Pioneering Extra-legal Settlements through Interventional Design

by

Anusha Varudandi

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Architecture
in The Lawrence Technological University
[2022]

Thesis Committee:
Scott Gerald Shall
Erin Kelly
Emily Kutil

Pioneering Extra-legal Settlements through Interventional Design

Anusha Varudandi

0.0 ABSTRACT

Extra-legal settlement communities have long existed and will continue to exist and grow exponentially as part of the world's inhabited landscape. By definition, these settlements are realized into places without plan and without legality of land ownership. Unfortunately, marginalization of these communities continues to widen, not due to a lack of desire or ability to improve connectivity, partnership and healthy co-existence, but rather from an infrastructural framework that does not support the fundamental nature and behaviors of the extra-legal. In order for any defined infrastructure to work with an extra-legal settlement, it has to tap into the inherent resiliency of that settlement. Government leaders and design professionals must institute a new approach and new solutions that recognize, honor and engage the inherent resiliency of the extra-legal settlement. Understanding habitual patterns and social instances will help create a structure that is not driven by first world dilemmas but one that applies solutions connected to the value systems that already exist in the community. Incremental instances of solutions may, in fact, require a phase-to-phase implementation, one that will build out of the inherent resiliency of the extra-legal community. Any viable solution will be required to integrate “new” ideas with the lived experiences of the people and establish parameters for shared use of resources, creating new social opportunities that do not diminish the significance of old ones. This study will focus on those things within the extra-legal community patterns of behavior that must be celebrated, salvaged, and utilized optimally in order to make any plan for incorporation viable and appropriate. This discussion will consider the history of the extra-legal settlements and through that as its basis, introduce interventive architectural and infrastructure practices that can encourage spaces that support existing lifestyles of extra-legal while also improving, elevating, and sustaining it.

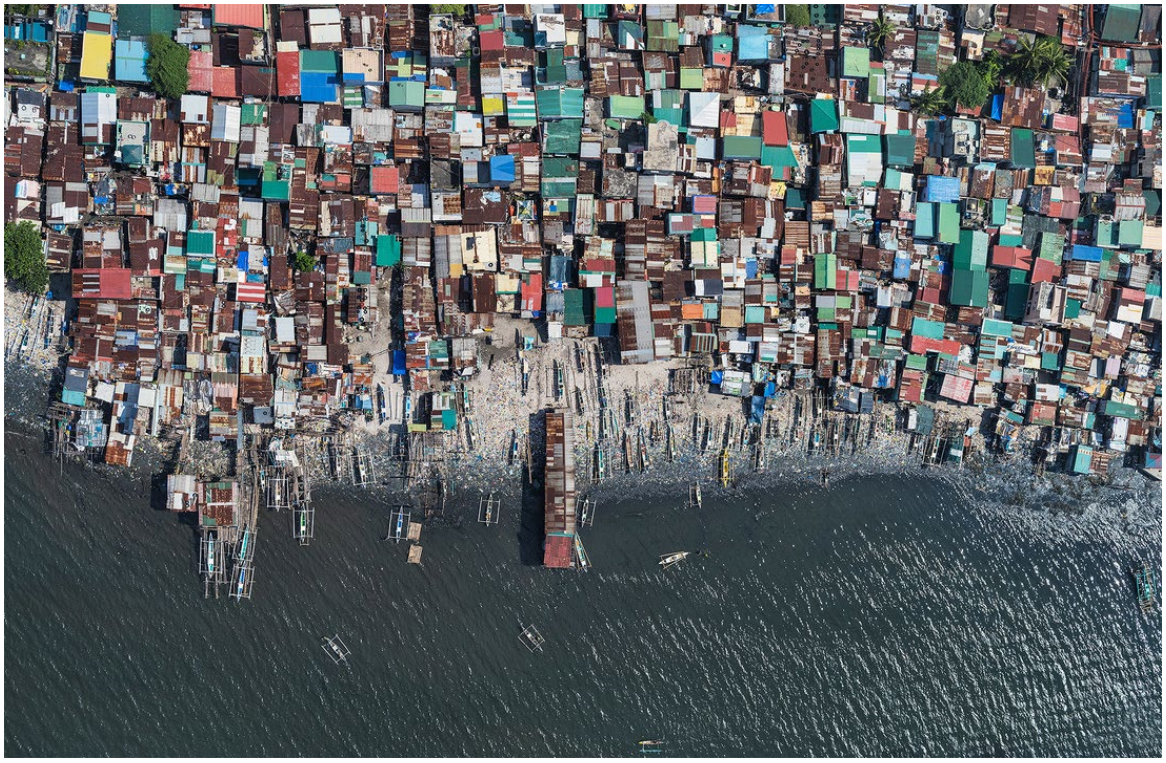

Image One: Manila is the capital of the Philippines. “An estimated 200,000 people live in a single square mile, in some neighborhoods – nearly three times the density of Manhattan. Manila sits on the northwest coast of the Phillippines. In the poorest region, multiple families cram into makeshift homes along the river. The units are built on stilts as a precaution against frequent flooding.”(Robinson 2017). (Image courtesy of Bernard Lang)

[TABLE OF CONTENTS]

[CHAPTER ONE: BACKGROUND DEEPDIVE]

Part One: Extra-legal Settlements Overall

1.1 What are Extra-legal Settlements

As cities within cities, extra-legal[1] settlements will continue to embed themselves into metropolises across the world. These settlements are developed in unsanctioned areas located on borrowed land. They exist outside the legal framework and generally lack access to architects, urban planners, engineers, and government aid. Residents here lack sufficient space, permeable structures to protect themselves from extreme climate conditions, access to clean/affordable water, adequate sanitation, and security of tenure land.[i]

These settlements are constructed outside the limits of the formal construction processes, built using unapproved plans and scavenged materials, and attribute survival to local knowledge and practices. These are places where structures and infrastructures are built by the community without the aid of professionals. Marginalization is prevalent. The current parameters under which extra-legals' are studied are based on experiences that are fundamentally opposed to the inherent existing patterns within the extra-legal settlement. The perspective of the professional[2] who wants to genuinely help manufacture viable change for the extra-legal settlements must be based on science and economics but must also consider history and culture to drive effective change.

