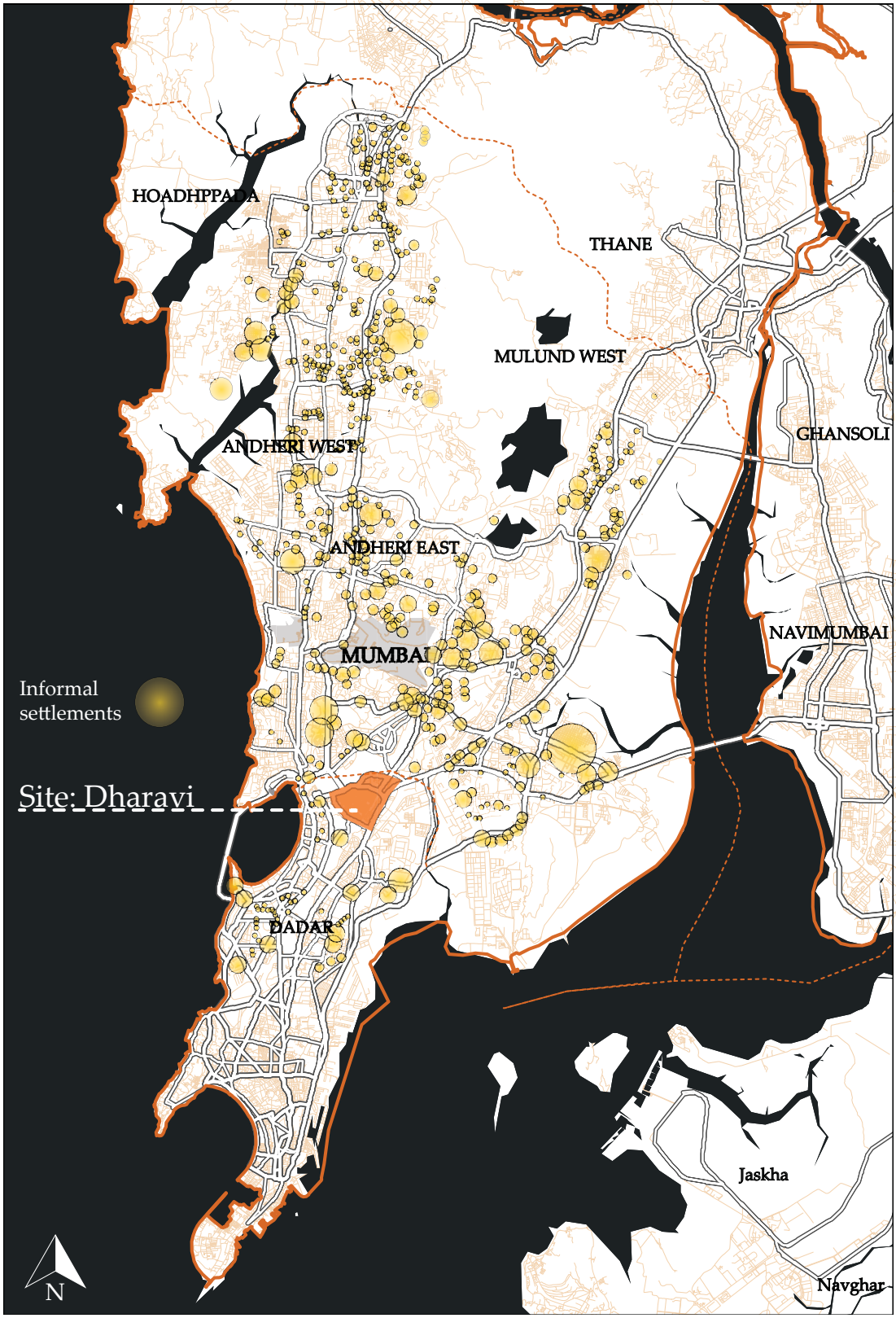
room tenements with shared corridors in the front and back. The shared restrooms are located toward the back of the corridor (Neera 2003, 4729). These chawl complexes are distinguished by their drab box-like exteriors and are built with reinforced cement concrete frame construction and brick walls painted in dreary gray. These chawls and public structures in Mumbai defined the building practices in the city. Housing expansion flexibility is perceived as a negative element through the chawl example and will be improved through the design.

Climate

The weather is characterized by high humidity and muggy weather, Mumbai's proximity to the Arabian Sea creates fluctuations in its temperature. Summer is the most humid and the weather cycles between summer, winter, and monsoon seasons. Western winds characterize Mumbai's monsoon seasons. May is the warmest month, with temperatures ranging from 32 to 40 degrees Celsius. January is the coolest month, with a temperature range of 24 to 18 degrees Celsius (Kanyinda 2019). Between June and September, up to 1800 mm of rainfall can be experienced in Mumbai. Though the air is cool at this time, the air retains moisture and is thus very humid. The ocean is turbulent and choppy, with high winds and a rough sea surface. Boats are sometimes too vulnerable in this weather and remain anchored at shore. Locals prefer November to February in Mumbai as the most pleasant time. Temperatures can drop as cool as 10 degrees Celsius (Kanyinda 2019).

Dharavi, Mumbai

Spanning 500 acres, Dharavi is estimated to be around half the size of New York's Central Park, yet a million people



The city of Mumbai with the location of informal settlement. The site and the largest slum in the area are shown in orange (Dutt 2014).

live in it. It is ten times denser than the rest of Mumbai. This renders the slum the most densely populated piece of land on earth. Previously, water was accessible only once a day before dawn at standard taps in designated areas. Given limited water access, residents must share their bathroom facilities. Most residents must access communal taps for around 30 Rs. Per month. Bathrooms are the most unsanitary and unpleasant parts of Dharavi. Residents queue up outside these communal spaces every morning. Women and children are especially vulnerable during the night. Limited access to water and scarcity of communal spaces is a negative elements that will be improved through the design in Dharavi.

The negative element minimal water access will be improved through the design.

New migrants to the slums prefer to live as close to their working quarters as possible. This means living near high-income residential areas for domestic helpers, heavily industrial complexes, and construction sites. Informal settlements are built on vacant land peddled by slumlords that cannot pass the land off to public or private owners. The decision towards permanence is only made once the dwellers have occupied their unit for some time. The threat of slum clearance and a lack of ownership always leaves occupants wary of settling down. 70% of slum families enjoy a regular income from some job. Though many are part of the informal economy, some people have regular jobs, such as taxi drivers, police officers, and telephone mechanics. Domestic workers earn 5000 Rs. Per month while carpenters earn 30,000 Rs per day. While money is prevalent, ownership of land is not. Slumlords continue to collect informal taxes, and police officers hackle residents for bribes regularly.

Social Networks Developed

Instead of utopias that can develop community networks, crowding people into congested and uncomfortable spaces created sites of social friction (Ayyar 2007, 10). Large cities, such as Mumbai, provide migrants with the most opportunities for social mobility. However, the social aspects of rural settings also play a role in the migration of low-income people. Social networks are essential for just an entrance into the city since they include friends, neighbours, and villages from the same class. Such class-based social networks facilitate access to possibilities in the local labour market, earning a living, obtaining loans from moneylenders, and so on. These networks not only serve to give housing and food upon arrival but also to assist in establishing a base in the neighborhood (Ayyar 2007, 19).

Dharavi's habitat is dense, both in terms of social interactions and the variety of land uses. In contrast to designated conventional housing, poor housing nearly always blends living and working activities. Every community is a complicated environment in which every individual node depends on every other node, like a compact web of social networks. These social networks manifest spatially in the street's prominence as a location of contact, production, exchange, and survival (Lozano 2009, 7).

Social networks actively exclude and isolate those that are not members of their income class. However, the significance of social networks among the low-income poor is growing at resettlement sites. As a result of the involuntary settlement projects, affected families must now share their living spaces with a new community with various social and religious origins (Ayyar 2007, 24). This section shows that

Dharavi's social network will be preserved in the design.

Dharavi's social connections should be preserved through design. This is a norm practiced in the settlement and could be the reason for the backlash against some governmental proposed relocation projects.

Economic Network Of Dharavi

Economic Practices & Culture In Dharavi

Dharavi hosts 10,000 skilled artisans and 15,000 factories, and the country's most literate population with a literacy rate of 69%, turning the slum into a self-organized informal economic zone that functions independently from the city itself (Andreoni 2022). Residents are well-versed in politics and are often politically active in attempts to change their situation. They are well-read and informed about their situation despite their socially deprived condition. The government is relocating people from other slums in the city to Dharavi. However, looking at it from their perspective, they are happy being where they are.

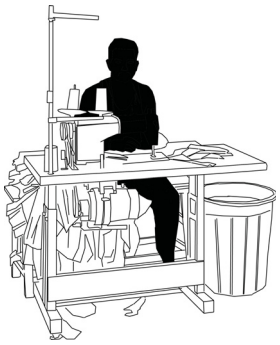
Industries found in the slum include recycling, where waste materials are sorted through, dismantled, and resold by individuals. Waste metals and plastics are all recycled onsite in Dharavi itself. Artisans sell knockoff wears, such as backpacks, at local malls. Tanneries dye animal skin to make bags and wallets. Many of these factories function outside in backyards, exposed to smells and toxic fumes around the clock. Pollution, shared toilets, poor sanitation, and air quality are daily struggles. These inhabitants form the majority of India's labour economy. Their jobs are usually to serve, sweep, chauffeur, cook, and deliver food. The average living shanty is 6'x10' in size, with an average of seven occupants per space (Lokhorst and Troost 2018, 22).

Industrial Density

Each industry in Dharavi is arranged at a fine granularity to take advantage of the slum's restrictions. Industries trade-off between boosting profits and providing superior infrastructure to employees. Surprisingly, the workers are also pleased with the contract because their net money is sufficient to meet their primary life goals. This results in a decentralized, labour-intensive, homegrown, low-tech organizational paradigm (Lee 2012). The density of the industrial or economic practices is evident in the map. Since 90% of these industries are unofficial, their interactions are unique to Dharavi. People are available to labour at meagre wages due to low motivation and terrible living conditions.

Dharavi has a high density of factories within the area that provide jobs and produce waste. All the professions are on display (Sayani 2021).

For starters, there is a lot of unskilled but inexpensive labour, and for another, being located in the middle of Mumbai, one of the most expensive cities in the world, is advantageous (Lee 2012).



The positive element economical craft practices will be preserved because this is the livelihood.

Dharavi's economic and industrial network strives to provide the inhabitants with jobs and a hidden platform to use their skills. On a positive note, this study shows the need to preserve these industries for the livelihood of the inhabitants and to celebrate the skilled craft produced by illiterate people.

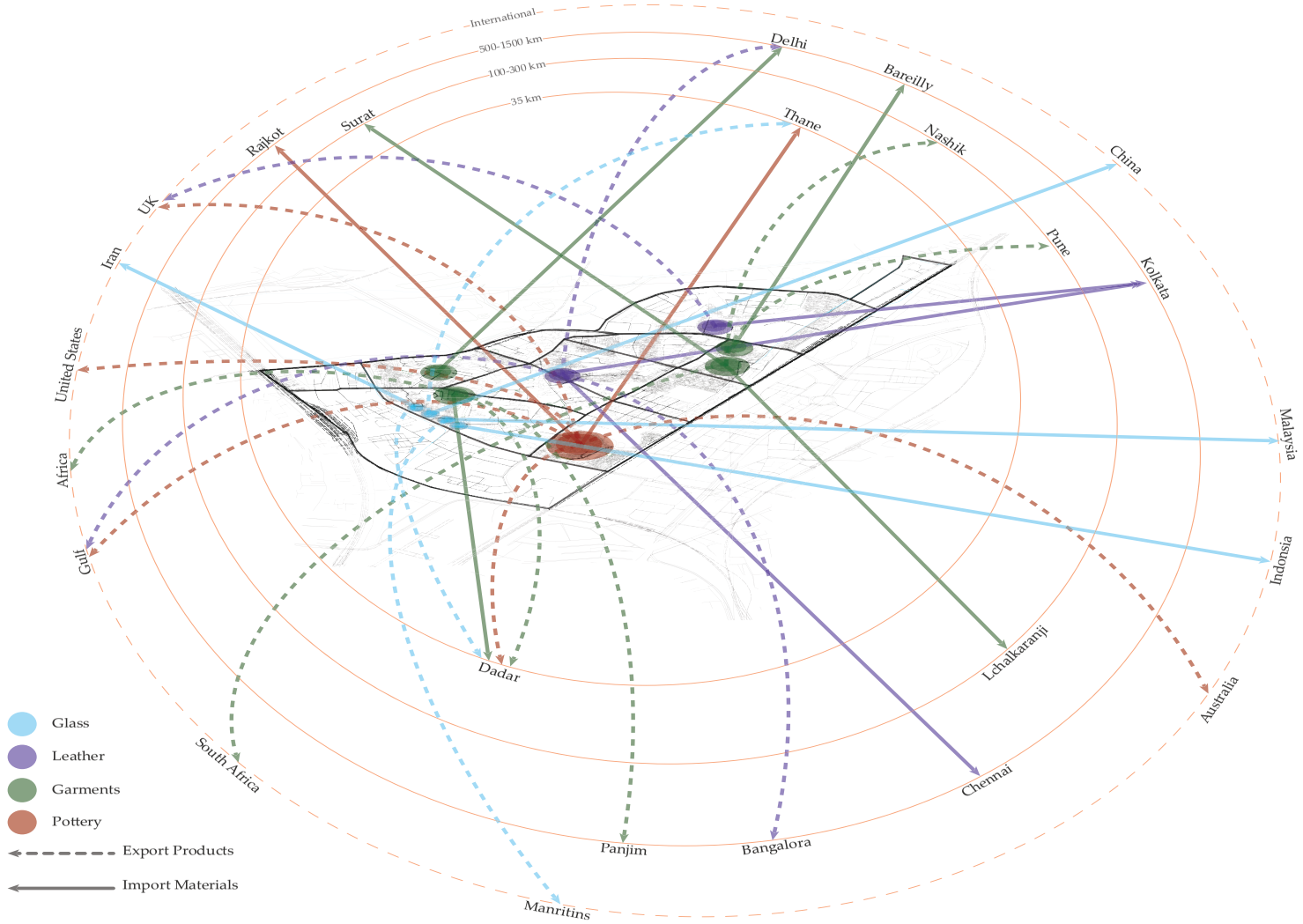
Industrial Kinetic Compared To Housing Static

Since women cannot leave the house, they are primarily involved in minor home-based services such as food catering or private education. Conversely, men work 12-16 hours daily, six to seven days a week, in the manufacturing and recycling industries (Lee 2012). This indicates that living near an industrial zone and keeping a job to survive is critical. Industrial spaces are the static element around which people grow and build homes to live near work. The map above displays this concept to indicate that the industry needs to remain around a potential site for the people to accept the proposed project and for their livelihood to continue undisturbed. Industrial density also produces waste that remains in the area and contaminates the living conditions of the people. However, that same waste can be used for the building block that can clean up the streets and provide a construction model for people to live better. Residing near an industry will be required to dictate the site's location.

The residents of Dharavi like to live in close proximity to their place of work. The industrial spaces become static to the kinetic housing growing around it like bacteria (Sushmita 2021).

Goods Imported And Exported

One of the unnoticed elements of the area is its capability to import raw materials to produce goods but to export the finished product nationally and internationally. An example is the production and exporting of the leather goods internationally. The raw leather is made in butcher shops, where the animal skin is dried, and chemicals are added. This leather is then shipped to several developed countries and used in labels such as Gucci, Armani, Versace, and others (My India 2017). The scale of the operation is evident in the diagram shown above and is another element that should be preserved.



The import of raw materials like glass, leather, garments, and clay. The industry produces goods and then exports them internationally (Sharvari 2021).

Governmental Policies

Since the 1970s, the government has attempted to solve the slum problem in Mumbai through unorthodox strategies for housing improvement. The strategies are shown in the chart below. These incremental housing improvement or slum redevelopment approaches involved the demolition of informal settlements and proposed subsequent rebuilding at a vertical density. However, the primary motivation for these projects was not slum redevelopment but profits that can be reaped by redeveloping prime real estate (Jagdale 2014). John Turner also argues that the physical preference of the slum dweller were ignored in these strategies (Turner 1977, 65). Gradually, the government replaced informality clearance plans with slum-improving strategies that provided essential services and better amenities. Between 1971 and 2004, numerous separate redevelopment schemes were explored to solve the housing problem, but they failed due to budgetary, administrative, relocation, and residential inclination issues.

	Project	Year	Salient Feature	Reasons for failure
1	Slum Improvement Project	1972	Provision of basic amenities to the slum like water, electricity, latrines and sewage disposal.	No comprehensive census on number of households and residents obtained.
2	Slum Improvement Project (contd.)	1976	Granting the residents "legitimate status", Photo identities were issued to establish legitimacy of residents.	Administrative issues due to lack of census; factual control of slumlords over parts of the slum in which no redevelopment could take place.
3	Slum Upgradation Project	1985	Leasing out existing slum land to cooperative groups of slum dwellers at affordable rates; granting loans for environmental and housing improvements.	A large portion of the area to be redeveloped was held by private developers and could not simply be redeveloped without adequately compensating them.
4	Slum Rehabilitation Scheme	1995	Transferable Development Rights introduced to attract private developers; central monitoring and clearing agency developed; redevelopment efforts more decentralised than before.	The scheme required consent from 75% of the slum dwellers, which was not obtained due to fragmentation of slum communities.
5	Dharavi Redevelopment Project	2004	Rehousing Dharavi's residents into tower block apartments; freed up slum land would be sold for private development.	Unacceptable to Dharavi residents since livelihood depended on Dharavi's sprawling layout.

A chart of all the redevelopment schemes in Dharavi (Patel 2021, 53).

The 2004 slum redevelopment scheme, however, introduced 300 sqft apartment units that would provide housing to the residents of the slum. The study briefly examines all of the previously mentioned schemes to conclude with a size parameter that dictates the limitation of the final unit size. The lessons from the study are used as a guide and restriction when striving to create housing units of 300 sqft. This will also helps achieve the sustainability target established in the report at the start of the thesis.

Surveys & Voice Of The People

Before, after, and during the proposal of numerous slum redevelopment schemes, surveys were conducted to learn different things about the area of Dharavi. Some surveys and interviews show the current housing conditions, people's desires, and the organization's failure to complete the study. In 1986, the National Slum Dwellers Federation recorded 1044 manufacturing units, including 722 scrap and recycling units, 152 food-making units, 111 restaurants, 85 units fully dedicated to export, 50 printing presses, and 25 bakeries. The study also identified 244 small-scale units with 5-10 people and 43 medium-scale firms with more employees (Bhide 2013, 11). However, these studies primarily ignore the home-based and loft-based businesses. The NSDF also conducted a survey in Dharavi examining the plastic recycling industry and its waste. Their results stated that the Dharavi plastic recycling sector employs approximately 5000 people. Furthermore, it indicates that the people who migrate from rural areas are looking for work to make a living (Bhide 2013, 32). This also speaks to preserving Dharavi's economy while using waste as a building material to improve sanitation.

Charles Correa was commissioned by the government to conduct a survey and study Dharavi's structures and settlement patterns in Dharavi (Bates 2015, 89). According to the Correa report, 43,000 homes should be in Dharavi, while 55,000 residents should be relocated to adjacent areas (Bates 2015, 90). This indicates the dense nature of the area and how difficult it was to conduct any study to help with the design parameters. A significant disconnect exists between the government, architect, and community because most surveys, and housing attempts addressing true community desires have been unsuccessful. The overarching, media-influenced issues of sanitation, infrastructure, and housing space were known and addressed through unsuccessful attempts.

Sanitation is an overarching issue in Dharavi and it will be addressed in the design.

Theories To Comprehend Informal Settlement

Cities must urbanize to keep up with the flood of people entering the city every year while attempting to develop the appropriate skills for a rising economy. The predominance of lucrative employment resources and the marginalization of the poor from the city had also translated into a hybridity between informal and formal development. A city's formal and informal components are interconnected, with numerous integrated economic and social networks. Understanding the significance of this relationship is essential for understanding how a modern city in the developing world operates and how the informal sector plays a role in altering the urban environment.

Kinetic City By Rahul Mehrotra

Rahul Mehrotra proposes that the city is divided into two opposing elements: the kinetic, which is informal/ transformative, and the static, which is fixed/formal

(Mehrotra 2008, 209). Kinetic and static elements exist in the metropolis. They constitute equivalent aspects when viewed as a ‘service’ required for the city to operate. When they are placed on the same footing, their worth as city components becomes clearer. The infrastructural transportation system, such as trains and roads, becomes an essential backdrop, even though it is regarded as the ‘formal’ component in this connection and allows both to coexist. (Mehrotra 2008, 210).

The kinetic vs static is understood through the analysis of the Dharavi area. The dwelling within Dharavi is a kinetic symbol of building environmental culture. It forms an impression of the city through its materialistic transformation while giving evidence of a waste material circular economy in the community. The apartment buildings, communal spaces, and industrialized recycling facilities are the existing static element in the Dharavi settlement. After that, the kinetic elements depend on the static aspects of physical location and the structural development of the dwelling, while the usage of minimal space amongst its surrounding architecture creates the community’s identity within the city. However, the roads, alleyways, trains, and other circulation connects the two elements to co-exist and thrive.

The Kinetic is a symbol or memorial of culture that is not locked into materialistic activities excluded from global finance and has formed the city’s identity: trading activities, festivals, pedestrian mobility, and transportation form the contemporary culture of the urban reality. Furthermore, even though the kinetic is informal and dependent on the structure for its development, the usage of spaces amongst and surrounding the architecture produces a picture of the city.

The City Is Not A Tree By Christopher Alexander

In *The City Is Not a Tree*, Christopher Alexander begins to examine the connections between the fixed pieces of the urban fabric. Alexander depicts the fixed components' hierarchy through an analogy of a tree, which is fragmented and limited to rigidity and discipline (Alexander 1987, 145). The tree's hierarchy expresses the significant components of a city and the desire for order. This is similar to a master plan, which may look at formal street lines, land use, and the general shape of structures, but organizes them in a rigid/ symmetrical hierarchy.

The Dharavi settlement contains fixed pieces of the urban fabric, such as industrial factories and communal washrooms. However, the housing branches off from rigid spaces without structure, roads, vegetation, or hierarchy. The fixed spaces can be considered paramount to survival, and the housing or gathering spaces are secondary to them as support. Numerous minor pieces, such as gathering or socializing spaces near a refreshment store, frequently function without a formalized area or hierarchy. These minor parts are parallel to one another and represent the significant nature of the settlement. The significant social and economic networks interact with these secondary spaces.

Cityness By Saskia Sassen

In the Urban Age, Saskia Sassen introduces the term Cityness to characterize the urban landscape of cities in Africa and Asia that do not correspond to our Western assumptions of a city (Sassen 2002, 2). The concept of Cityness urges that we reconsider these notions, accept variances, and understand different cities' cultural, social,

Minimal to no vegetation in the slums impacts the environment, thus will be addressed in the design.

and economic connections. Urban spaces in Asian cities are an activity in progress rather than a reflection of the ‘ideal’ public space that has been defined by our civilizations from the dawn of urbanity (Sassen 2002, 2).

In Asia, cities prioritize the individual pieces over the sum (Sassen 2002, 3). In the context of Dharavi, the individual community, which employs and houses people, is more vital to a resident’s life than the whole city of Mumbai; however, on a deeper scale, the various space use habits that make and transform the dwelling into a home are vital compared to the finished formal building. Every resident within Dharavi uses their indoor and outdoor rooms in multiple ways, making the spatial use components of more value than the room itself. These activities within the community also define commercial spaces inside the settlement; this moulds new professional activities that can take place in residential locations.

The community has innovatively utilized the space to generate income without any additional renting cost, thus contributing to the self-build scheme through residential and commercial space creation. The residents donate the ground floor of their dwelling as commercial while producing and selling goods during the day. They also convert space for socializing and sleeping purposes (Dey 2021, 37). This practice has a new, visible, and productive outcome that benefits the owner while utilizing the area. The person who sleeps or socializes in the evening will also utilize the space as their factory and store during the day; thus, the interaction is not conflicting but is beneficial to all parties. This also shows that dense spaces are used due to a cultural ideology of space use. This relation is a positive element

of the Informal settlement and part of the inhabitant's daily lives, which should be preserved in the proposed design.

The Urban Advantage By Jeb Brugmann

An investigation of the influence of globalization in developing cities, where the economic and interconnection systems that bind cities together start to manifest in the architectural form. Everything is connected, the foundation for the legality and legitimacy of urban developments and activities. This seems especially true in informal settlements, where the architecture results from meeting fundamental needs like shelter and food and creating a living through income-generating spaces. Jeb Brugmann analyzes the urban economic ideas that provide a competitive edge within the city: density, scale, closeness or concentration, association, and development (Brugmann 2009, 289).

The multi-space utilization practices of the settlement will be preserved in the design (Rooms 2018).

In Dharavi, a large group of people lives in a closer vicinity. The individual can accept more risk because the density of people represents a potential for trading, either as services, ideas, or products. Within the community, there are more enterprises to network with, resources to borrow, and other locations to occupy for commercial space. If a person is more ambitious, then it is a more significant economic benefit. Similarly, Mumbai has a deep connection to Dharavi, and the settlement contributes a significant amount to the globalized economy of Mumbai. Dharavi, from a perspective, is serving as an extension of the central metropolitan city, while goods, capital, and resources are freely imported and exported internationally. The small business owners within Dharavi are also at the forefront of representing Mumbai globally; through products similar to those produced in China's production districts. Extending these services creates global

networks and urban markets that connect a city to its informal borough, city center, and community. The urban advantage is evident and applicable to many cities worldwide due to the common goal of pursuing success.

Site

The site is selected based on the economic production and the inhabitation patterns of the people within the area. The people desire to be near work, and thus the site needs to be near an industry. The site also has to be within the area of Dharavi and near the stores to sell products made within the personal workspace or the factories. Here, the site is near the garment and leather industry within the area. The people already live near the industry, but moving them across the

The location of the site within Dharavi (Taneja 2019).

street will not warrant significant change and will maintain their social, cultural, and economic networks.

Access to sunlight will be addressed in the proposed design.

Conclusion

Durable housing, water, sanitation, sunlight, and infrastructure are all concerns faced by informal settlements in India. They migrate from rural areas to big cities mostly for financial reasons, so people live in slums close to industrial zones. Dharavi is the city's largest settlement. Hence, its social and economic networks are being studied.

Some concepts are analyzed and applied to understand an urban area of an informal settlement in order to understand the distinction between formal and informal. This entire study also assisted in informing the site's location and specifying some design requirements of space use or the importance of social spaces.

Chapter 4: Investigation Of Informal Dwellings

The chapter investigates dwellings within informal settlements. Precedents will also be explored and challenges that the residents' face.

Self-Build Housing

In the 1930s and 40s, some architects began to question their role in meeting the requirements of those who could barely afford their services. For generations, homeowners had constructed their own homes. Furthermore, they had done so without the assistance of architects, government agencies, or external funding. Slums were simply another type of owner-built housing. These ideas sparked the self-build movement (Sinclair 2006, 133).

Informal housing production is more commonly connected with rapid urbanization in emerging economies as a response to those countries' failure to build worker housing on a large enough scale and fast enough speed to accommodate immigrants. The gradual self-construction of a house is viewed as a highly reasoned and functional process because it allows access to land at no cost and uses household labour. Land on the outskirts of cities was either occupied by squatters or sold piecemeal to very low-income people who staked their claim by self-constructing a primitive dwelling. As eviction threats faded, those households began to consolidate their homes with more permanent materials. They would collaborate with their neighbours to hook up to nearby electricity cables and collectively hustle local authorities to replace informally harnessed services with formal infrastructure (Ward 2019, 3).

Architecture For The Poor **By Hassan Fathy**

“For, of course. a man has a mind of his own and a pair of hands that do what his mind tells them. . . . Give him half a chance and a man will solve his part of the problem without the help of architects, contractors, or planners-far better than any government authority ever can. . . . Each family will build its own house to its requirements and inevitably make it a living work of art.” (Fathy 1976, 32) Hassan Fathy’s work in Egypt was among the most noteworthy early experiments in self-build housing. Inhabitants of Gourna village were forced to relocate to a nearby neighbourhood in the 1940s after discovering that the community originated above the graves of virtuous ancient Egyptians. Fathy had seen developing the new village as an opportunity to test his ideas for low-cost architectural style based on ecological building methods.

The architectural discipline has evolved forwards and backward because the resident’s input needs to be addressed or used by different designers. Decisions made by Fathy in the past are a great example of the role of an architect and the materials used in a slum context. In traditional Egyptian construction, Fathy used natural materials like mud brick (Fathy 1976, 35). Furthermore, the government’s lack of enthusiasm left the project with insufficient funds to employ contractors to help build the design. Fathy collaborated with the inhabitants to develop his strategy rather than abandoning the project and leaving the villagers homeless. He adapted his design to include traditional village crafts and architectural structures in Gourna, ensuring the village’s identity was preserved (Fathy 1976, 44). Fathy envisioned the architect’s job as a professional consultant, adapting their education to the client’s objectives and the limitations

of construction methods (Sinclair 2006, 134). The role of an architect has evolved, and thus far, these thoughts by Fathy seem to be the beginning of change.

Freedom To Build By John F.C. Turner

“The certified professional makes a fool of himself and often does a great deal of harm to other people by assuming that he knows more than the uneducated by his schooling” (Turner and Fichter 1972, 35). John F.C. Turner similarly challenged the architect’s involvement in dealing with the problem. Instead, he considered these villages as reservoirs of indigenous knowledge from which the architect could draw inspiration. The topic of informality is intrinsically complex because no two circumstances are the same. When individual features of each unique event are considered, architects find it nearly impossible to produce optimum solutions for each informal settlement case. Fathy and Turner acknowledged the essential role that everyday inhabitants play in addressing the issue.

Turner proposes that the architect would thus act as a building project educator and mediator between the built environment and inhabitants, directing people’s wants through their expertise in the construction profession. By training individual’s feasible and efficient construction procedures, each individual may solve their problems. To accomplish this, the architect must first research the local environments and learn from the individuals who live there to determine which construction methodology would be best for that specific location. A new alliance is created through the idea of residential design input that changes the approach to informal settlement rehabilitation and reframes the self-help housing movement.

Visitation of the tsunami safe house, an interior view that shows materials and haptic feel. (Ratti 2005)

Render of the tsunami safe house in Sir Lanka. (Brehm 2005)

Exterior view of the safe house, displaying it within its surrounding environment with natural building materials. (Sheldon 2011)

Interpretation Of Prior Frameworks

Safe House, Sri Lanka, 2005

Following the 2005 tsunami, the Sri Lankan government established a zone along its coastal districts, prohibiting structures within 100 meters of the water. Despite the good intentions, the restriction decreased the space available to build relief housing for damaged towns which had severe economic, social, and cultural ramifications for those accustomed to living near the coast (Sinclair 2006, 133). The Harvard school of design initiated a project to allow buildings to be situated in disaster zones. The final design of the Safe house is a construction that blends conventional Sri Lankan building practices, such as using local wood with solid cores and essentially a rigid structure that houses the building's critical utilities (Sinclair 2006, 134).

The structure employs several overarching strategies that might be applied to Dharavi. The idea that a building should be able to adapt to the evolving requirements of its inhabitants is critical. As materials or funds become available, exterior elements can be updated. The system is sufficiently adaptable because the primary home can be expanded horizontally or vertically over time. The flexibility of the structure and the ability to improve dwellings gradually are both positive elements that the design proposal will include. Another learning element is the vast roof of the model developed for Sri Lanka, which provides shade for its inhabitants and keeps water from flooding the inner volume. Due to the Mumbai weather, this roof system could be utilized as a water collector for reuse and fluid retention.

Kampung Improvement Programme, Java, Indonesia

During the 1960s, Jakarta saw an inflow of rural migrants, primarily drawn to the city to fulfill the needs of the construction sector (Holod and Rastorfer 1983, 215). Most sought sanctuary in unserved, unplanned squatter settlements known as Kampungs on the city's outskirts. While residents in urban Kampungs updated their dwellings according to the availability of income and materials, the settlements lacked essential amenities such as water supply, appropriate sewer systems, and electricity (Holod and Rastorfer 1983, 217). The Jakarta city government considered many redevelopment options; for the Kampungs, the site and service model was utilized. The government acquired the property in the settlement to build infrastructure like water taps, sewer facilities, and paved roads. Housing development would be down to individuals who have been able to supply and enhance their housing for generations. At the same time, the government could give services to a greater populous (Holod and Rastorfer 1983, 218).

Kampong informal settlement streets and the livelihood of people living in mixed housing. (Sudrajat 2018)

Since the 1970s, the Jakarta government has been able to help improve the lives of 3 million slum dwellers while improving 7700 hectares of Kampungs with World Bank aid (Devas 1981, 209). This initiative illustrates the possibility of allowing them to develop autonomously as part of a strategy to address the squatter settlements throughout Mumbai. The Kampung strategies have inspired the thesis design to incorporate communal spaces that can be viewed as infrastructure. These communal spaces of washrooms, showers, and laundry can lead to sanitation, water access, and organized living within the chaos. This transformation would take some effort in Dharavi, just as the slum communities had taken time to develop.

The streets of Jakarta informal settlements post infrastructural project implementation. (Sucahyono 2015)

The livelihood of inhabitants within Jakarta. Structure and infrastructure on display. (Sluijs 2012)

The Quinta Monroy project post construction but pre-settlement. (Block 2019)

Interior image, pre and post settlement of the inhabitants of Quinta Monroy. (Jalocha 2017)

Quinta Monroy Housing Project, Chile, 2002-05

The Chilean government attempted to upgrade the existing squatter settlements in Iquique, called the Chile barrio program. In order to improve the housing quality on the existing plots, the program introduced a reduced loan subsidy of $7500 to each homeowner (Sinclair 2006, 134). The ELEMENTAL worked with the budget restrictions to design, construct, and show that housing for the poor is possible with the loan subsidy (Levinson 2004, 160). The informal settlement allowed the inhabitants to live close to or within networks supporting their livelihood, social relations, and employment. The networks were the reason these inhabitants created their settlement utopia here. ELEMENTAL created a framework that would allow the homes to expand with time and resources by the residents rather than only providing achievable shelter with the issued loan/subsidy. The Quinta Monroy base unit has unfinished walls with wood structures, base floods, and concrete blocks. Resources or funds supply costly components like plumbing fixtures or windows instead of installing flooring and wall finishes (Rethinking the Future 2008).

In Dharavi, the expandable spaces could also be designed for income generating at the grade level. Room renting or small family house renting is possible. Additionally, the incorporation would occur at a higher density and have amenities beyond only residential. Communal amenities like washrooms, showers, kitchens, or laundry spaces would be part of the design embodiment. The site will associate with existing industry or income-generating spaces in the form of factories that would be embedded into the project. The development methodology will provide access to air and light

Design strategy of the incremented housing to show what kinds of spaces are created.(Basulto 2009)

in the units while establishing a sanitary and comfortable living environment for the resident.