1.2 Global Implications

By 2050, the world will be populated by almost nine billion people, almost 70% of whom will be urban dwellers. Of this 70%, as many as a third of these people will live in slums or so-called extra-legal settlements.[ii] Poor city planning and management systems have been unable to effectively manage, provide for, and mitigate the needs and concerns of certain segments of the migratory populations around the world. Global economic uprisings have led to uneven wealth distribution but that is only one of many contributing factors to the burgeoning establishment of extra-legal settlements resulting from the construct of this rural-to-urban migration.

Once established, management of extra-legal settlements is not able to be supported by private and public (government) entities and there is evidence that they discourage lack of access to essential infrastructures within these areas for reasons that may be categorized as political, profit-driven, and culturally selective. Infrastructure has different forms, roles, and interactions in legal settlements and extra-legal settlements. The pattern of precarious and preferential infrastructural aid poses problems like lack of access to safe water, structurally poor housing, overcrowding, unstable residential population, and poor sanitation and infrastructure.[iii]

The inherent wealth gap between legal and extra-legal communities will continue and proceed to create an environment more prone to malnutrition, disease, and segregation for billions of people globally. This wealth gap stems from infrastructural inadequacies.[iv]

To bridge this gap the solution must be geared towards an approach that works in partnership with extra-legal communities in order to understand habits and patterns from the perspective of extra-legal residents. Designers and professionals must consider that, in order to ethically work with extra-legal settlements, the fundamental design approach has to tap into the inherent resiliency of that settlement, and purposefully avoid imposing frameworks that do not support the fundamental nature and behaviors of the extra-legal.

This thesis investigates how extra-legal settlements have developed, adapted, and sustained themselves and how that understanding has implications for dense urban environments. The goal of this exploration is to develop infrastructures more suitable to the needs of the extra-legal settlement and more appropriately and culturally attached to the lives of the people who live there. This study seeks to use current placements of separative infrastructure and architecture to evolve its purpose into a more healthy, effective, and self-sustaining system through interventive design decisions to better serve those living in extra-legal settlements.

---

[1] The term extra-legal is used in creation by professor and humanitarian, Scott Shall. This term is used in substitute the more popular yet undermining word of slum.

[2] Professional- One who has access and has completed formal and higher education in specific field, then applies those skills to real world, (ex. doctor, architect, urban planner, lawyer, engineer, political member.)

Part Two: Extra-legal Settlements Dharavi

2.1 Introducing Dharavi

While extra-legal settlements exist all over the world, the specific and particular focus of this project's investigation is located in Dharavi, Mumbai. Dharavi is one of Asia's largest extra-legal settlements. Its population of extra-legal citizens totals roughly fifty - five percent of the twenty million people living in the mega city of Mumbai. With a focus on Dharavi, the research herein includes an examination of the history of this place to find patterns of success and viability (what works) and, even more importantly, patterns of failure and dysfunction (what does not work).

2.2 History of Dharavi

Dharavi's original inhabitants were the Koli fisherman. For more than 500 years the Koli Fishing community "have been living and working along the coastal waters of Mumbai."[v] During the late 18th century, India had succumbed to drought across the country. Farms were left crop less, thus, famine started to plague the outer edges of India. From all parts of India, people migrated to Dharavi for their survival. This diverse migration brought an array of skilled labor. Those who migrated from Gujarat (West of India) brought with them the foundation of the pottery industry; those from, Konkan, the textile industry (West); those from, Tamil Nadu (South), the tannery industry, and those from Uttar Pradesh, the embroidery industry.[vi]

2.3 Origins of Drought

Evidence about the droughts is more than a historical pin. The impact of the droughts is significant as they impacted farmers all across India. The cause and effect of the droughts is provocative, suggesting that they were more than just a natural phenomenon. The impact of the droughts is significant as they impacted farmers all across India. How and why they occurred bears examination on a deeper level. Human Rights Lawyer Bela Bhatia argues that the droughts were not due to lack of rain but rather to a depletion of ground water through inequitable and exploitative practices.[vii] The introduction of water extraction methods which only the rich could afford gave them the ability and advantage to dig deeper into the ground, inevitably depriving water from poorer neighbors. The cultivation of this analysis introduces the question of who owns groundwater. The qualifying distinction of the rich versus the poor subsequently corresponds to access to infrastructure; specifically, access to water.

Part Three: Spatial Analysis

3.1 Transportation Proximity

One specific and qualifying reason for Dharavi's ever-growing population is its proximity to three main train stations and multiple bus stop locations. These transportation nodes make it possible to access economic opportunities across the country.[viii]

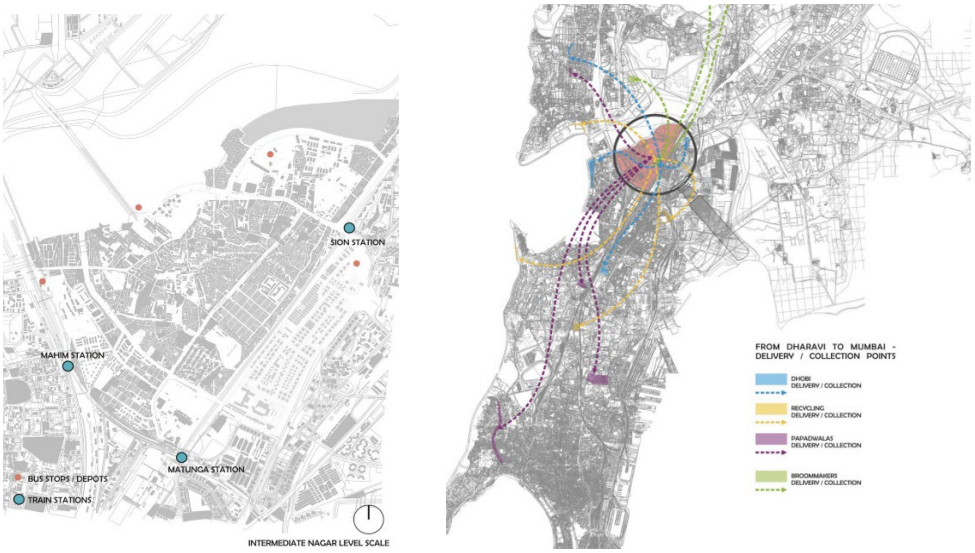

Image Two: Shows transportation nodes surrounding Dharavi and different linkages the investigated communities and the city through their livelihood. (Image courtesy of Amita Bhide and Martina Spies)

3.2 Entrepreneurship within Extra-legal

Dharavi is a thriving business center fueled by thousands of micro entrepreneurs. Despite the lack of civic infrastructure Dharavi is one of the largest economic contributors within Mumbai.

Eighty percent of Mumbai's solid waste is given new life within the area through the recycling industry within Dharavi, which employs almost 10,000 to 12,000 people. These industries create hundreds of thousands of jobs within the area.[ix] However, because there is no government effort to plan or invest in any infrastructure in or near Dharavi, living quarters and small-scale factories have grown haphazardly, with no provision for sanitation, drains, safe drinking water, roads or other basic services. "In these areas, a home is not just a residence. Houses double as tiny factories, shops, and hostels. This quality makes the whole area enormously productive" (Echanove,Srivastava 2016, 19-24). Hundreds of industries blossomed without any professional or governmental assistance. The people of Dharavi are creating networks of self-sustaining businesses, and in the process are creating livelihoods for themselves and their families for generations to come.

3.3 Proximity Implications to Bandra Kurla Complex

Bandra Kurla Complex is a financial district comprising one of the most upscale businesses and residential complexes in the city of Mumbai. The commercial development includes private and government offices (state and central), banks, and other wholesale establishments, and will ultimately provide about 2,000,000 jobs in the area.[x]

With its economic advancements and thriving financial status the proximity of this complex to the extra-legal settlement pose a major threat to Dharavi's residents. This form of neoliberal urbanism[3] made surrounding areas unaffordable for the working class, let alone for those living in extra-legal settlements. Consequently, due to the staggering market for surrounding land, the government is evicting thousands of Dharavi residents in order to build architecture for commercial viability. By uprooting hundreds of thousands of families with generational roots in the area, the government is stripping away those things most substantively important to the residents of Dharavi. These things include and encompass emotional and cultural factors such as those associated with community, neighbors, family and friends, and more tangible factors such as those related to family- owned businesses, proximity to food markets, public transportation, and work. Even more attention-worthy is the fact that, not only is the government abruptly evicting families, but they are also then placing them in toxic environments causing permanent health issues and affecting an inferior quality of life.

Part Four: Redevelopment Case Studies

4.1 Dharavi Redevelopment Plan (DRP)

Learning more about the lack of infrastructure in Dharavi provides an opportunity to discover and understand more about the government's efforts to improve life for the residents. In 1971, for the first time, the government acknowledged Dharavi as an area within Mumbai. This meant that money could be allocated for government led redevelopment projects. The Dharavi Redevelopment Plan (DRP) has been the main vehicle to drive the government's plan to improve Dharavi. This plan splits Dharavi into 5 sectors to make the plan commercially viable to connect to the Bandra Kurla Complex, which is emerging.

As with many large-scale civic plans with insufficient financial, political, and humanistic motivators, many of these plans are at a standstill. The main goal of the DRP is to advance commercial viability based private entities. Regrettably it seems to ignore the current economic wealth within Dharavi and the inherent needs of the residents.

4.2 Displacement of Mahul Residents

Privatized economy and financial uprisings in Mumbai have resulted in government led initiatives to rehouse the extra-legal residents resulting in dubious removal strategies. The case study of Mahul residents, another extra-legal settlement in Mumbai, portrays the purposeful relocation to undesirable and, more importantly, unhealthy locations.

Five-thousand residents were evicted and their homes were demolished by the Brihan Mumbai Municipal Corporation under the guise of redevelopment. The buildings allotted to the residents were surrounded by a vast complex of oil refineries and chemical factories. For all intents and purposes, the government had relegated these residents into a death chamber. Within weeks the majority of residents began to fall sick and few even died due to the chemical toxicity.[xi] This is by no means coincidental and nor is it humane. Current relocation practices like these are sacrificing the residents' health for wealth.

[3] Neoliberal Urbanism -Privatization of urban footprint, exludes extra-legal.

4.3 Government Slum Rehabilitation

Government-led rehousing development builds structures to simply compact as many people vertically as possible. This practice ignores the business, family, and lifestyle relations along with the existing spatial formations around those elements. The failure of this type of residential unit rests in the fact that it ignored the existing sustainable strategies within the community's lifestyle. The aspect of re-creating communal outdoor spaces is ignored and thus, issues like high electricity bills, separation, and lack of ventilation arises. Not only is the government creating vertical hot spots but it is also increasing overall lifestyle expenses that residents did not spend before.[xii] With Mumbai's existing high levels of pollution this type of design cannot continue. Due to the lack of sources Dharavi residents are forced to implement sustainable strategies, especially in the sector of ventilation. Mimicking spatial context within a high-rise can create a more efficient and comfortable environment for the occupants while reducing global emissions and saving costs.