Incremental Housing, Pune

The informal settlement in Pune, India, developed the first Incremental Housing strategy designed by Sarah Göransson and Filipe Balestra. The Slum Redevelopment Program's sole ideas were to demolish and rebuild,' which resulted in residents being uprooted from their community networks and stuffed into apartment towers in or near the original settlement (Urban Nouveau 2008). The team devised a method in which the pre-existing fabric would be improved over time, incorporating a community design input but eventually delivering a methodology enabling inhabitants to build the houses themselves. Three distinct housing designs were created, all offering a range of space vertically. The initial option would be one-story, with potential vertical extension, possibly one floor at a time. In alternative

Implementation of the incremental housing in Pune. Rendering that displays how the strategy is incorporated. (Andreini 2014)

A street view render of the incremental housing in Pune; how people interact with the structures on the street. (Fairs 2009)

housing options 2 and 3, cavities were placed in the design to provide extensions or open-air space or extension.

In Pune, they designed private washrooms per household. However, this is impossible in the Dharavi settlement because the density is much higher. Furthermore, a methodology that could be developed to create shared community amenity spaces is inspirational for the thesis. The overall plan assures the survival of the settlement's economic, social, and cultural networks by safeguarding the authenticity of the informal network. Another central point to learn from community engagement is that the designed system allows homeowners to build homes. Creating more income-generating spaces on the ground floor or combining community space in new construction for people is critical for this thesis.

Conclusion

Self-build housing is considered a chance for architects to intervene and explore the low-cost architectural style based on ecological building strategies in the literature review of "architecture for the poor" and "freedom to build." The research recognizes residents' critical role in tackling the housing issue. Architects can serve as educators and mediators between the structure and the inhabitants, assisting residents in achieving their goals.

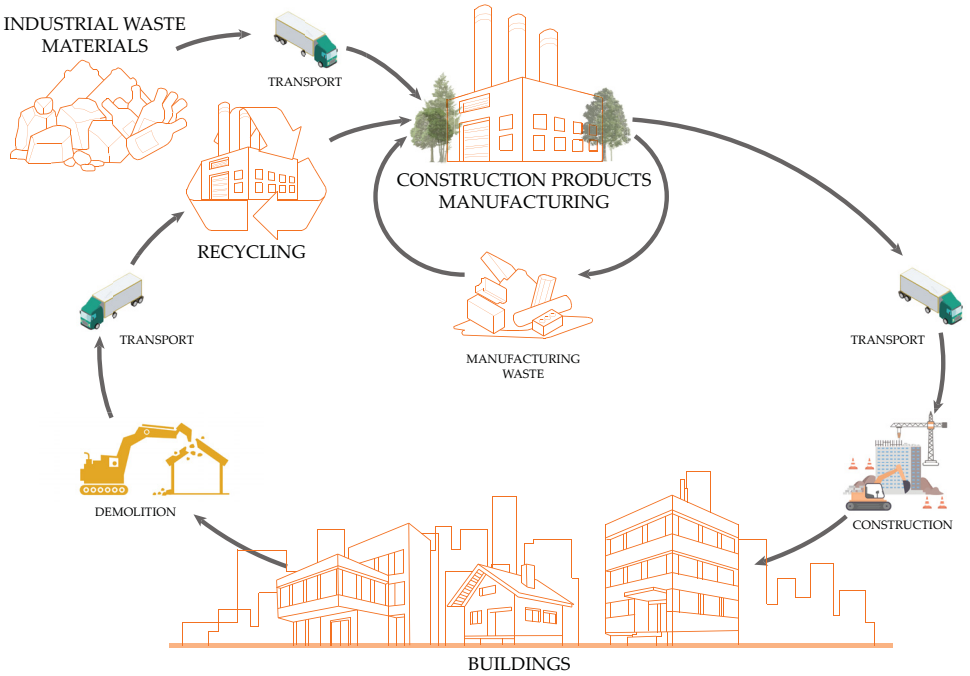
The precedents educate about the numerous projects conducted worldwide to address the challenges faced in the informal community. The idea that each settlement has unique requirements and difficulties is reinforced as each project targets a specific problem within the slum. Housing is proposed in all four case studies, albeit in various ways. The incremental housing project in Pune and the Quinta Monroy

project in Chile are related to the potential solution and issue within the Dharavi settlement. One is self-built, while the other is working to give housing on a budget. Based on this, the thesis offers an intervention within Dharavi's self-construction process. This procedure can construct homes and communal spaces that fall under the infrastructure wing while also meeting the goals of sunlight, sanitation, durability, and sustainability.

Chapter 5: Natural & Recycled Materiality

Circular Economy

The section researches and conducts a study on the circular economy to explore how it works and what issues will be solved. The circular economy is being investigated because waste products will help clean the streets of the informal settlement and work to structure the design in a viable manner. What exactly is the circular economy? How does it differ from the linear economy? What applications does it have in architecture? What is the function of architects in this system? What exactly are the principles? Some precedents involving circular economies or waste material integration will also be investigated to educate on how the materials can be utilized.



This is an illustration that represents circular economy in the context of architecture material reuse.

What Is A Circular Economy?

Today, a linear economic system of consumption involves taking resources from the planet, making something of them, and then throwing them away. However, a circular economy (CE) is a system that reuses the resources after they have been classified as ‘waste’ by putting them back into the system. In this way, the economy becomes circular. This ensures that nothing truly goes to waste since everything that can be used again goes back into the system. A circular economy is a sustainable, environmental, and economic development method. This idea has been accompanied by the argument that it reduces negative environmental impact and stimulates new business opportunities. Unlike traditional recycling, the practical and business-orientated circular economy emphasizes product, component, and material reuse. (Korhonen 2018, 40). Once a raw material is extracted, refined, and produced, it makes economic and business sense to use the value created for as long as possible. The currently popularized CE concept extends conventional waste and by-product utilization while recycling emphasizes on utilization of the high-value embedded in materials.

Application To Architecture

Rapid urbanization produces negative consequences that could be more conducive to the long-term achievement of sustainable goals for any given country. It polarizes populations and creates slums, squatter settlements, a degraded environment, and traffic congestion (Petkar 2013, 2). Within this context, the broadening of design symbolizes a more significant shift in designers’ roles as they move

away from object-centric thinking and toward a more system-based design approach.

Circular economy can offer a new building system for self-build housing. The circular economy reimagines the system from the standpoint of a “closed loop” of resources that eliminates waste formation. The transition to a circular economy requires designers to become problem solvers instead of object producers. Designers have little guidance on implementing these techniques efficiently within a complex design process (Dokter 2021, 697). The application of circular economy is implemented at three scales macro or urban, meso or dwelling, and mirco or component scale. Recycled materials can be used differently to make homes more feasible and sustainable. Using recycled materials can form a new building system, operating at the base of the urban, dwelling, or component scale.

Role Of Designers & Architects

The role of designers is changing, and particular abilities and skills are being emphasized, such as anticipating future building material production cycles, evaluating environmental effects, and circular economy storytelling. Architects may be critical in transforming the circular economy by connecting many actors, like industry, to the building process. Dokter demonstrated that the circular planning process differs dramatically from the standard design approach. The design process will describe a new building system, method of material production, and reuse of waste components. Designers will serve as connectors and facilitators, facilitating interactions between players and creating a platform for cyclical creativity. The importance of

incorporating circular economy into the construction industry is relayed through waste production.

Principles Of Circular Economy Within Building Methodology

The social dimensions of designing Circular economy systems are important to consider. The overall influence of the essential economy to bring about an entirely sustainable approach to consumption relies upon challenging existing norms. This can only be done by bringing on three principles to define the application of circular economy to the thesis. The first is building in layers, similar to the building systems using layers of recycled building materials. Multiple features place each layer; each component must have distinct processing rules that are autonomous of others. Layers allow you to quickly detect and repair damaged items without changing the surrounding layers. The second principle is designing-out waste. This is done by regarding a building's entire lifecycle and considering waste as a chance to be turned into new materials. The third principle is to design for adaptability. The design will accommodate a new system that caters to the people's different needs but currently uses materials available. The circular economy's potential in the construction industry completely alters the value chain related to all levels of involvement in existing buildings (Mangialardo 2018, 340).

Prior Developed Frameworks

Precedents

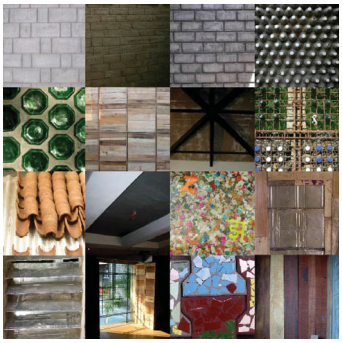
This section examines projects that use waste or natural materials to construct the building and help the community better inhabit the space. Two projects will be investigated and compared to my site.

Courtyard view of the Manav Sadhna activity centre which is made using salvaged waste materials. (Pandya 2011)

Manav Sadhna Activity Centre, Ahmedabad

Nearly 27.4 million tons of trash are made in the urban centers of India daily. Instead of being processed equally fast, the waste is dumped in open landfills. This waste then takes up enormous amounts of fossil fuel to dispose of, generating toxic fumes that harm the environment. Sourcing waste materials readily available onsite to construct a community center, the Manav Sadhna project is a prime example of reusing construction waste. It is situated in the largest slum of Ahmedabad; the center primarily serves potter families and lower-income individuals.

The center's walls comprise six different materials, each with unique processes. These are cement-bonded fly-ash bricks, mould-compressed bricks created from landfill waste residue, stabilized soil blocks, recycled glass bottles, recycled plastic bottles filled with ash and waste residue, and cement-bonded fly-ash bricks (Pandya 2020). The fly-ash brick is produced to save 25% of brick consumption. The glass bottles are arranged after being filled with waste residue over a cement mortar bed. The plastic wrappers for the reinforcing are cleaned with scissors before being laid. The center's inner partition walls are made of vegetable crate wood panelling. Instead of fibre-reinforced plastic in the door panelling, chopped packaging wrappers and covered paper waste are used. The toilet doors are made of produce crate wood (Pandya 2020). These low-skilled building processes allow for community involvement and turn construction into a community-empowering activity. This project is an excellent example of how waste can be combined with existing construction methods and used as building blocks. Similarly, the thesis proposes using on-site



How all the salvaged materials have been used within a structure to make walls, floor, doors, and steps. (Pandya 2020)

waste as building blocks to propose a project across the urban, dwelling, and component scale.

Ahams Ravi Builds Green Home, Kerala

Exterior view of the house made from salvaged materials and brick in Kerala. (Ravi 2020)

Ninety percent of architect Ahams Ravi's Kerala green home has been built from recycled waste. Taking only what is necessary from the environment, he treads lightly on the land and ensures his home does the same. The residence is almost entirely bamboo, as a locally grown material, production costs have been low as transporting. The mahogany tree that grew at the heart of the site was left to stand as it was. Instead, the house was built around it, thus incorporating the tree into the design (Ravi 2020).

Whereas most homes contribute to almost 40% of the world's carbon emissions, construction waste makes up 50% of the world's landfill sites. Instead, his green home is a natural extension of its environment (Ravi 2020). Bamboo has been used as the structural skeleton of the building. Once treated with borax, the fat content of the bamboo is crystalized and thus prevents insects from infecting it. The bamboo shafts were sealed with cow dung for the floors, a local practice that sufficiently treats the material for the climate. The trunks of discarded coconut trees were also treated with borax and reused as pillars. Beer bottles were used as a stand-in for stained glass, treated with mud and lime. Obtaining material that could be recycled from demolition sites was similar to bartering at a flea market. Bricks were also bonded vertically instead of horizontally to save material and labour by up to 30 percent (Ravi 2020). This technique also allows the home to remain naturally cool in summer and warm in winter. This is a bonus in saving energy and reducing carbon footprint. This precedent displays the combination of

Interior view of the house displaying the use of wheel frames and glass bottles to fliter light into the house. (Ravi 2020)

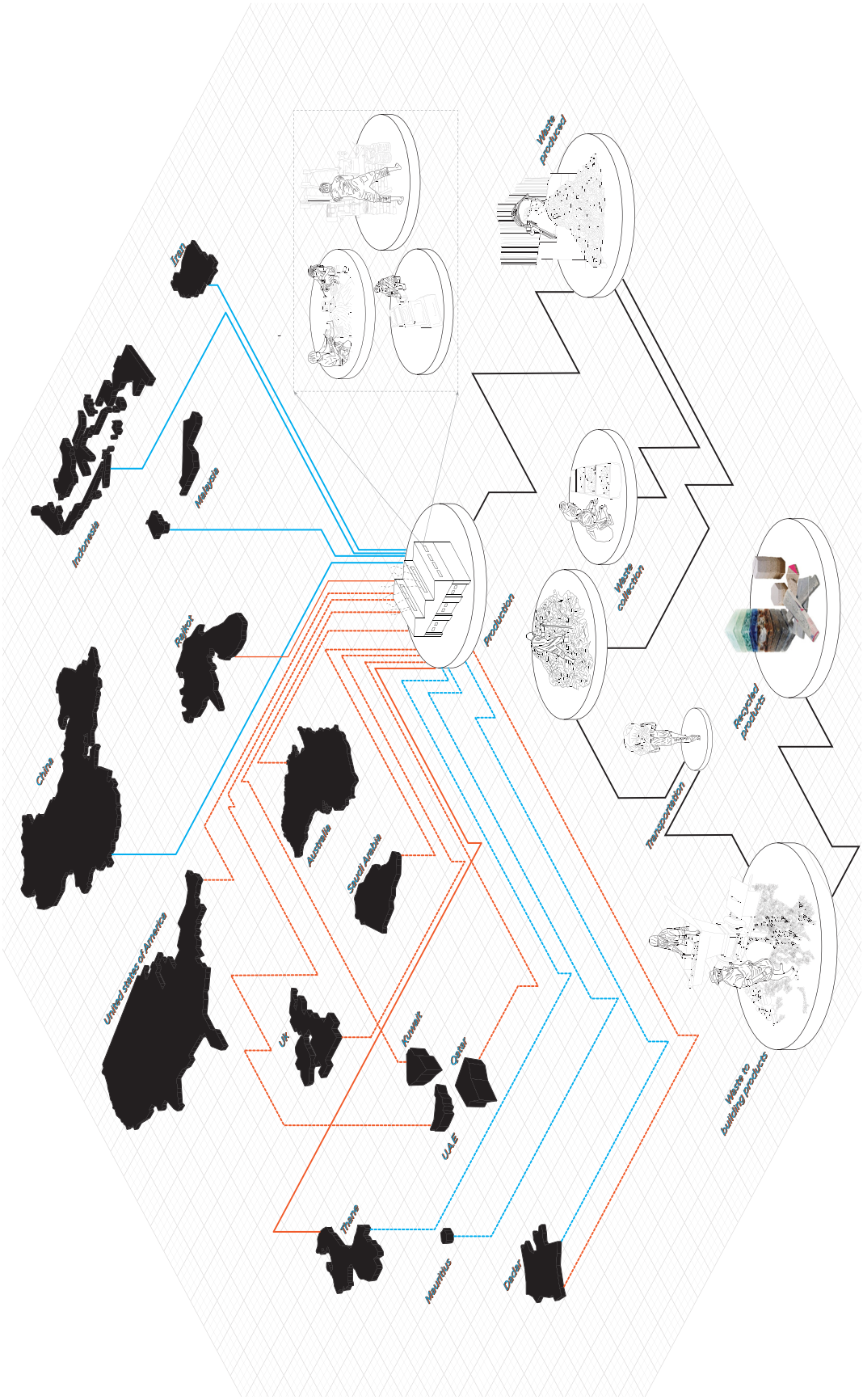
waste and natural materials as building blocks to create a sustainable home. The thesis will also combine natural and waste materials to propose a new self-build system.

Circular Economy In Dharavi

Rapid urbanization, population growth, and changing lifestyles due to greater consumption have contributed to solid waste generation issues (Dey 2021, 18). A circular growth model could help India achieve its developmental goals by engaging the formal and informal sectors. Some components of a circular economy are embedded in people's routines, demonstrating a culture of product repair and re-utilization (Dey 2021, 106).

The circular economy concentrates on "how to produce," nourishing best practices of recycling, reusability, and renewable energy (Merchant 2020). Dharavi is one of Mumbai's most economically productive neighbourhoods. The current circular economy is one of the most advanced in the country. Nothing is thrown away in Dharavi. Plastics and automobile batteries, computer components, fluorescent lights, ballpoint pens, plastic bags, paper, cardboard boxes, wire hangers, and other scrap materials are acceptable. Its economy is a forerunner in the field of sustainable waste management techniques. Geographers today characterize the area as a "plastic recycling goldmine." (Merchant 2020). Dharavi also has links and partnerships with most of the city's restaurants to collect waste. Dharavi recycles 60% of Mumbai's plastic garbage.

Surprisingly, Dharavi's leather industry is among the largest in the world. The mentality of never wasting anything rules in Dharavi. As a result, all leather scraps are further converted into energy and repurposed in slum industries like ceramics.



The import and export cycle with the existing circular economy in Dharavi (Sharvari 2021).

Dharavi may be seen as underdeveloped; however, a circular economy is one reason for such a vibrant informal sector (Merchant 2020). Dharavi's billion-dollar economy is the result of a circular economy. The idea of not wasting anything may not have originated with sustainability in mind, but it nonetheless functions as a sustainable paradigm (Mascarenhas 2018).