4.4 Urban Upgrading

A strategy that has successfully aided extra-legal settlements across the globe is that of urban upgrading. Upgrading consists of improving the existing infrastructure, e.g. water reticulation, sanitation, storm drainage and electricity, up to a satisfactory standard. Urban upgrading does not consist of any home construction as residents are capable of doing this independently. However, the upgrading program does offer optional loans for home improvements. In addition, it consists of aid for the removal of environmental hazards, providing incentives for community management and maintenance. A vital part of upgrading is transferring tenure rights to the occupants at prices they can afford. "The security provided by transferring these tenure rights has been shown to motivate occupants to invest two to four times the amount of funds that the government invests in infrastructure improvements in a slum area" (MIT, 2000). It is an affordable alternative to clearance and relocation (which costs up to 10 times more than upgrading), and it minimizes the disturbance to the social and economic life of the community.

[CHAPTER TWO: WATER INFRASTRUCTURE]

Part One: Water Investigation

1.1 Distribution

Water is emblematic of what is the pinnacle of health and wealth within this community and across the world. Thus, it is the continued focus of this research. As a commodity, water is becoming scarcer every year. The main issue lies not solely on the quantity of water but on failing or less than adequate methods of distribution. The exponential growth of extra-legal settlements has resulted in less than adequate quantity or quality of water distribution for the extra-legal population. Water distribution methods have been overwhelmed by demand. Unfortunately, the existing systems tend to exacerbate inequities and in return create ill-founded solutions or no solutions at all.

Mumbai is considered to have one of the largest water supply and distribution systems in the world. Due to the overwhelming inhabitation of the city, there are limited sources of water within the city limits. The government has to tap into sources of water as far as 75 to100 kilometers away from the city. This in turn results in the need to resort to "an intermittent supply of water that is distributed at different times to different areas" (Sharma, 3).

The implications of this method of distribution result in legal settlements receiving more water even though they are of the less populated. Legal citizens living in high-rise buildings who acquire better economic status are able to acquire individual connections to their homes, in addition to having more space to store vast quantities of water in, "overhead tanks to which the water is pumped up by electrical pumps" (Sharma,3). This results in uninterrupted access to a 24-hour supply of water regardless of the time the municipal corporation releases water. To quantify this comparison a "resident of an affluent locality of Bombay, who probably consumes in excess of 300 lpd, pays the same rate as the slum dweller who may receive and use only 20 to 50 lpd" (Sharma,3).

Image Three: Women carrying water through extra-legal settlement in Mumbai (Image courtesy of Meena Kadri)

1.2 Water Retrieving Methods

Extra-legal residents use multiple methods to retrieve water.

- Water Tanks: The most government reliant way is that water trucks come to specific locations and with hose connections, release water for a couple hours.[xiii]
- Fire Hydrant: Another tactic employs a shanti that is located near a fire hydrant. The owner of that property creates a system in which the community comes to them for water.[xiv]
- Coming Together: A common tactic is that of families coming together to strike a deal with a local plumber.[xv]
- Gutter Tapping: A much more toxic way of retrieving water is attaching taps to pipes which run adjacent to the gutter. To collect water from these floor level taps, the residents must either carry a plastic pipe with them to attach to the tap or a mug in which they fill all the water before pouring it into their handis[4]. It is a long and tedious task.[xvi]
- Ground Pumps: Apart from shallow wells, the groundwater can be tapped for non-drinking purposes.[xvii]

All of these water retrieval methods result in residents paying significant amounts of money, more than legal counterparts, while still receiving miniscule amounts of water in comparison. In addition, residents are never promised clean water. To retrieve this water, they must walk sometimes long distances while carrying heavy amounts of water. In many cases these systems come with desultory maintenance practices. Due to this tendency, there is an inherent problem of leaking pipes and badly maintained pipes. This poor system of upkeep and care takes away even more water from the already deprived residents.

[4] Handis – vessels to store or cook. They are carried to transport collected water to homes.

Image Four: Residents fill their containers with drinking water from a municipal tanker in New Delhi on July 1, 2019. (Image courtesy of Reuters)

1.3 Methods of Storing Water

Parallel problems with retrieving water come with its storage as well. There are two inherent forms of water storage in extra-legal settlements across Mumbai. Large plastic bins are placed outside the home capable of storing one-hundred to three-hundred liters. Water collected in this way is used for bathing, toileting, and washing clothes. It is important to note that "Water from these larger storage containers is used for drinking only during times of severe water scarcity"(Bloom et al. 2013). Smaller capacity (50 liters) containers are placed within the home and used for storing drinking water.

1.4 Unhealthy Outcomes

Scarcity of amount, erratic distribution, inadequate storage space, toxic and/or no sewerage and sanitation on these sites exacerbates unhygienic practices and culminates in diseases. "Data from the SWA show that, in different seasons, 81-95% of households do not meet the WHO recommendation that all human beings use a minimum of 50 liters per capita per day (l/c/d) of water" (Bloom et al. 2013).

The majority of contamination including traces of coliform bacteria and E. coli were found at the house-hold level (i.e., the point-of-use) and *not* at point-of-source or in the distribution hoses. Contaminated water intake has resulted in health implications such as diarrhea, typhoid, cholera, jaundice, malaria, and intestinal worms.[xviii]

1.5 Toilets

Many of the diseases can be sourced from the cleanliness of extra-legal settlement toilet usage. The number of government-initiated toilets built are by no means enough for the population. With false promises and inadequate upkeep, the government placed systems are detrimentally failing extra-legal communities across Mumbai.[xix]

[CHAPTER THREE: DESIGN INVESTIGATION]

1.1 The Site

To further focus this study, the site shown in the figure below has been selected. This settlement is called Sant Dnyaneshwar Nagar. Located just north of Dharavi, and parallel to the Bandra Kurla Complex. Virtually this site encompasses the implications of separative infrastructure between legal and extra-legal settlements. On the left lies construction within the framework of governments and professionals, on the right are buildings built using scrap and material scavenged locally. Parallel to the site runs the Vikola Sewer. From above one might confuse this body of water with a canal; however, this water consists of an overwhelming degree of pollution, pollution that breeds disease. Few meters to the right the land is taken over by highly invested architecture within the Bandra Kurla Complex.