Incremental Development Approach

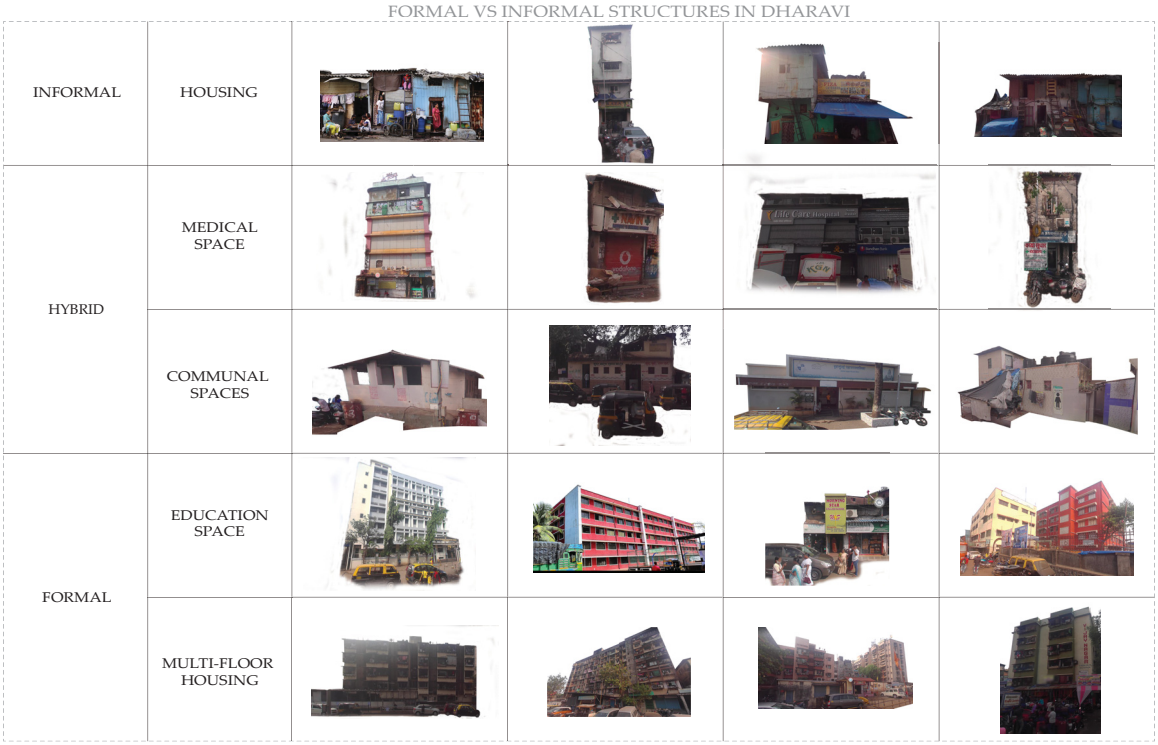
The government's existing approaches and procedures for addressing the issue of slum housing are unsustainable. The top-down strategy to achieving a slum-free Mumbai will damage these people's livelihoods and lifestyles. Most residences are self-built and owned by residents who ultimately become landowners. Many inhabitants own up to four rooms, some rented out for housing or businesses. Plans for comprehensive formalization face fierce opposition because they imply employment losses, the conversion of homeowners to renters, and the eviction of former tenants (Dovey 2013, 84). High degrees of informality allow for micro-flows of information, goods, resources, and behaviours. The techniques are combined with micro-spatial adjustments that thrive in informal urbanization. Mumbai has no formal waste management strategy; therefore, removing the residents of Dharavi from the existing framework would mean that the tons of trash generated in Mumbai each day would end up in landfills. Though recycling helps to keep waste away from the slum, it is crucial to recognize that this comes at a cost in terms of individual health.

This thesis proposed that houses in slums be built using recycled materials with little embodied energy and follow an incremental upgradation pattern based on monetary

resources obtained through time or the availability of waste materials that can be used to improve their houses. The pragmatic solutions have traditionally relied on an incremental approach in which the formalized design element is a structure that serves to ease the unstructured building process while utilizing fewer resources (Federighi 2013, 60).

Dwelling Construction In Dharavi

Each house has to up to six people. The bamboo and wood are embedded into the muddy earth to create a frame for the tin metal sheets. These sheets are extremely hot during the day. Rusting creates holes which cause water to penetrate during the rainy seasons. Thus tarpaulin is used to shield the roof from water, and asbestos sheets are used to protect inhabitants from the heat despite the toxicity of this material. All these materials are recycled through the



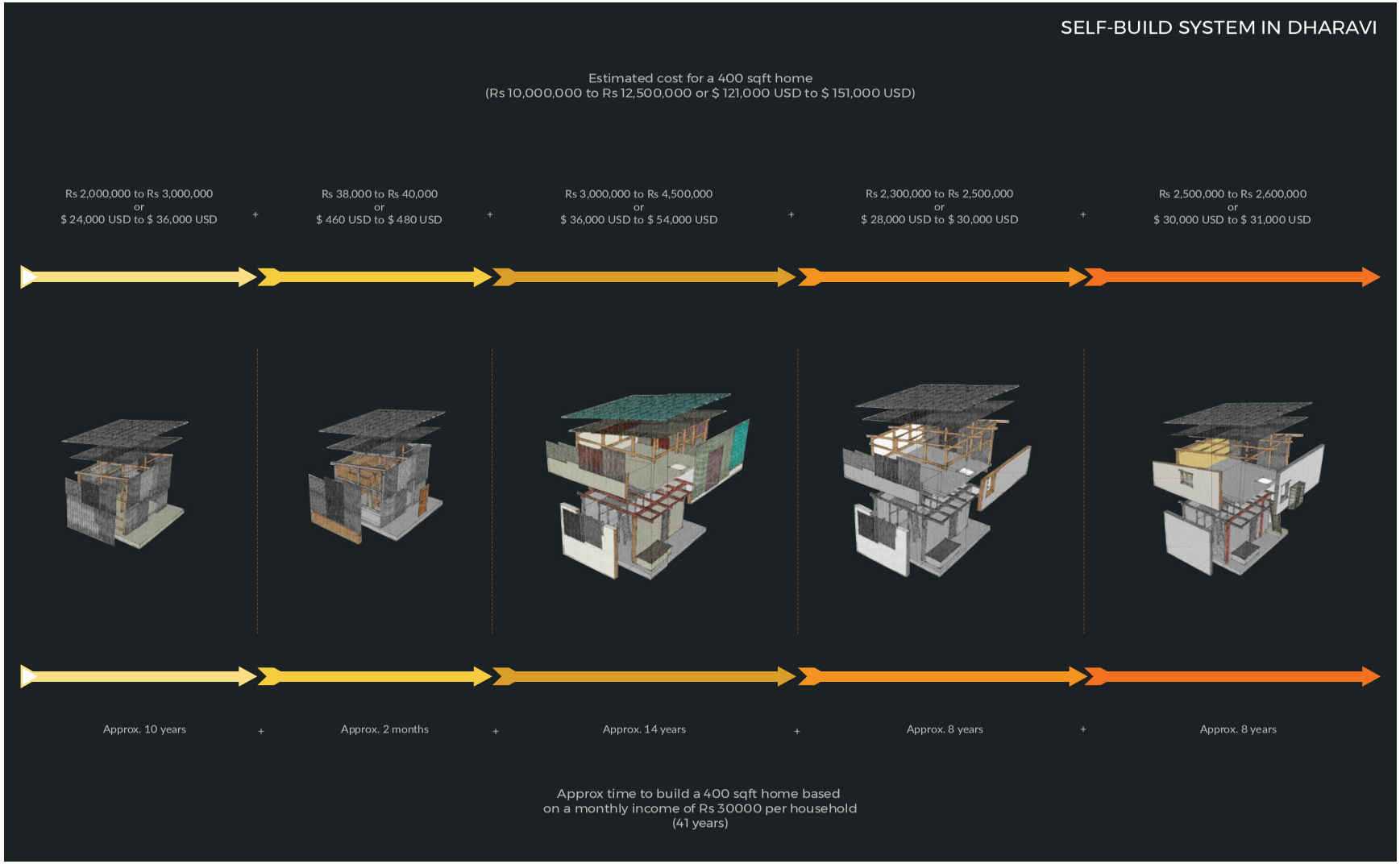
A collection of all the types of structures in Dharavi.

informal economy. Alternative materials would improve the living standards of residents dramatically.

With the help of local artisans, more permanent structures are made of brick, wood, concrete and rusted iron with steel I-beams and rendered in ceramic, slate clay, asbestos and tarpaulin. Upper floors are constructed using metal I-beams on top of load-bearing brick walls spanning three or four meters. Two-by-two-foot slate square tiles are placed between the beams, and cement is spread on top (Dey 2021, 7). Corrugated metal sheets are used for roofs, and grill box projections allow spaces for glassless windows. The furniture in these spaces is often moveable to create a workspace. Mattresses can be stacked, tables folded away, to provide an area for working or renting, thus increasing the productivity of the space. Inhabitants may begin with the more temporary shelters and eventually finance their way into the permanent structures. Their financial state can be read in the construction of their home as they rebuild their house in brick and mortar, one wall at a time. Verticality can also be added as families grow, with stories added to accommodate more inhabitants.

Informal To Formal Housing Timeline

Informal settlements inspire the self-build movement, visible in Dharavi, where each homeowner constructs and enhances their home. These houses are one or two levels high due to the archaic building materials and methods used in self-built buildings. The diagram shows that the transition from informal to formal housing takes at least 41 years. The financial situation of the family also dictates the improvement of their house. A basic monthly household salary of Rs 30,000 or 362 USD is a significant factor that



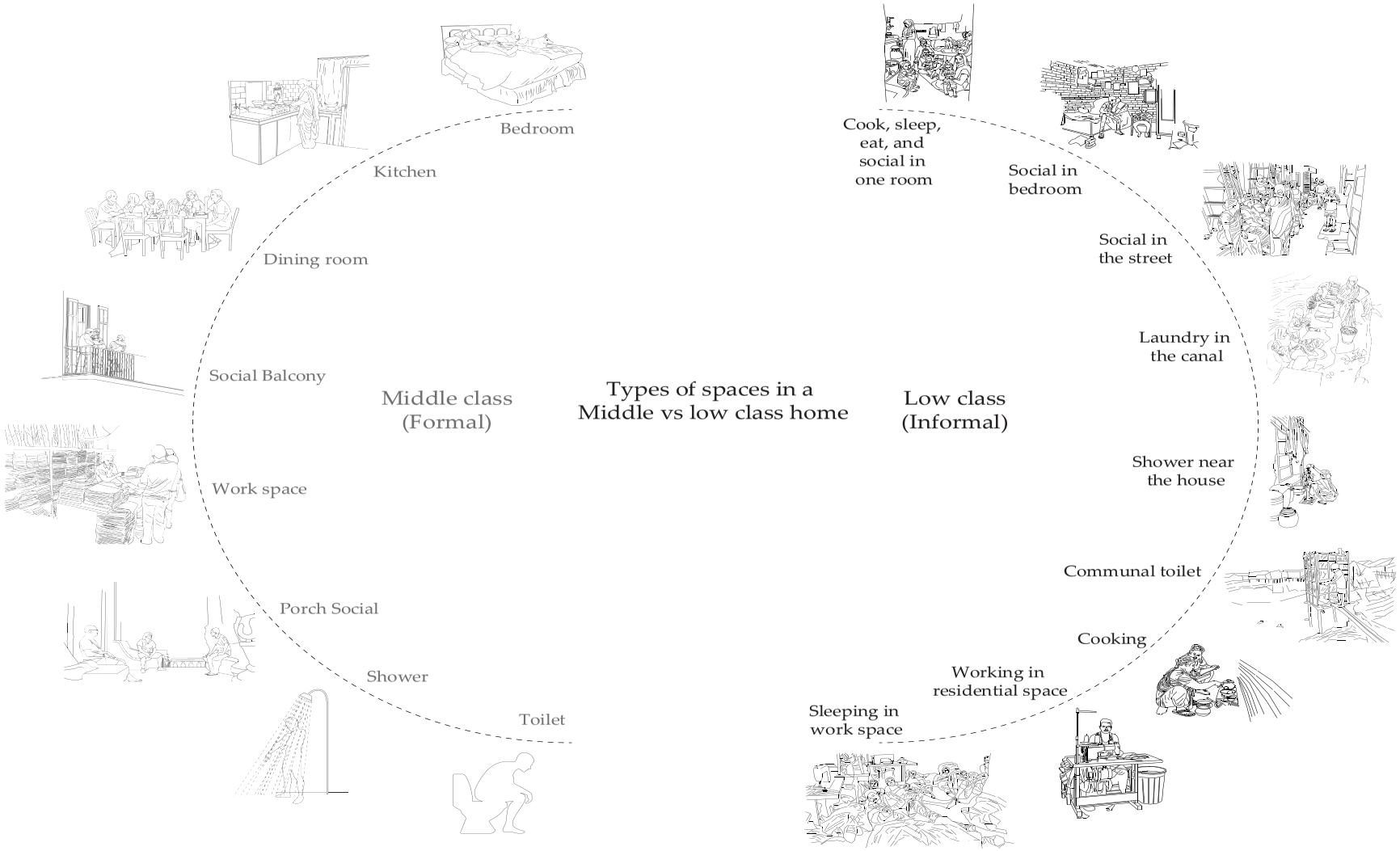
The self-build system in Dharavi showing how much money and how long it takes a resident to build their own home (Dey 2021, 42-45).

commands the speed at which a resident obtains materials to improve the dwelling. The metamorphosis is gradual, with each wall replaced based on a family's financial situation. Families typically begin with impermanent materials such as plastic, wood, or cardboard before advancing to more permanent structures such as bricks, blocks, cement, or asbestos or zinc tiles. Their economic circumstances prevent them from acquiring or renting a home; they are forced to seize public or private land to self-build their dwellings in exceedingly dangerous conditions. Thus, an intervention at the urban, dwelling, and component scale can improve the informal building system to be feasible and sustainable while preserving the cultural, social, and economic life.

Interior Spaces Created And Preserved

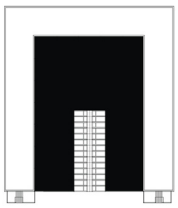
The diagram below displays the different spaces in a traditional home and how these rooms are used spatially. Low-income homes only have one room, which creates some interesting spatial usage internally and externally. One room is used for cooking, sleeping, eating, and socializing. Laundry, showing, and washrooms are done outside near the house or in communal areas. Finally, most homes have a work area or factory space where the men work daily and sleep at night (Lokhorst and Troost 2018, 22). This study outlines the importance of communal washrooms, laundry and shower rooms in an informal settlement. Designers must consider these living conditions and maintain these living arrangements for Dharavi's residents and their lifestyles. Mixed-use spaces are the positive design element of low-income residences. Integrating collaborative spaces will be a part of the design, and the methodology will support the construction through waste usage.

The multi-space utilization practices of the settlement will be preserved in the design (Rooms 2018).



Types of spaces created by middle class vs low class residents. The middle class dwellings are more formal and the low class dwellings are informal.

According to Banister Fletcher, many traditional houses and other buildings were created based on the temperature of the location and the available materials (Karandikar 2010, 35). Most of the structures were built around an inside courtyard where people slept, sat, and did their daily chores. Climate-responsive vernacular structures are known locally as wadas or wadis. They have courtyards surrounded by numerous light, ventilation, and one room homes. The courtyard is a signature housing design in Mumbai and can be incorporated into the creation of this thesis. Still, the main focus will be providing natural light and sanitation lacking in informal settlement housing.



Courtyard spaces will be integrated into the design.

Building Technology

The design proposes to move only one demographic of people that work in a specific industry. Thus, these people can maintain dwellings near industrial areas, where they can produce and sell products to sustain a livelihood. These industrial spaces produce plastic, leather, glass, paper, and cardboard waste. These waste materials will be used to create building blocks through the circular economy methodology while achieving the design of a dwelling for the inhabitants. The industry closest to the site will provide easy access to waste materials produced and discarded. These materials, such as leather or garment, will be the primary materials recurring in most building blocks and will be used throughout this thesis. Other natural and waste materials will also be used on a smaller scale.

Spaces will be multifunctional to allow the living and working cycle to continue as much as possible while maintaining sanitary conditions. Bamboo will be the primary structural material employed as it is locally sourced, and artisans are

well-versed in using it. The remaining materials used in the construction process will be recycled on-site to reduce costs and make the construction process as efficient as possible. Ropes will be used to strengthen the bamboo when connected at the joints; the rope is the most water-resistant, durable and robust. It is cheap to use at 10 rupees a meter (Lokhorst and Troost 2018, 23). Currently, residents of Dharavi upgrade their homes in stages from temporary shanties to more permanent ones. As such, this design proposal is also built in phases. The residents of Dharavi are free to choose which phase of stage design they employ first, either the bamboo structure, roof or walls. In this way, they are free to exercise autonomy over their built environment, a process they are accustomed to undertaking that allows for a greater sense of control.

Conclusion

The circular economy is a method that reuses ‘waste’ resources and reintroduces them into the system, making it circular while ensuring that nothing goes to waste. According to the research on the circular economy, it can be utilized to make any system or region more sustainable, and the reuse of waste resources makes the process practical. A designer’s or architect’s job is as a connection and facilitator, promoting player interactions and establishing a platform for cyclical innovation. This is comparable to the role of architects as outlined by the research on self-build systems. There is a circular economy in Dharavi as the residents try to use waste to improve their job or social lives. The construction process in the area transitions from informal to formal due to the materials used and the financial status of the family or owner. The thesis proposes using this methodology to improve the self-build construction process in Dharavi and

assist residents in sustainably attaining official dwellings. Furthermore, the examples analyzed are novel ways to incorporate waste materials into construction as building blocks that can be used to construct elements of a house or building.

Chapter 6: Recycled Building Materials

The primary focus of this chapter is to narrow the list of materials that will be used to create a building system and investigate the process of producing them. On-site natural and waste resources will be investigated to inform and examine a palette of construction blocks. Their combination and characteristics will be further investigated to support the assembly of durable components.

Natural Materials

Depending on their residents, the quality of homes in Dharavi varies and can be deciphered from the materials employed.

WASTE MATERIALS FOUND ON SITE


Cardboard waste


Glass waste


Paper waste


Plastic waste


Leather waste


Tetra-Pak waste

NATURAL MATERIAL FOUND IN INDIA


Bamboo


Ferrock


Ashcrete


Timbercrete


Hempcrete

A collection of natural and waste materials found in India and on site in Dharavi.

There are shanties made of bamboo and wooden sticks with corrugated metal sheets for roofs. Growing close to Mumbai, the Dendrocalamus brandisii and the Dendrocalamus strictus species are most often used to construct Dharavi (Dey 2021, 25). Dendrocalamus brandisii are sourced from local forests near Mumbai and grow 20m long.

In contrast, Dendrocalamus strictus grows 10 m long in high, dry and open deciduous forests. Bamboo is cost-effective, lightweight and locally sourced. The material offers design flexibility and strength because it grows faster and is more potent than timber, with the ability to withstand earthquakes. Due to Its hollow tube-like appearance, bamboo can create piping that can mimic cement and plastic in drain pipes. This enables bamboo to be laid into concrete foundations. The bamboo used in this thesis will be treated for water and fireproofing. It will also not come in contact with the soil and go directly into the concrete. Concrete is a highly durable substance that will last a long time. The residents of Dharavi use concrete as footing or foundation, and this practice will be maintained moving forward with waste aggregates.

Dharavi Recycling

Dharavi recycles 80% of Mumbai's dry waste discarded by 19 million citizens. The slum currently has 1200 units of waste recycling, of which 780 units are focused on plastic. The thirteenth compound focuses on most of the scrap recycling in the slum, with cotton, iron, glass, tins, bottles and plastic bags passing through the area in large quantities. Slum inhabitants are waist-deep in tech waste from cars, computers, paper, and metal waste. Oil drums can either be successfully hammered back into shape and sold back to companies or flattened out and used to construct the shanties

in the slums (Dey 2021, 9). While efforts continue to source better materials for the construction of the slum, some critical considerations for developing new materials from recycling include performance, affordability, availability, sustainable production, non-commercial processes, economically viable and contributing to the overall improvement of the lives of residents.

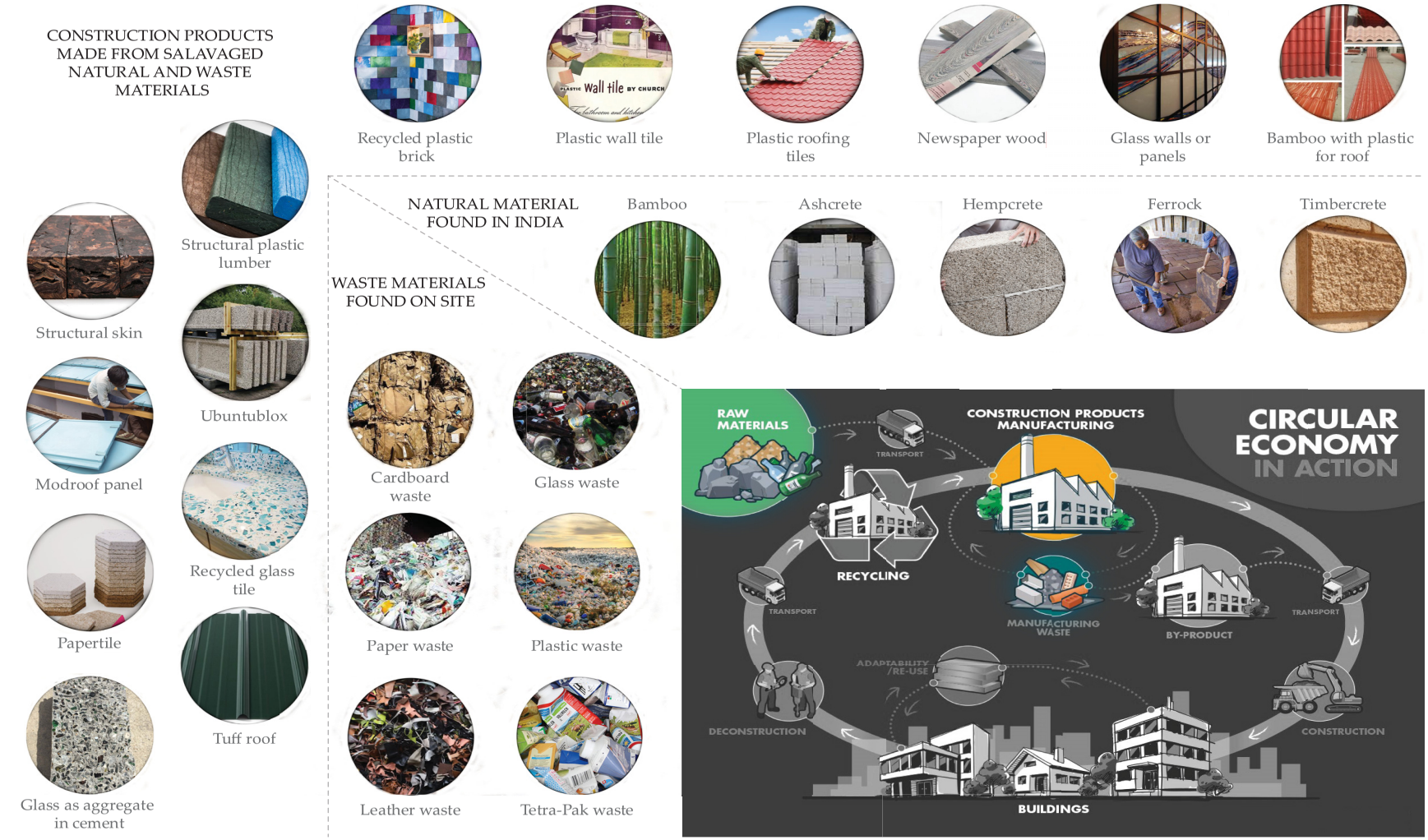
Waste Materials Found

The seven waste categories in Dharavi that can be employed in the construction industry are plastic, cardboard, glass, paper, leather, tetra-pak and e-waste (Dey 2021, 10). These materials should be recycled sustainably to allow for durability without maintenance in adverse weather. Given the lack of means available to Dharavi artisans, the material can be usable in the building industry, not just in recycling but to produce these new materials. The knowledge and skill necessary for processing the material should be accessible to local artisans. If training is required, this should be easily accessible. The following is a catalogue of recycling potentials for construction categorized by materials.

Palette Of Blocks Made From Natural And Waste Materials

This section examines different building blocks made of natural or waste materials in Dharavi. These blocks would be investigated for feasibility, durability, and sustainability while investigating the application of these blocks to a wall, floor, roof, or structural assembly.

Understanding circular economy requires knowledge of how waste is converted into building materials. This is highlighted by looking at case studies of recycled building materials and



A list of building blocks made from natural and waste materials (Croze 2018).

types of habitation (Dey 2021, 108). The primary five factors will be used to evaluate materials and narrow the list. These factors are identified as: -

1) Suitability of Use in Dharavi

2) Suitability of Use in Formal Housing/Buildings

3) Manufacturing Inventory Needed for Production

4) Suitability of Local Production

5) Availability of Technological Knowledge/Research (Dey 2021, 108).

The factors are explained below.

1. Suitability of Use in Dharavi

The basis for the criterion is the informal population's need for homes. The three sub-categories are, sturdy goods that do not require routine maintenance. Stronger, lighter load-bearing materials allow for taller construction. The home exhibits high thermal resistance and prevents rainwater infiltration

2. Suitability of Use in Formal Housing/Buildings

The evaluation standard is based on how well the construction product will function as a substitute in the established building market. The three sub-categories are, sturdy materials that do not require routine maintenance. materials that exhibit high thermal resistance and prevents rainwater infiltration. Easy to incorporate into the current formal building process.

3. Manufacturing Inventory needed for Production

It determines whether additional or new machinery is required to produce the building material from the waste inventory (Dey 2021, 109).

4. Suitability of Local Production

This criterion identifies if manufacturing inventory can be established in Dharavi's work sheds and operated by those with low f technical expertise.

5. Availability of Technical Knowledge/Research

Information on the material characteristics – Is there enough research to produce housing? To determine whether a product is appropriate, it should undergo testing for qualities including compressive strength, flexural strength, insulating value, water permeability, and fire resistivity (Dey 2021, 110).

Materials that will be evaluated are listed as follows.

- Plastic lumber
- Plastic Wall Tile
- Plastic Roofing Tile
- Ubuntublox
- Recycled Plastic Bricks
- Corrugated Cardboard Pod
- Modular Roof
- Recycled Glass Tiles
- Recycled Glass Walls or Panels
- Waste Glass as Aggregate in Clay Brick

- Newspaper Wood
- Papertile
- Structural Skin
- Tuff roof
- Admixture in Cement Mortar from Printed Circuit Boards

Plastic Lumber

In Dharavi, plastic lumber would be useful as an alternative to steel I-beams. The plastic beams developed are robust, and lighter than steel, and thus plastic beams prove advantageous in construction. Residents can build higher due to less stress on the load-bearing walls. The current production methods require specialized heavy machinery in assembly line production, demanding ample space for installation. Technical Knowledge and research are required to identify the specific commercial plastic products locally, which can be sorted and processed further for production.

Conditions met:

1.Suitability of Use in Dharavi

2.Suitability of Use in Formal Housing/Buildings

Plastic Wall Tile

The plastic items used in this product are mainly composed of a mixture of low-density plastic, high-density plastic, polypropylene, and polystyrene. The materials are more weather-resistant, thermally resistant, acid-proof, durable, and structurally weather-resistant than conventional materials. Plastic bags, bottles, milk packets, and sachets are used (Vyawahare 2017). “Additionally, they are better than the corrugated sheet metal envelope as plastic is not a good

conductor of heat, and the wall tile is much more durable" (Dey 2021, 74). Existing production requires specialized machinery in assembly line production, demanding ample space for installation.

Conditions met:

1.Suitability of Use in Dharavi

2.Suitability of Use in Formal Housing/Buildings

3.Availability of Technological Knowledge/Research

Plastic Roofing Tile

There was no water absorption in the tile. The crushing strength of the plastic tile showed a 15% decrease in power compared to a conventional tile, which means that it would not be suitable for loading applications. The composite flammability test by application of heat from oxy-acetylene gas also showed better results than conventional tiles, which split under a flame. However, no specific fire rating value was specified in the research (Temitope, Abayomi, Ruth, and Adeola 2015, 3).

The material qualities of the tile are suited to serve as a roofing tile as they are durable, light, and waterproof. Moreover, they would not corrode. There needs to be more information on the insulation values of the plastic. Still, this kind of plastic roofing tile would improve the existing metal sheet used, as plastic could be a better conductor of heat. It is unsuitable in existing urban construction but could be applied in t as roofing tiles in the rural informal market e case study is intended to deal with low-quality plastic products. Research is required to identify which commercial plastic

products are suitable in the Indian context to be locally produced in Dharavi.

Conditions met:

1.Suitability of Use in Dharavi

2.Manufacturing Possible with Existing Inventory

3.Suitability of Local Production in Dharavi with existing or new manufacturing inventory

Ubuntublox

From Dharavi's perspective, Ubuntublox seems to be a good solution for non-load-bearing envelopes. Still, since it requires additional steel rods and chicken wire mesh for reinforcements and stiffeners, it adds extra financial burdens. The blocks could have been used in repairing or improving these single-story units. It takes up too much floor space and needs expensive steel stiffener rods. Not suitable in the existing urban framework of urban construction but could find its potential application in informal rural settlements.

Conditions met:

1."Manufacturing Possible with Existing Inventory" (Dey 2021, 112).

2."Suitability of Local Production in Dharavi with existing or new manufacturing inventory" (Dey 2021, 112).

3."Availability of Technological Knowledge/Research" (Dey 2021, 112).

Recycled Plastic Bricks

Being lightweight and easy to build, these recycled plastic bricks can effectively replace the existing materials as

building skin. The fact that it can be quickly assembled and disassembled could indicate applicability. New machinery of compression, melting, moulding and a cooling tub is needed to cool off the plastic in the mould. The machinery and the cooling tub used in the case study for production demand ample space and, thus, are unsuitable for production in the informal settlement. Technical Knowledge and research are required to identify the specific commercial plastic products in the local context, which can be sorted and processed further for production and the proportion of different plastics to be mixed and fed into the moulding process. Production machines cost around USD 12000 or Rs. 10.5 lakhs, but it costs approximately Rs. 75/sqft to purchase.

Conditions met:

1.Suitability of Use in Dharavi

2.Suitability of Use in Formal Housing/Buildings

Corrugated Cardboard Pod

The Corrugated Cardboard blocks have been tested to build walls from the ground. In Dharavi, there is a need for walls on the higher stories. Even if the cardboard blocks are used to replace the dilapidated wall of the ground floor, they are not a viable option. Making the blocks thinner would take away all the benefits gained from the unions, such as thermal mass and high insulation values. Using the blocks as wall material is not viable as the 800-mm thick wall takes up too much space in Dharavi. We need to determine its durability, fire-resistivity, and if it is prone to insect infection and takes up too much space.

Conditions met:

1.Manufacturing Possible with Existing Inventory

2.Suitability of Local Production in Dharavi with existing or new manufacturing inventory

Modular Roof

The raw materials of cardboard and coconut waste as fibre can be easily sourced in the slum of Dharavi, and thread does not contain any toxic materials. The modular roof has been implemented in the slums of Ahmedabad. This roof design provides better heat insulation, does not corrode, and protects from rain. In the slum community in Ahmedabad, the roof was available through a loan system. An average 23 square meter roof costs $1000, which is more expensive than a metal roof but cheaper than concrete construction. Extrusion machinery is needed. Production machines cost around USD 20,000, but they cost approximately Rs. 70/ sqft.

Conditions met:

1.Suitability of Use in Dharavi

2.Suitability of Use in Formal Housing/Buildings

3.Suitability of Local Production in Dharavi with existing or new manufacturing inventory

4.Availability of Technological Knowledge/Research

Recycled Glass Tiles

People in Dharavi decorate the interior floor of their houses with tiles. With local production and decreased cost, the tiles have the potential to be sold both in the formal and informal markets. The glass tile is easy to produce, and the production of it does not involve sophisticated technologies. The small

industrial work sheds are suitable for production with manual labour in Dharavi. These values are similar to the maximum density of 1.94 g/cm³ with the sintered specimens at the temperature of 1000 ºC and with the addition of magnesium oxide. The flexural strength varied between 66 and 84 MPa. The building product is straightforward to produce with manual labour.

Conditions met:

1.Suitability of Use in Dharavi

2.Suitability of Use in Formal Housing/Buildings

3.Manufacturing Possible with Existing Inventory

4.Suitability of Local Production in Dharavi with existing or new manufacturing inventory

5.Availability of Technological Knowledge/Research

Recycled Glass Walls Or Panels

Manufacturing glass panels involves very low-tech technology and can be easily implemented by the people of Dharavi. The retail shop in and around Dharavi could serve as markets for the building product as low-cost and durable decorative wall panels for the interiors.

Conditions met:

1.Suitability of Use in Dharavi

2.Suitability of Use in Formal Housing/Buildings

3.Manufacturing Possible with Existing Inventory

4.Suitability of Local Production in Dharavi with existing or new manufacturing inventory

5.Availability of Technological Knowledge/Research

Waste Glass As Aggregate In Clay Brick

The requirement for bricks in the informal settlement would be limited to repairing damaged brick walls on the ground floor or improving the upper floors' lightweight metal envelope. Since the bricks with recycled glass additives are an improvement to the conventional bricks, it is possible to make clay products in the informal settlement with the help of the heating kilns used for pottery.

Conditions met:

1.Suitability of Use in Dharavi

2.Suitability of Use in Formal Housing/Buildings

3.Manufacturing Possible with Existing Inventory

4.Suitability of Local Production in Dharavi with existing or new manufacturing inventory

5.Availability of Technological Knowledge/Research

Newspaper Wood

Newspaper wood could have some uses in Dharavi. Since it has wood-like properties, it could be applicable in making furniture in the slums, lintels for windows, and ladders and boards for the lofts. It could also be used as a decking material for the floor instead of the natural grey stone tile, provided a reinforcement material is inserted into the fabric to achieve the desired flexural strength. The strength of the material is based on the power of the glue, which limits using Newspaper Wood as a structural component. As said by one experiment on paper and waterproof, it is durable.

Conditions met:

1.Suitability of Use in Dharavi

2.Suitability of Use in Formal Housing/Buildings

3.Manufacturing Possible with Existing Inventory

4.Suitability of Local Production in Dharavi with existing or new manufacturing inventory

5.Availability of Technological Knowledge/Research

Paper Title

Following the trends of the middle and upper class, the people in the slum aspire for a better aesthetic using floor tiles. Paper tile could find its application as a decorative floor tile in the houses of Dharavi. The paper tile could also serve as a roofing tile that can span between the wooden joists of the building roof and overlaps at the edges. However, attention must be given to the long-term effects of rain and sun on the waterproofing coating used. Add a layer of Self-adhesive wallpaper that is waterproof and moisture-proof on the paper tiles.