The distinct typologies currently create a defined boundary that oppresses the extra-legal to a confinement surrounded by unhealthy patterns. Patterns which have been imposed by infrastructural design led by governing authorities. These typologies will act as leading control variables.

Image Five: "The structured congruence of the Bandra Kurla Complex to the right stands in sharp contrast to the dense conglomeration of shanties on the left". (Image courtesy of Johnny Miller)

1.2 Design Premise

To quote Paulo Freire: "True generosity consists precisely in fighting to destroy the causes which nourish false charity. False charity constrains the fearful and subdued, the "rejects of life," to extend their trembling hands. True generosity lies in striving so that these hands--whether of individuals or entire peoples--need be extended less and less in supplication, so that more and more they become human hands which work and, working, transform the world" (Freire, 2000, p. 45).

To create sustainable solutions that will not only relieve residents of water scarcity but improve daily habitual patterns, a vernacular phase-to-phase strategy must be introduced. This implementation must consist of using local site conditions and materials. Overtime these interventions will result in a long-term interlinkage system that will provide access to clean infrastructure developed and supported by the residents of extra-legal communities.

1.3 Arteries and Capillaries

The formulation of this is analogous to that of the human body's system. There are two main arteries in this site's systems: the main road, and, opposite to that the sewer. This is where the largest and most impactful strategies will occur. In between these arteries

are the thousands of capillaries that exist within the labyrinth of shanties[5]. Here smaller interventions will thrive and aid to build upon the arterial bodies. The four speculations are differentiated by vitality of impact, longevity of intervention, and the most prevalent aorta is the scale of extra-legal residents involved.

1.4 Interventions

- Redevelopment of the Public Toilet: Existing across the main road lies a SBM (state government) public toilet system.. The current system is mainly septic tank toilet “comprises a sealed tank having both an inlet and an outlet into which excreta are flushed from a conventional cistern flush toilet using typically between 10-20 liters of water for each flush. ”The septic tank acts as a settlement unit in which solids settle out by gravity, the solids undergo a process of anaerobic decomposition. This flow and removal of the septic tank creates potential health hazards as well as is relatively expensive.

  Multiple methods of toilet systems that have been implemented in extra-legal communities across the world that have had positive outcomes to the community were examined. The system of a Bio-fil Toilet that had been installed and led by the The National Slum Dwellers Federation of Uganda in partnership with ACTogether. The advantages of this toilet system is that it uses very little water and extraction is once only 3 years. How this system works is that a biological filter consists of 3 layers. One is a block of pervious concrete stone, on top of that sawdust is spread over, then three inches of soil. The soil's function is to house the worms; solid waste including toilet paper, water are degraded, decomposed, and converted into rich soil. In order to accommodate 150 people, 8 standings and 4 toilets will need to be installed. Based on costs of the installations in Uganda it would cost approximately 10 lakhs in Mumbai to build.

  This specific effort would initially utilize design professionals, government authorities to finance and design/build, however, management must be employed by the community. This initiative cannot be done by the community alone; professionals, government, and the community must work in tandem with one another to serve for the greater good.

Image Six: Redevelopment of Public Toilet

[5] Shanti: The home which extra-legal live in built by using scavenged materials. No direct source of electricity or water is included.

- Plant Enclosure: Across the road from the *public toilet* and where Sant Dnyaneshwar Nagar begins, will be the placement of the Plant Enclosure. Through the process of the digester, within 2-3 years, rich soil will be available to the community. This soil will be utilized in the next phase of intervention. The soil will be used to plant specific species which will be used for future irrigation and water collection methods. This intervention takes place alongside the road consisting mostly of businesses on the ground floor and the beginning of the residential mammoth of the extra-legal settlements. This street edge is currently used for parking and the width of this space currently lies at approximately 5 meters. Using ample empty water bottles within the area that will be the container for plant species like A. Lemon Grass (Cymbopogon) main plant, Song of India (Dracaena reflexa) D. Elephant Ear (Alocasia sanderiana) all of which have biofilitative properties. These will be hung through any form of ties onto scaffolding that is local and readily available in the area. These scaffoldings will act as an open enclosure creating new urban space that gives back to the community and is integrated within a closed loop system. These garden structures will be managed by business owners and for additional support and encouragement of upkeep, the business will get monthly income from the government. This structure will not only beautify the street but invite more business to the area, on top of purifying the air, all in all, revitalizing inherently for a healthy interlinkage for extra-legal settlers. This intervention is to be led and initiated primarily by the community without government or design professional aid.

Image Seven: Plant Enclosure

- Rain Garden: The smallest but most common place intervention, the vertical garden, consists of growing small gardens utilizing bottles, pipes, that can attach to elements of shanties such as ladders, and windows. As the cycle of the plants outgrow the bottles, the community will work together in its transfer to two other points of intervention. In addition to the already available soil, these plants will be the bases of a rain garden located in between the existing roads as well as the center of the toilet, amplifying and purifying that space as well. Rainwater will be led into this engineered ecosystem where the water will be filtered naturally through plants, and below that is layers of mulch, sediment, and an installation of high performance underdrains.

  Based on the square footage of the area and the annual rainfall, this system shall create 250 liters of water annually for the 150 residents. Even though this does not equal the 1,080,000 already minimally drunk, this creates 23% aid for accessible and more importantly clean water for the residents of this selected sector.

Image Eight: Rain Garden

- Constructed Ecology: Reverting scale back to the largest scale and longest-term investment along the sewers edge would be the revitalization of pollutants through actions like plant bombing, creating floating green islands and in turn creating an ecosystem for constructed mangroves that will revitalize the water to a greater purpose. The intervention that most happens in tangent with the other interventions is that of the converted ecology within the existing canal. This is the longest intervention, consisting of aid with cleaning existing pollution as well as using the plastic within the water ways to create floating islands.

  This strategy is deploying principles and methods of a precedent that took place in Bengaluru India. A decade ago the lakes of Bengaluru started to foam, due to the sewage and industrial pollution. Usha Rajagopalan, a lake activist and community member, led a community based initiative to clean the lake.

  "The islands are designed to be lightweight and easily installed by one person," he explains. The only materials you will need are PVC pipes, 4 elbows, used plastic bottles, a nylon mesh, and tags. In a decades time, the lake is continuously tested as clean, and community members are able to experience the beauty of the lake.

  With the confines of this project, over time the plants that are grown within the business street edge can be transferred to the sewer and be held up by ample disregarded pvc pipes that can be found locally and act as the form and outer shell for growth. Below it will be floating with existing intertwined water bottles which will hold biofiltration plants grown in front of the business street edge. These plants will over a 10-30 year period clean the water providing fuel for ecology to naturally come back and convert this dumping ground of muck into a peaceful estuary full of life. Over a longer period of time this water could be part of the system that provides filtration drinking water for much more percentage of the residence.

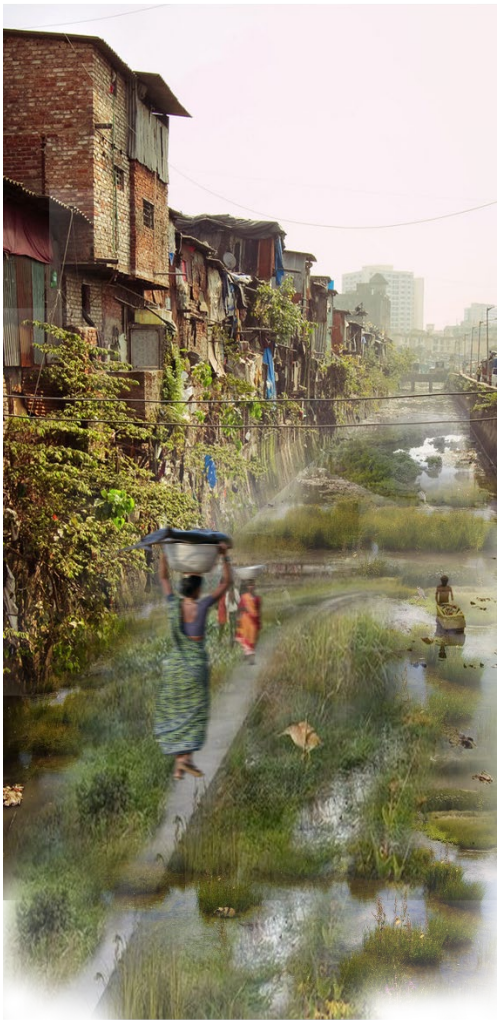

Image Nine: This image is to represent how the water ways can be transformed through interventive practices into an ecological oasis.

Image Ten: This image is to represent how the water ways can be transformed through interventive practices into an ecological oasis. (Image courtesy of National Geographic)

It is important to note that initial investments from government and design professionals will be needed for plants and some building material. The goal of these interventions is to create design solutions that are able to be built, used, and sustained by extra-legal residents with positive support and partnership from outside organizations. In return, aesthetics and urban revitalization create a better environment and experience for the city of Mumbai in its entirety.

1.5 Interlinkage of the Interventions

Separately, these interventions can lead to great benefits to the community, however the integral linkage between all of them can create a future that can inherently bridge the gap between legal and extra-legal settlements and introduce ways to build for the future metropolis.

Residents can use the vertical gardens as nurseries for larger plants. Residents then can transport these plants into bigger interventions like the green belt way and later place them into the sewer system.

These interventive applications will become the building blocks on which to create an integral pattern of ecological systems that support the well-being of extra-legal communities.

Image Eleven: Interlinkage

1.6 Conclusion

Extra legal settlements embody persistence in the form of resiliency. In order to adapt to global development these strategies intend to integrate healthier patterns with the people through accessible tools, and designs. These orchestrated interventions can lead to a landscape that ties back to the history of the Koli fisherman's relationship with mangrove ecology and to the land of the farmers before the drought. The current pollutants will be the base of an ecosystem that will form into estuaries through the guidance of Dharavi Residents. These actions will create a permanence of an eco-environment where the residents will not only be able to receive clean water but have an area that creates eco-systems for food, shelter from floods, and possibly an area to grow edible vegetation for centuries to come. The long-term investment and potential of these interventions is immense and can help diverge this population to change their livelihood for the better more importantly bring extralegal settlements out of the shadows and into the light of society.

Image Twelve: Interlinkage over Time

Appendix A

Rediscovering Dharavi: Kalpana Sharma
In the preliminary phases of my exploration I first needed to understand the history of Dharavi as well as the experiences and social interactions. With these elements in mind it was important that these instances were shared through the people who live in Dharavi in order to truly understand and design with their perspective in mind. The book Rediscovering Dharavi by Kalpana Sharma looked into the lives of Dharavi's residents from the perspective of its residence. This source gave me a glimpse into a perspective that has been blurred due to misconceptions. This book created a guide for me to put together an analysis of where people migrated from, the reason for migration, and compare lifestyles before and after moving to Dharavi. Through reading I found out that Dharavi's original inhabitants were the Kolisherman; however, during the late 18th century, India had succumbed to drought across the country. Farms were left crop less, thus, famine started to plague the outer edges of India. From all parts of the country, people migrated to Dharavi for their survival. This diverse migration brought an array of skilled labor. From Gujarat(West of India) the pottery industry was born, Konkan the textile industry (West), Tamil Nadu (South) the tannery industry, and Uttar Pradesh the Embroidery Industry. I also discovered that even with the lack of infrastructure the residents were proud to be brought up in the settlement and would rather stay than leave.