Conditions met:

1.Suitability of Use in Dharavi

2.Suitability of Use in Formal Housing/Buildings

3.Manufacturing Possible with Existing Inventory

4.Suitability of Local Production in Dharavi with existing or new manufacturing inventory

5.Availability of Technological Knowledge/Research

Structural Skin

The material could be used as a replacement for the wooden slats widely used in Dharavi as frames for the metal skins of the buildings. The product can be built without sophisticated technology. There is an established leather industry whose waste would be helpful for the production and the bone glue that can also be sourced from animal bones out of the local meat shops in and around Dharavi. The product is already being produced in the area. Structural skin is durable, according to three articles and waterproof, according to two reports. (Dey 2021, 99)

Conditions met:

1.Suitability of Use in Dharavi

2.Suitability of Use in Formal Housing/Buildings

3.Manufacturing Possible with Existing Inventory

4.Suitability of Local Production in Dharavi with existing or new manufacturing inventory

5.Availability of Technological Knowledge/Research

Tuff Roof

The TUFF sheet would be extremely useful in Dharavi, as it is lightweight and provides suitable resistance to heat conduction compared to metal sheets. Moreover, it is an excellent alternative to the existing asbestos corrugated sheets due to health concerns, as asbestos exposure has been found to correlate with carcinogenic diseases. Boards made out of TUFF sheet material could also serve as wall panels, further improving the interior’s comfort conditions during summer. The material does not need a fastener for jointing and can be achieved by nailing. There is evidence of

recycling Tetra Pak in Dharavi; thus, its potential as a part of the waste material inventory must be addressed.

Conditions met:

1.Suitability of Use in Dharavi

2.Suitability of Use in Formal Housing/Buildings

3.Manufacturing Possible with Existing Inventory

4.Suitability of Local Production in Dharavi with existing or new manufacturing inventory

5.Availability of Technological Knowledge/Research

Admixture In Cement Mortar From Printed Circuit Boards

Electronic waste poses little risk to the people or the environment until it is dismantled over precious metals. The current trend of informal electronic waste recycling is harmful and only encouraged once proper protocols are implemented. Dharavi can only contribute to two types of labour for a circular economy of electronic waste. Manufacturing needs to be possible with existing infrastructure.

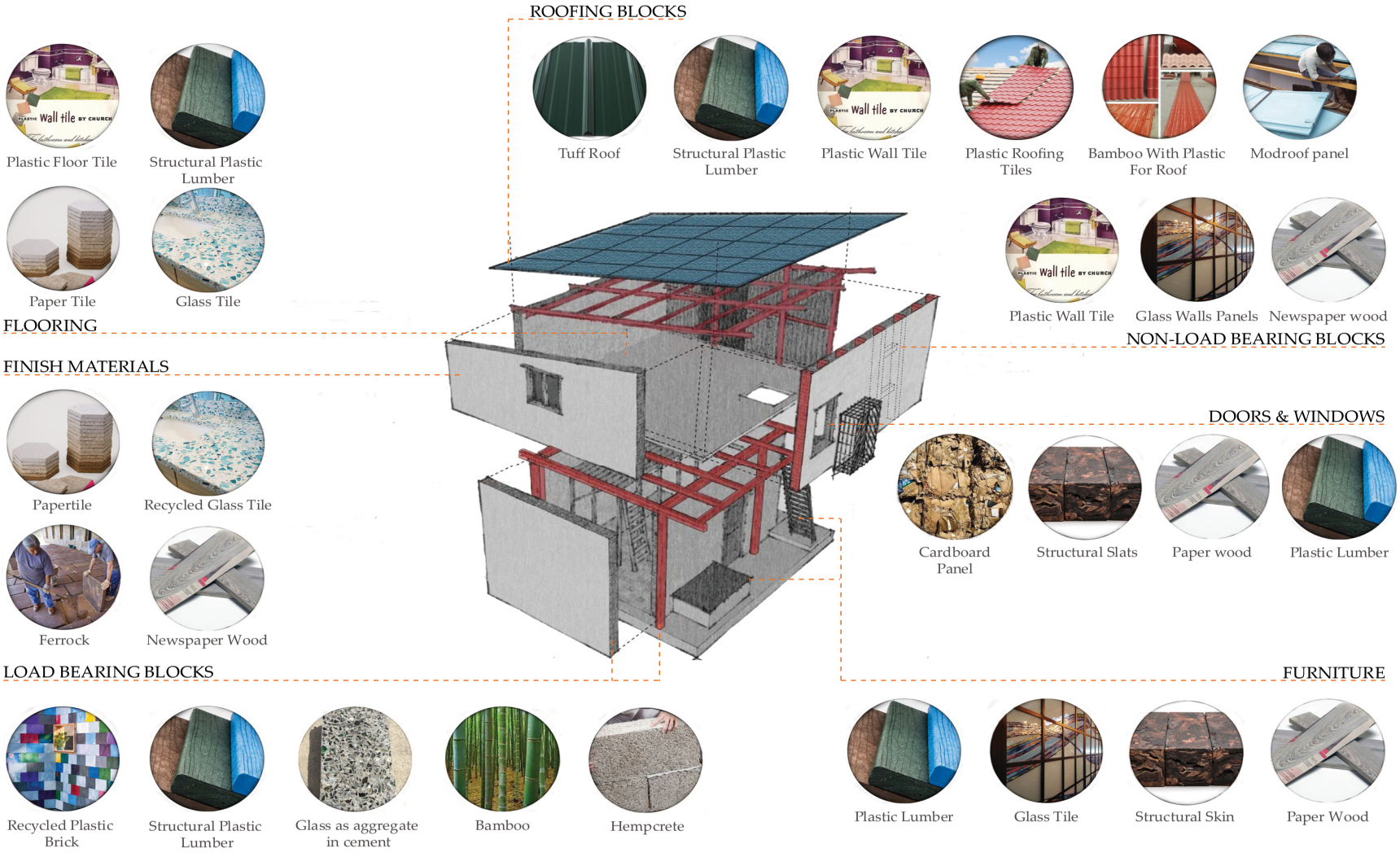
Conditions met:

1.Suitability of Use in Dharavi

2.Suitability of Use in Formal Housing/Buildings

Materials that can be used and produced:

- Recycled Glass Tiles
- Recycled Glass Walls or Panels
- Waste Glass as Aggregate in Clay Brick
- Newspaper Wood



A diagram of how the found building blocks can be used to make the elements of a building like walls, floors, roofs, or structure (Dey 2021).

- Paper tile
- Structural Skin
- Tuff roof (Dey 2021, 126).

Waste To Recycled Building Materials

Each material has its process that needs to be broken down to understand how long it would take to make each material. The method of producing these materials will also relate everything to a circular economy. The ways that each produced waste can be transformed into a building product to improve workers' lives contribute to the Dharavi settlement's economic pattern.

Process Per Material

Recycled Glass Tiles

Glass is collected from the waste produced by the local factories and other waste deposits as the raw material. The recycled glass tiles are made through the process of crushing and shredding. The fine or medium crushed material is mixed with sand and soda ash. After that, it is melted at a temperature of 1400 degrees Celsius and poured into an iron table that can give it shape and size. Once on the Iron table, it is moulded and pressed into the tiles (Chang 2013). The entire process takes approximately five days, and the machines needed are a shredder, mixer, melting furnace, and a mould or iron table.

Recycled Glass Walls Or Panels

Making recycled glass panels is very similar to the operation of tiles. The recycled glass panels are made by shredding collected waste glass. The material is mixed with sand and soda ash. After that, it is melted in a furnace at a temperature

of 500 degrees Celsius and poured into an iron table or mould that can give it shape and size. Once on the Iron table, it is pressed into panels (Bahamon & Sanjinés 2010). The entire process takes approximately five days, and the machines needed are a shredder, mixer, melting furnace, and a mould or iron table.

Waste Glass As Aggregate In Clay Brick

Waste glass, when added to brick clay, led to an improvement in some of the properties of the clay brick. This was tested at the Afyon Kocatepe University in Turkey, where waste glass is mixed with clay (Demir 2009). The bricks are made by crushing the clay brick with a roll crusher. Simultaneously, the waste glass is crushed with a jaw crusher. The crushed materials are sieved, clay brick through a 1mm sieve and the waste glass through a 0.5mm sieve. Furthermore, both are mixed and fired in a kiln to create clay bricks with aggregate waste glass (Dey 2021, 93). This process takes approximately five days, and machines like jaw ca crusher, roll crusher, a sieve, mixer, and kiln are needed.

Newspaper Wood

Waste newspapers and other papers are collected from waste deposits. The process begins by soaking paper waste in glue. It is then layered and wrapped along a linear axis on a wooden log. The technique imitates the circular rings left behind after a tree log is cut. The material can be treated like any other type of wood, including drilling, cutting, milling, and nailing. (Hebel, Wisniewska, & Heisel 2014, 69). This whole process takes approximately 4 or 5 days, and the machines needed are a soaking station or machine and a wrapping machine large enough for wooden logs.

Paper Tile

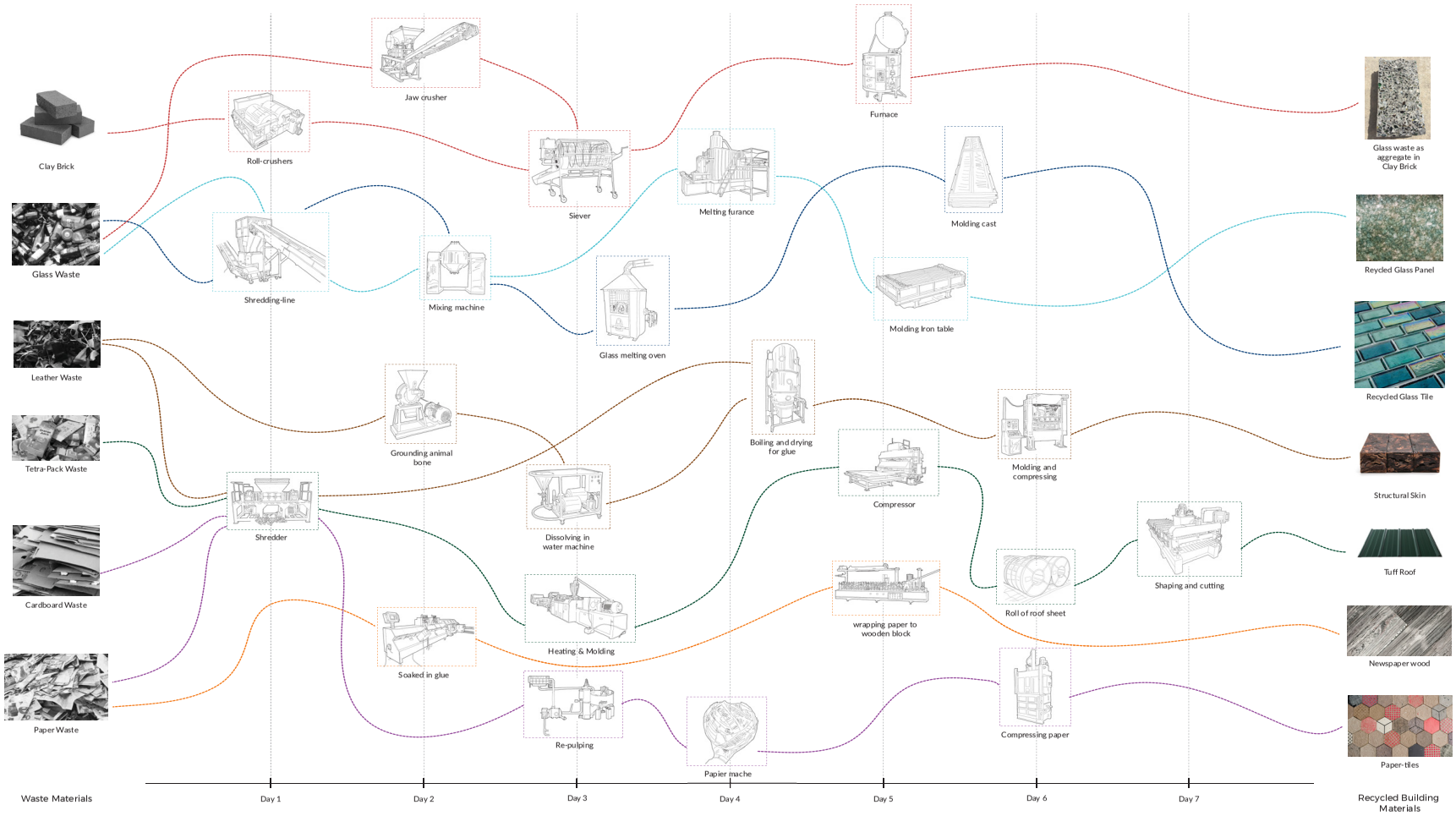
Paper tiles are made through the collection of cardboard and paper waste. Both cardboard and paper are shredded and then re-pulped. Water is added to the re-pulped material to make papier mache. The papier mache is layered and compassed, adding wheat starch paste to create the tiles (Dey 2021, 96). The entire process takes approximately six days, and the machines used are a shredder, a re-pulping machine, and a compressor.

Structural Skin

The leather industry produced much waste that can be collected and turned into building material. Simultaneously, bone is grounded to powder and dissolved in water. It is then boiled and dried to create glue. Waste leather pieces are shredded and combined with glue to form a durable product. The combination is moulded into layered and compressed strips (Morby 2015). Bricks of different sizes are created using this process and the waste leather. The process takes approximately 5 to 7 days and uses machines like a shredder, moulder, compressor, grinder, dissolving machine, and a boiler with a dryer for the glue.

Tuff Roof

Tuff roof is made from tetra-pak carton waste mainly used for juice, milk, or other liquids. The waste can be collected and shredded before moulding it with heat, so all the existing plastic, paraffin, and glues act as adhesives. The heated materials are then compressed into a sheet (Hebel, Wisniewska, & Heisel 2014, 75). The sheet is rolled before reusing it through a shaping machine to give it the shapes. The process takes approximately a week, and the machines



A timeline of how each waste material is turned into a building material. All the machines used are shown as hand drawings (Dey 2021).

used are a shredder, moulding, heating, compressor, and a shaper that can cut it to size.

The design is proposed across three scales of urban, dwelling, and components to fulfill all the design requirements set previously based on the needs of the current inhabitants. All urban-scent machines listed are available in Dharavi but in different factories. Therefore, creating building materials out of waste or recycling will be an urban-scale adventure. Since the inhabitants of Dharavi build their own homes, the materials can be made simultaneously for the gradual home improvement as the process is a week long.

Conclusion

Waste, recycled materials, and natural materials are investigated to identify specific building blocks that will be used to inform construction elements. The investigation is based on five principles to help identify building products suitable for Dharavi. Each found material is evaluated and eliminated if it cannot be used in the Informal settlement. This provides a narrowed list of materials that can be produced and used in the design phase to create elements such as a wall, roof, floor, structure, and finishes. The process of producing recycled building materials is also highlighted. The components are used to construct homes and communal spaces that will improve the lives of the residents of the informal settlement.

Chapter 7: Proposal

Throughout the thesis report, the positives and negatives of the slum have been outlined. Those concepts will be formulated in a chart to show how the design intends to improve or preserve existing conditions. The design is considered at the urban site, dwelling, and component scale. Each element will complement one another to create a design that works with the site and design requirements. The informal settlement issues, the inhabitant's needs, and the availability of materials can change in the following months or years; however, the design will be based on the current scenario.

A narrowed site in the northern half of Dharavi.

Site

As previously stated or demonstrated, the site is in Dharavi's northern portion. As part of the government's effort to slow the rise of the informal economy, this area was among the first to be cleared for formal development. Informality began to spread, but proper construction still comprised most of the region. An unusual mixture of formal flats, community areas, unofficial homes, and retail establishments can be seen throughout the region. Within this area, the site is vacant land under the control of the municipal government. They have not let anyone build homes but allow children to play cricket and trees to grow. The site map shows trees and a water pump facility on the unoccupied land's southernmost portion. Also, this location satisfies the criterion for sites to be close to the industry to maintain chances for money generation. Lastly, the proposed design will enable numerous personnel to relocate across the street.