This book uncovered the idea that relocation is not the answer for improving the lives of Extra-legal settlers as their lives are intertwined in the social maze of the area. Dharavi is a city within a city with its own different communities from different parts of the country all coming together to find better economic opportunities for themselves and their families.

This piece of literature gave me more connection and closer relations to individual lives through interviews done by Kalpana Sharma. Even though I was not physically I was able to get a more in depth social understanding of the circumstances and specific attributes of Dharavi and its people.

[I CLAIM] that designing through the experiences and knowledge of Extra-legal settlers have, will create a much more integrating and sustainable solution to the lives of people of Dharavi and surrounding communities.

Appendix B

Revisit: Aranya low-cost housing, Indore, Balkrishna Doshi
Many of the precedents I studied incorporated many of the failures of the design, infrastructure, and governmental regulations, however, I wanted to explore methods of architecture designed for extra-legal settlements that have been successfully arranged and designed. Balkrishna Vithaldas Doshi an Indian Architect was commissioned by the Indore Development Authority to develop low-income housing in Aryana, Indore India.

This site at the time was vast land, but Doshi's team built it with the intention of it becoming an urban jungle. With that in mind, they studied the formation of extralegal settlements for almost a decade to understand and focus on the emergence and growth within urban centers of this specific demographic. "Through the observation and study of traditional ways of living, vernacular traditions and residential structures built by anonymous architects, he tried to look beyond aesthetic considerations" (Mollard, 2019).

There were originally 80 homes built, and that principle of initial design propagated itself into the maze of thousands of urban housing surrounding it.The principles of this precedent are geared from research of the aspects and specific attention to propagation in extra-legal communities. Because of this focus it was able to successfully allow healthy growth within the area while keeping existing social dynamics in addition to creating a framework for accessible infrastructure.
This element of successfully engaging with extra-legal settlements and understanding through the lens of their lives in order for sustainable design within this sector of the population is an aspect that geard how I looked into my own design iterations. The idea of "planting a seed" in this housing project and letting it naturally propagate by the community was also a strategy that was influenced and implemented through ecology within my own design iterations.

[I CLAIM] that integrating the community in small scale projects that study and understand aspects of infrastructure, lifestyle, and spatial needs for Dharavi residents can create a more sustainable and adaptive design solution that can grow with the exponential rising extralegal settlements of Dharavi and the around the world rather than inhibit financial growth and physical wellbeing.

[i] "Living in these settlements often poses significant health risks. Sanitation, food storage facilities and drinking water quality are often poor, with the result that inhabitants are exposed to a wide range of pathogens and houses may act as breeding grounds for insect vectors. Cooking and heating facilities are often basic, with the consequence that levels of excessive exposures to indoor pollution may occur. Access to health and other services may be limited; overcrowding can contribute to stress, violence and increased problems of drugs and other social problems" (WHO, 2000).

[ii] "Tokyo is the world's largest city with an agglomeration of 37 million inhabitants, followed by New Delhi with 29 million, Shanghai with 26 million, and Mexico City and São Paulo, each with around 22 million inhabitants. Today, Cairo, Mumbai, Beijing and Dhaka all have close to 20 million inhabitants. By 2020, Tokyo's population is projected to begin to decline, while Delhi is projected to continue growing and to become the most populous city in the world around 2028. By 2030, the world is projected to have 43 megacities with more than 10 million inhabitants, most of them in developing regions. However, some of the fastest-growing urban agglomerations are cities with fewer than 1 million inhabitants, many of them located in Asia and Africa. While one in eight people live in 33 megacities worldwide, close to half of the world's urban dwellers reside in much smaller settlements with fewer than 500,000 inhabitants" (UN 2018).

[iii] "Approximately one-fifth of slum households live in extremely poor conditions, lacking more than three basic shelter needs. Generally, the lack of sanitation and water in the region's slums is compounded by insufficient living space for families and inadequate, makeshift housing" (UN-Habitat).

[v] "Climate change is no longer something which can be denied and these environmental changes are directly affecting the livelihoods of Indian fishermen by changing the weather patterns and altering fish behaviour. According to the World Economic Forum, India's coastal water temperatures have risen by half a degree, which has had a devastating knock-on effect for the fishermen: some fish numbers are severely down (anchovies), others are migrating to cooler waters (sardines), while others still are moving into deeper waters (mackerel), where the Indian fishermen don't have the deep sea fishing equipment to reach them" (Schapova, 2019).

[vii] "Broadly speaking, one can distinguish two (interrelated) causes of this accelerating depletion of groundwater resources. First, the depletion of groundwater can be seen as one aspect of a broader ecological crisis, involving particularly the disruption of the hydrological cycle. Second, there are important economic forces leading to the direct depletion of groundwater resources, especially the indiscriminate expansion of modern water extraction devices and of water-intensive crops in areas of groundwater scarcity" (Bhatia 1992, 17)

[viii]

[ix] "So what's the process? 1. Sorting and segregation – after receiving the waste, a few thousand workers sort and separate the waste into recyclables (metals and plastics) and non-recyclables. The plastic is then sorted further by colour and quality. 2. Crushing – The sorted materials are crushed into tiny plastics, microplastics if you will, with the help of crushing machines made of scrap waste metals. 3. Cleaning – the plastics are cleaned thoroughly. 4. Sold off to melting facilities – due to safety and health regulations, there are no plastic melting facilities in Dharavi itself. The plastic is sold off to industries all over India to be melted and reused as 60,000 different plastics and resold to companies" (Mascarenhas 2020)