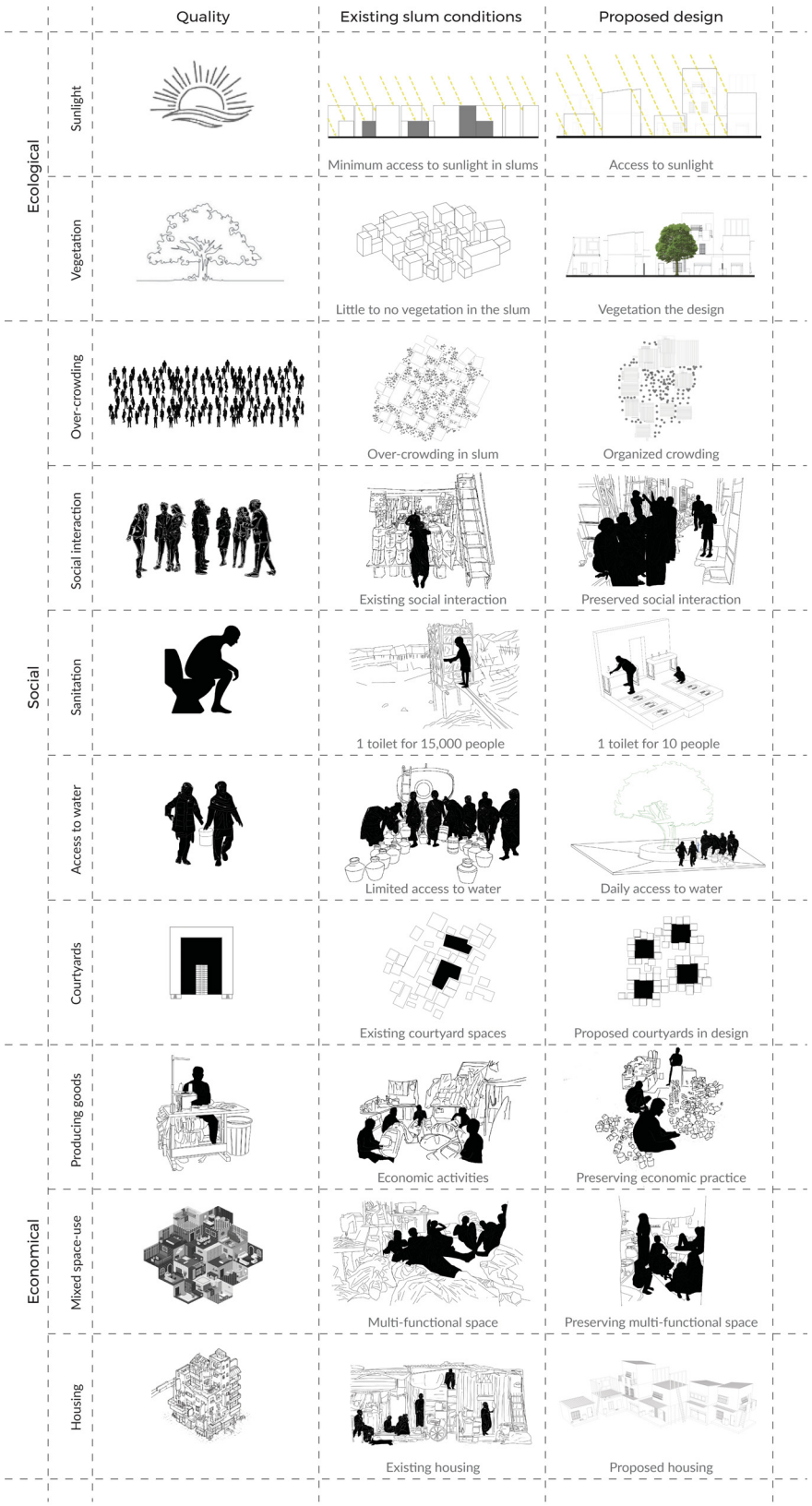
Positives And Negatives Of The Settlement

The chart below displays the different concepts that have been discovered through research. These elements are either positive or negative of a slum. The positives are critical to the settlement's identity and, thus, need to be maintained in the proposed design. However, the negatives cause inhabitable living conditions and need to be improved. The proposed attempts to address the negatives while preserving the positives.

Urban Scale Design

Bricolage Approach

The design approach is modular at the urban scale to maintain current social and economic habits. The design



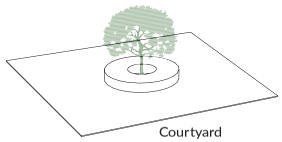
A chart of existing concepts that are improved or preserved through the design.

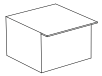
requires sunlight, sanitation, maintenance of space use habits, and income-generating spaces. The washroom, showers, and laundry were not a part of the dwelling but communal and outdoor spaces in the informal settlement. Therefore, the design proposes fixed elements that can be predicted and controlled. These are factories, washrooms, showers, laundry spaces, a community courtyard, and fire-resistant walls. Additionally, the 300 sqft unit size from the 2004 governmental development scheme is used in this design to give shape to structures.

The courtyard is introduced to bring in sunlight and establishes a slight distance between the housing units and communal spaces. It also features a tree with a pedestal in the middle, allowing the residents to socialize and gather around. In India, large trees have a concrete pedestal around them to accommodate the citizen's social life. People sit, talk, hold meetings, play, sing, and sometimes park their cars around this tree. The courtyard will have a minor slope, and the pedestal can collect and provide rainwater, which can be purified through personal purification systems. Children usually play cricket or other games in any open space. Thus, this courtyard will act as a playground and a social function.

The communal spaces are always crowded because the need for toilets, showers, or laundry spaces for everyone is high. However, if these spaces are provided to a smaller group of families through a modular system and replicated, the scarcity will diminish slowly. Usually, slums do not have any fire provisions, and the authorities also cannot help due to the density of space. The firewalls were incorporated to frame the assembly and provide some protection against fires. The initial idea was to prepare the courtyard using

COMPONENTS :

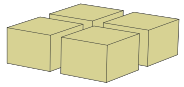

Courtyard


Unit


Washroom

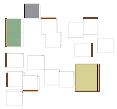

Shower

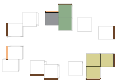

Laundry

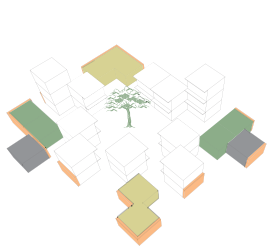

Factory

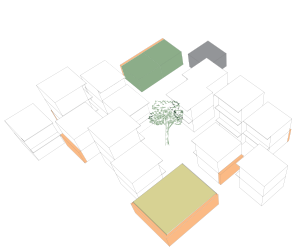

Fire barrier wall

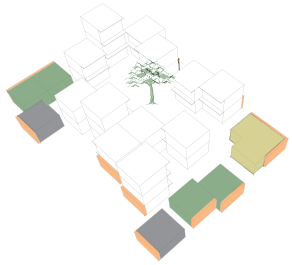
EXPLORATION 1 :

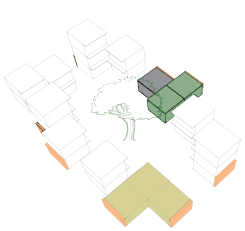


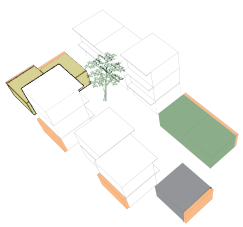




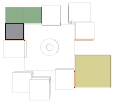


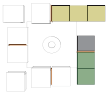


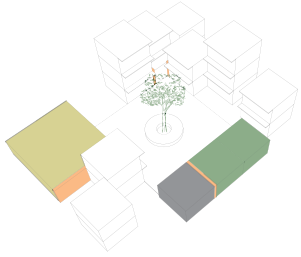


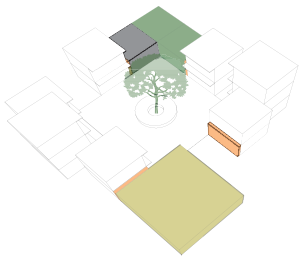


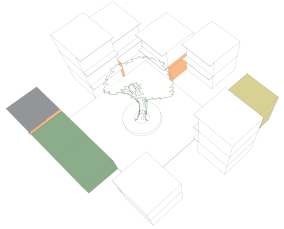
EXPLORATION 2 :

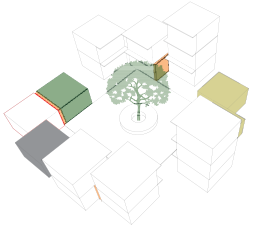


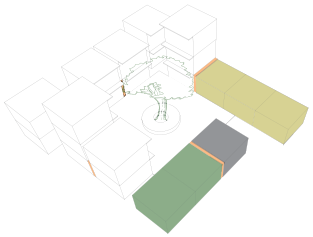












A bricolage exploration of two ideas to narrow down to one. The communal spaces of washrooms, showers, laundry, and housing unit spaces are used.

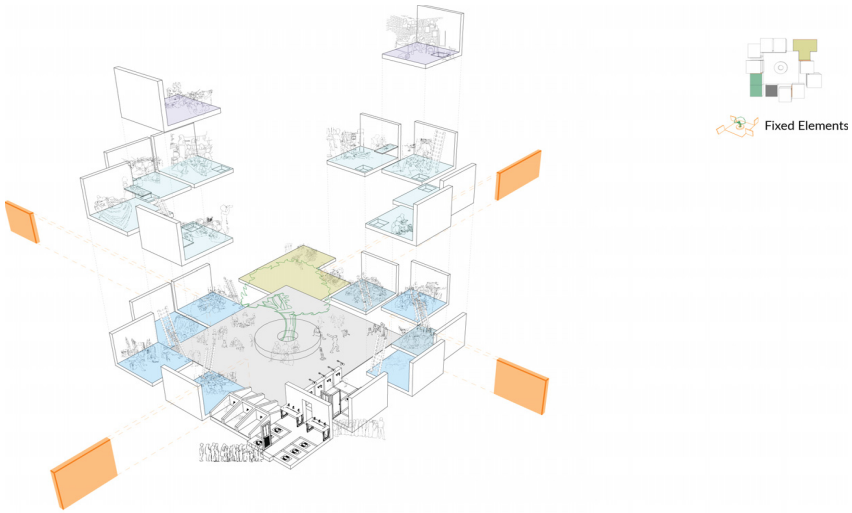
the firewalls, thus creating a space within a space. The courtyards link together, creating continuous circulation. However, the revised aim is to create an assembly of structures that could be very organized on its own, but when multiplied, it would look very similar to the current housing in the community.

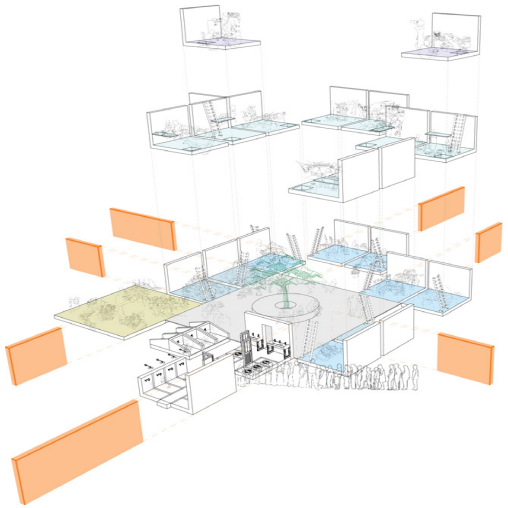
The proposed communal spaces are implemented around a slightly sloped courtyard with a tree and a pedestal for rainwater collection, social gatherings, and providing sunlight. The communal spaces and factories frame the corners of the bricolage for better circulation. Finally, the inhabitants can construct their homes using fire-resistant walls perpendicular to the courtyard. At the same time, it guides the location of their self-built dwelling.

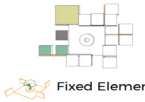
Implementation On Site

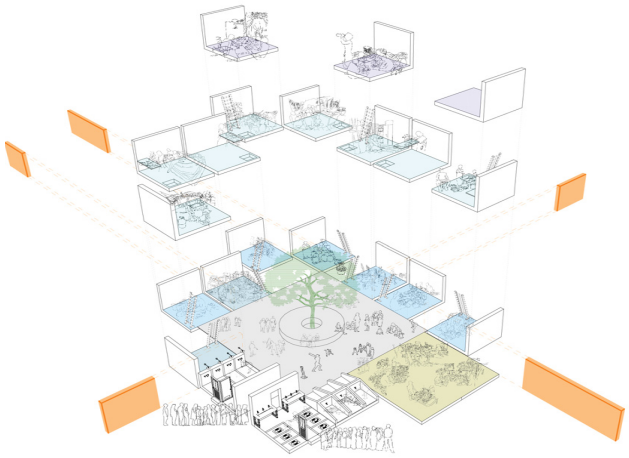
On-site, the idea of bricolage will be implemented in phases. The concrete pedestals and trees will be installed while the site circulation is maintained. With so many trees on one side of the site, this tactic will allow the first step to integrate with the community. Second, the sloped courtyards will designate where fixed spaces are located. By explicitly indicating the implementation pattern, this phase will aid in locating other fixed pieces. After that, the courtyard's fixed components, such as the showers, laundry, and fireproof walls, will be implemented. While leaving room for factories, the common spaces will frame the corners. The factory will be a component of the self-build system because it will be run and controlled by Dharavi inhabitants. The inhabitants will construct their homes using fireproof walls and establish a society that resembles their current way of life but is structured to preserve sanitary conditions, access to

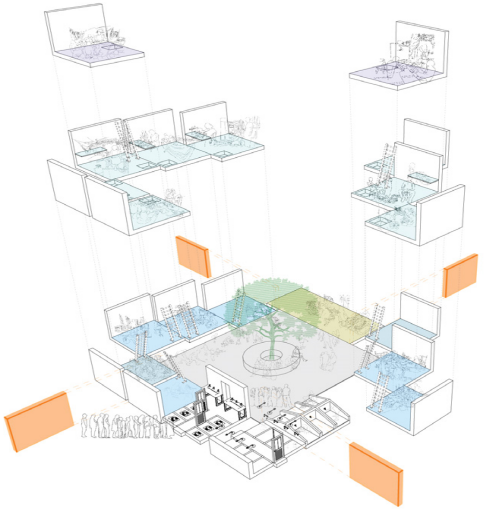
A timeline of how the assembly of units is implemented on site.







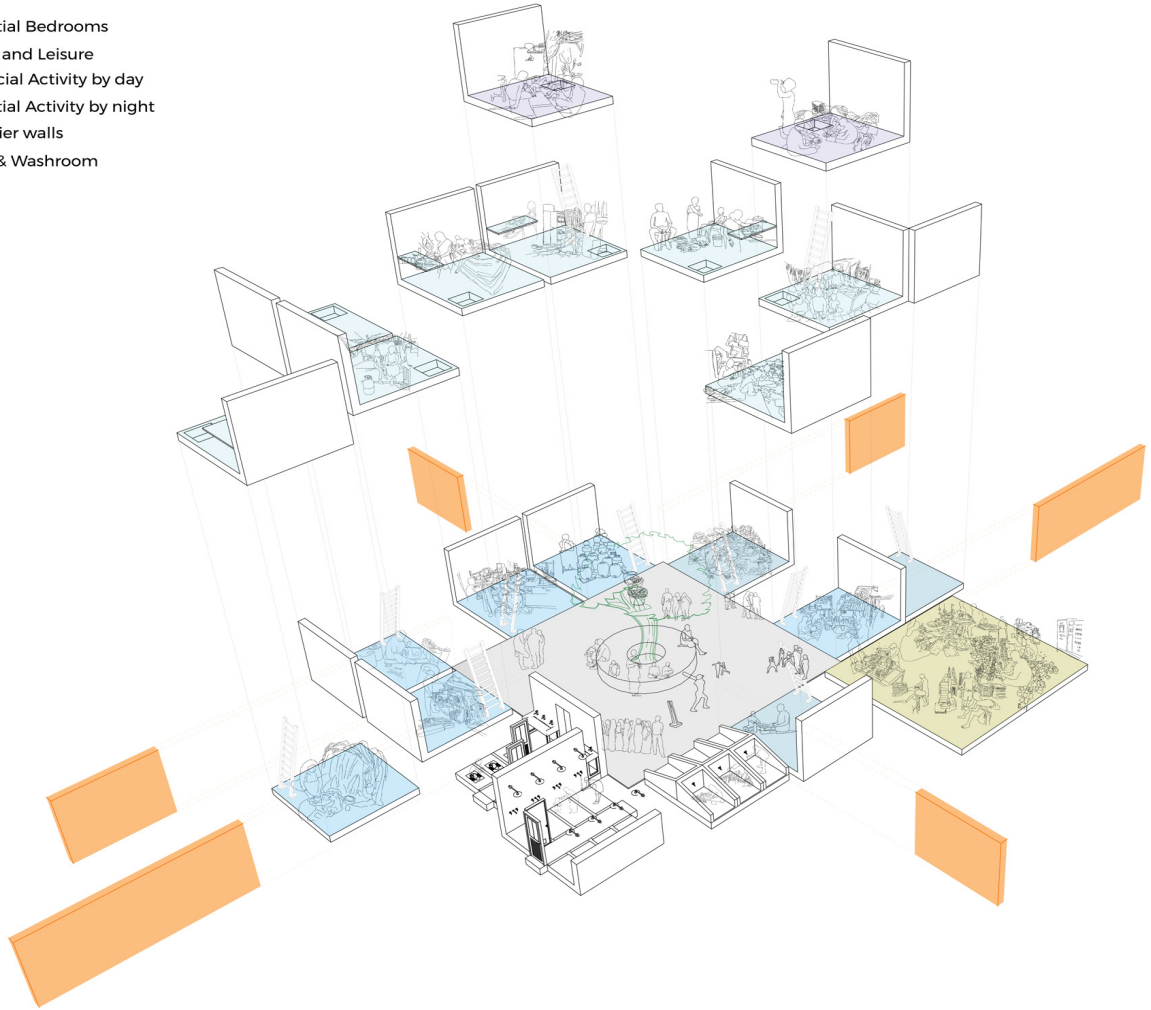


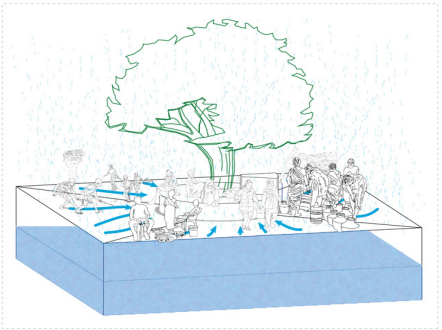


All assembly of units show how different spaces are used and their program.

EXPLODED AXO OF BRICOLAGE ASSEMBLIES

- Residential Bedrooms
- Cooking and Leisure
- Commecial Activity by day
- Residential Activity by night
- Fire Barrier walls
- Shower & Washroom
- Laundry
- Factory





Rainwater collection through courtyard

An assembly of units showing program and how different spaces are used.

sunshine, and efficient use of space. This modular approach fulfills the design requirements set earlier while introducing a new system through the circular economy methodology. The strategy reacts to the current needs and conditions of the inhabitants of Dharavi; requirements or priorities may be different in the coming month or year.

Dwelling Scale Design

Exploration Of Assembly

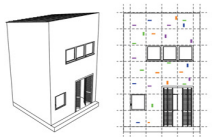
At the dwelling scale, the bricolage design is explored to show variation. Each exploration shows a new way to implement the fixed communal washroom, shower, and laundry spaces. This, along with the location of the fire-resistant walls, guides the incorporation of the housing units. In an informal settlement, people build in any way they see viable, thus predicting that is difficult. The variations of the assemblies provide a perspective on the unpredictability while feeding into the informal building pattern. The five diagrams show different possibilities for accommodating living, working, and socializing. The vignettes display each space's different ways, while the floor colours indicate the program. Each room or area is used in multiple ways, including commercials to sell goods, production of goods, relaxation, sleeping, cooking, socializing, eating, kids playing, and more. All these spaces, combined with the outdoor and communal space activities, paint an initial picture of how this design can accommodate the living habits of the residences while maintaining social and economic practices.

Materiality And Home Typology

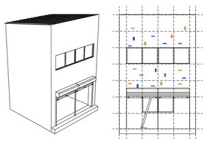
The different space use variations in an informal settlement dwelling hold great value and dictate the function and layout

STRUCTURE FLEXIBILITY & INHABITED SECTION

Unit types:

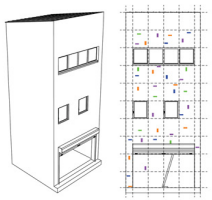


Unit 1
First floor small workshop by day and residential by night. Second floor residential

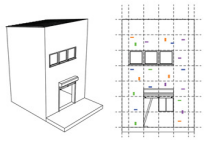


Unit 2
Two storey factory with next door living

Unit 3
First & second floor residential

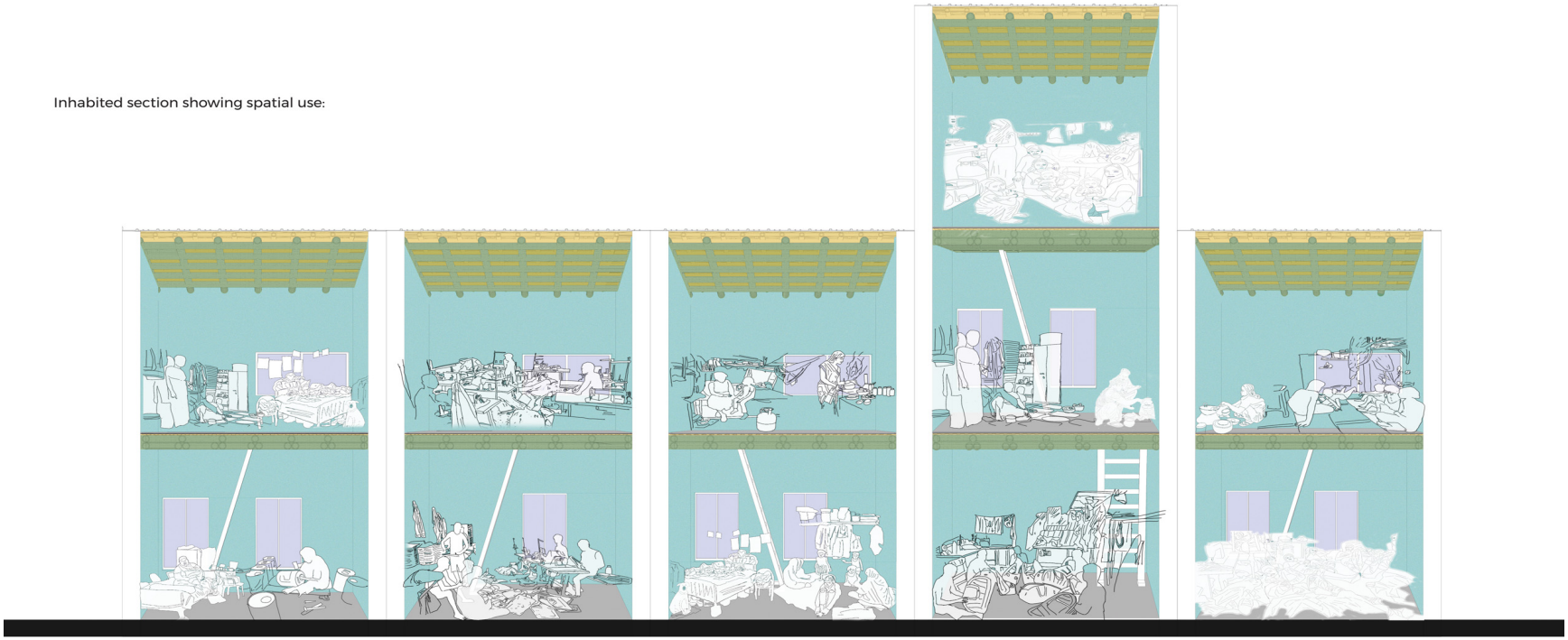


Unit 4
First floor factory & 2 storeys of residential space on top



Unit 5
First floor workshop with porch for selling goods, second floor residential

Inhabited section showing spatial use:



An inhabited section to show space use and the different types of units that the residents of Dharavi can make using the proposed bamboo structure.

of the structure. Preserving these spaces and their use was the initial step. However, the design must be flexible so each owner can make a house or factory their way but only use the system. The primary structure of the design is the bamboo framing spaced 3 feet apart. The plan will allow every user to construct a ground floor according to their specification. The render shows this flexibility of the structure, at the urban and dwelling scale, to accommodate a resident's different needs.

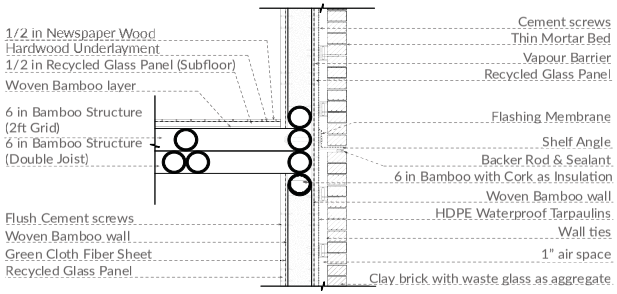
Structural Flexibility

The different space use practices are visible in the inhabited section showing how the slum living is unique and highly valued by the owners. The 3 feet spacing allows the resident to build a commercial ground floor, or residents emphasize half and half or the entire space is a factory while they dwell next door. The second and third floors are maintained as residential spaces but can also be storage spaces. The supplementary render further emphasizes the indoor activities within the houses.

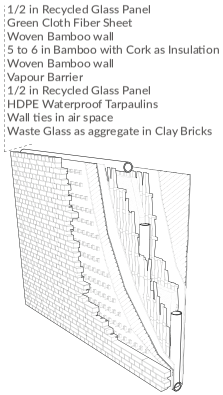
Component Scale Design

Building Systems

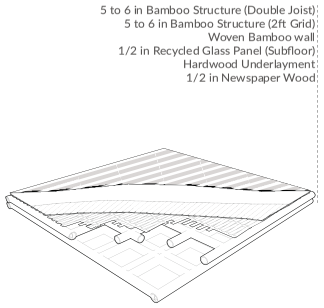
A brief description of the three elements created using recycled building components. These building materials mentioned at the beginning of the chapter can be combined with conventional vapour and waterproofing barriers to develop systems of wall, floor, and roof. The primary structure will be made using bamboo. While sheathing, finishes, or roofing elements are all made from recycled building materials.



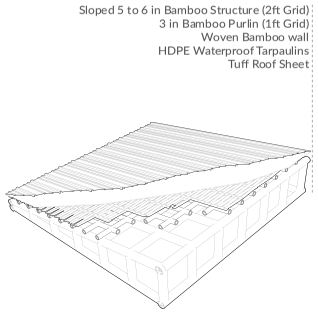
Floor meet wall (Scale 1:10)



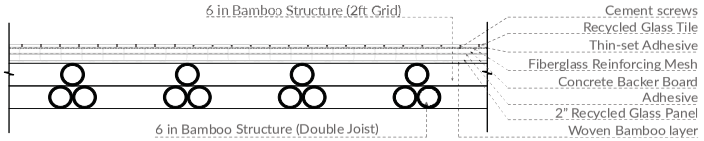
Wall



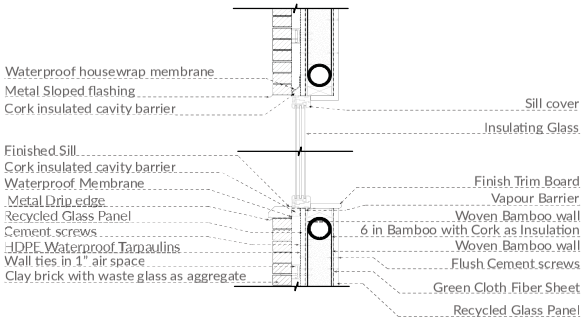
Floor



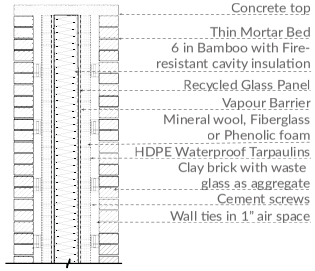
Roof



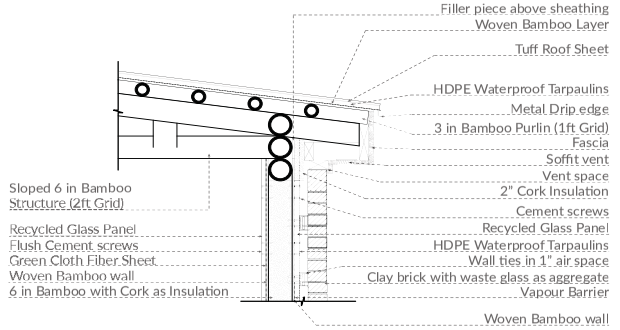
Floor detail - Communal washrooms & shower (Scale 1:10)



Window (Scale 1:10)



Wall detail - Fire resistant wall (Scale 1:10)



Roof meet wall (Scale 1:10)

A collection of the building systems and all the details of the different junctions.

The floor will be made of two structural bamboo layers. A double-joisted layer, followed by a 2 feet grid bamboo layer for structural integrity. Every bamboo joining will be done conventionally using polyester ropes. The foundation will still be concrete, while the bamboo will be set directly inside the concrete without any soil contact. The roof will have a minor slope to allow rainwater to collect behind the house and no water build-up because India commonly uses flat roofs.

These systems will be held together using nails, polyester rope, cement screws, and pins. This attempts to create a design from recycled building materials produced using Dharavi's waste and factory machines. This system is sustainable, feasible, and durable, with some on-site, in-person experimentation in the future. It will allow residents to build their homes by converting waste into building products and combining them to formulate the house. Junction details provide an overview of the roof-to-wall, wall-to-floor, or window meeting. These details also show how the systems are held together and how close it is to a conventional masonry wall or hardwood floor.

It was also important to detail the fire-resistant wall and the floor of the communal spaces. The fire-resistant wall will be masonry and an outdoor wall on both sides. It is tough to predict which side will be used, and if either side is an interior wall, it can be damaged over time. The washrooms and shower spaces typically have tiled flooring; thus, another floor is explicitly modelled for the communal areas. The laundry spaces are outdoors and made using concrete. Concrete can have any aggregate, and waste materials can be shredded or crushed to be used, but that is a potential that can be explored. These details will help the residents

People slowly build dwellings with available parts.

understand how each system connects so they can better implement it.

House Construction

The render displays 300 sqft units with all the system layers constructed by the settlement's people. The textures and colours of materials have been represented accurately, thus indicating how this space may look. The render is also set within a courtyard bricolage, thus showing how daily construction may look at a given moment. Materials may not always be available, so the residents will use anything on hand to improve their dwelling for a short period. The under-construction units portray the improvisation of building methods and use salvaged materials to fill in gaps.

Inhabitation

The combination of urban, dwelling and component scale design on site with the new building system can look chaotic but still needs to be organized. Implementing components in the houses and communal spaces in the bricolage will create a community that has sanitation, access to sunlight and water, is sustainable, feasible, and durable with homes that look closer to the formal structures of today. The outdoor gathering, playing, or socializing spaces are essential to visualize the first floor of the homes used to generate income and sell goods. Materiality, space use, community building, and social and economic spaces are all on display and working together while the inhabitants maintain their lifestyles and habits.

Conclusion

The circular economy methodology is at play in Dharavi, from producing materials to recycling, from building homes

A render showing daily social and economic practices

A render showing daily social and economic practices

to renovating, from working in a factory to creating one's business, and from the indoor spatial uses to the outdoor. Everything is connected and working in tandem with one another. The proposed design is implemented across the three scales - urban, dwelling, and component, working through the circular economy model. Design or site requirements include sanitation, sunlight, proximity to industry, preservation of indoor/outdoor spatial use, access to communal spaces, and an ability to collect water while protecting against fire. The urban strategy seems random compared to the existing housing but is very structured to meet the previously listed requirements. At the dwelling and components scale, the aim was to propose a feasible and sustainable model to improve the existing self-build system while preserving space use habits that give the community identity. The design depends on the available materials and individuals for inhabitation, as identified by the research. These requirements and conditions may change in the coming year or month as the area evolves towards better living or income-generating practices.

Chapter 8: Conclusion

An informal settlement is a community with without optimal housing, sanitation, and infrastructure. India is recognized as the nation with the largest population and the most significant number of residents in such circumstances. The initial analysis shows that all settlements are not decaying wasteland but rather vibrant communities with an expanding network of social and commercial spaces. In India's informal settlements, issues with infrastructure, water supply, sanitation, and housing durability are common. People move from rural areas to large cities mostly for financial reasons, which leads to them living in shantytowns adjacent to industrial districts. Mumbai's construction methods also focus on housing workers; therefore, high-density neighbourhoods that have evolved into informal settlements are widespread. Since Dharavi is the largest residential area in the city, its social and economic networks are investigated. Depending on their cultural needs, the residents' preferences are revealed through social networks. On the other hand, economic networks emphasize the vibrant nature of the neighbourhood and people's desire to reside close to their place of employment.

An analysis of the government's anticipated redevelopment established a unit size of 300 square feet. Some surveys were examined for comprehending people's demands and providing direction for the thesis' methodology and design. Other concepts are also utilized to understand the difference between a formal and informal settlement. Kinetic vs. Static, The City is Not a Tree, Cityness, and the Urban Advantage are four major concepts examined. These concepts shed light on hidden elements of the settlement

that can be preserved or improved. The site's location is near an industry, and the results informed its focus on a single population.

Self-built homes have become a cultural tradition in informal settlements. The study acknowledges locals' crucial role in addressing the housing crisis because locals are most qualified to assess how design may best serve their needs. It is generally accepted that the architect can act as a guide and liaison between the building and its occupants, helping them realize their objectives by understanding the construction field.

The thesis uses circular economy as a methodology for the design. According to the research of circular economy, it can be utilized to make any system or region more sustainable, and the reuse of waste resources makes the process practical. This technology is used to improve the self-build construction process in Dharavi and assist residents in sustainably attaining official dwellings. The residents of Dharavi are attempting to use waste to further their social or professional lives, which has created a circular economy. The construction process changes homes from informal to formal in the area. A circular economy reinvention is necessary due to the excessively long time frame. The feasibility and sustainability standards stated by the thesis at the beginning of the report are informed by the circular economy's use of waste materials. Furthermore, the spatial research shows unique settings low-income residents create to deal with constrained space. To find specific building blocks that could inform housing components, waste, recycled materials, and natural materials are examined. A more limited range of materials is chosen to produce components, including walls, roofs, floors, structures, and

finishes. The materials are utilized to build dwellings and social areas that will enhance the quality of life for those who live in an informal settlement.

Using the circular economy paradigm, the suggested design is realized at three different scales urban, residential, and component. Sanitation, sunlight, proximity to an industry, preservation of indoor/outdoor spatial use, accessibility to social spaces, and a plan to collect water while providing fire protection are all design or site criteria. At the scale of the dwelling and individual component, the primary goal was achieved by suggesting a workable and sustainable strategy to enhance the current self-build system while keeping the space usage customs that give the neighbourhood its individuality. All the investigations and studies create a system that can fulfill the need of the inhabitants of Dharavi. Overview of resilient structures while replacing temporary slum dwellings, preserving existing multipurpose spaces, and celebrating craft. These rules and conditions might also alter when the neighbourhood transitions to better living or income-generating activities in the future year or month.

Future Goals

Moving forward, there are three future goals. Make the design and the building systems adaptable to the changing material or site conditions. The current design is based on the materials available at the moment. However, if the design was adaptable, the changing materials may not impact it. Secondly, Mumbai and other cities have a sewage network. A future goal is to get access to those plans and use them to include an infrastructure element in the proposed design. These plans aren’t digital and must be accessed in person; thus, this is subject to further in-person research.

Finally, I wish to interview the people of the slum and visit the aforementioned economic network to document but also further solidify my research. All three future goals are subject to further in-person research and investigation.

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