[x] "In 1977, the MMRDA was appointed as the Special Planning Authority for planning and development of this complex. It covers 370 ha. area of once low-lying land on either side of the Mithi River, Vakola Nalla and Mahim Creek. The area had poor surface drainage and was severely affected by pollution in the Mahim Creek. The Authority has developed 19 hectares of land with the presence of prominent institutions such as the Reserve Bank of India, Income Tax, Sales Tax, Provident Fund and many other corporate and commercial establishments. Together, these buildings offer an office space as large as 1,17,000 sq. mtrs., potential enough to accommodate thousands of jobs. This meticulously planned complex also showcases a City Park which is regularly thronged with people" (MMRDA 2013).

[xi] Mahul is a tiny fishing village near Trombay in Mumbai. In the mid-2000s, housing colonies were built there for slumdwellers under the Project Affected People scheme. More than 10,000 families were reportedly moved to these colonies in the next few decades after they were displaced by various projects, according to *The Indian Express*. This included about 1,000 families living in Ghatkopar area near the Tansa pipeline. They were relocated after the Brihanmumbai Municipal Corporation demolished their homes in accordance with a 2009 Bombay High Court order. Around 5,000 families now live in these housing colonies in Mahul. The area is surrounded by oil refineries, chemical factories, petroleum companies and fertiliser plants, and is heavily polluted. Hundreds of residents have alleged that they either fell sick or lost their family members after moving to Mahul" (Scroll Staff 2019).

[xii] "In the slums, Bardhan points out, people lived with resource constraints over many generations. They did so by developing and passing on innovative ways to derive comfort from their built environment. But she says: "Slum-dwellers have always relied on their social networks for work and support. And when they move from the slums to rehabilitation housing these networks break down." Bardhan has found, for instance, that people who used to cook together in open spaces in the slums were now forced to cook individually in their homes, meaning that their fuel consumption has significantly increased. Bardhan has found that the policy has a particularly negative effect on women and children. She often hears women complain that they no longer know their neighbours and so can't share childcare with trusted people" (Williams 2017).

[xiii] "The politicians, civil servants and corporate lobbyists who live in substantial houses and apartments in central Delhi pay very little to get limitless supplies of piped water - whether for their bathrooms, kitchens or to wash the car, dog, or spray a manicured lawn. They can do all that for as little as Rs 700- Rs 1,000 a month. But step into one of the slum areas in the inner city, or a giant disorganized housing estate on the outskirts and there is a daily struggle to get and pay for very limited supplies of water, which is delivered by tanker rather than pipe. And the price is soaring as supplies are fast depleting" (Reuters 2018).

[xiv] "Some of them collect water from fire hydrants. If a hut is built near a fire hydrant, the resident of that hut manages to control the water from the hydrant. Of course, the fire brigade sends around people to check each morning. But somehow a way is found to avoid this and the water continues to be tapped from these hydrants on a daily basis. Sometimes a bribe to the security guard helps. "For the last two years, we are all getting water from the fire hydrant in Water Gully", says Bano. "We used to pay Rs 10 per month, now its more because the officer wants more money." Says Salma from Water Gully, "We pay Rs 30 per month for two handis per day per person to the person who has the fire hydrant in her house. We stand in line from 3 a.m in the morning often up to 7 a.m" (Sharma 4).

[xv] Around 40 or 50 families have struck a private deal with a local plumber. They have paid between Rs 700 to 1000 to access a water connection in the slum. Here water comes, at different locations, for a few hours every day. Some of the women say that they are able to fill six to eight handis a day

from this source. The women say that they must get 10 to 15 handis a day. They do not mind if 15 families get together and are provided one water connection. At present, MP Nagar families spend up to Rs 60 a month on buying water" (Sharma 8).

[xvi] "A second source is a slum called Bharat Nagar which has common taps. But these taps are attached to pipes which run adjacent to the gutter. To collect water from these floor level taps, the women must either carry a plastic pipe with them to attach to the tap or a mug in which they fill ll the water before pouring it into their handis. It is a long and tedious task. Given the weight of the handis and the distance they must walk, they can fill at most one or two handis a day. Each trip takes them at least 15 to 20 minutes" (Sharma 7).

[xvii] "Many communities, such as the railway slums, survive because there are still some traditional sources of water like the shallow wells from which they draw water for bathing and washing. No one takes responsibility for these wells even though, if maintained well, they could provide a valuable additional source. Similarly, many slums have been provided with handpumps and borewells for water that can be used for non-drinking purposes. But many such pumps have fallen into disuse due to bad maintenance. As a result, even if households get 8 to 10 handis or 120-150 lpd, it has to suffice for all purposes including bathing and washing" (Sharma 11).

[xviii] "Our data also highlight seasonal variations in contamination, with summer and monsoon having higher contamination rates than winter. The higher contamination rate in monsoon is partly attributable to point-of-source water contamination, though augmented household level contamination from ambient fecal matter due to flooding of homes is likely another major contributing factor. The higher contamination rate in summer may be due to frequent accessing of water containers due to heat-related body fluid losses (Bloom, et al. 2013).

[xix] "The community toilets in the area are not cleaned or sanitised by the BMC either, local residents said, pointing to a dirty, crumbling lavatory that stands on the main road. The walls of the toilet bore the name of the local MLA, with a message that it was slated for reconstruction. "This toilet is being used for 4,000 people living in the slum rehabilitation building opposite and the slums on all sides," said Sidhart Kasare, a local leader of the Republican Party of India, which is part of the central government as an ally of the BJP" (Agarval, Yadavar 2020).

Bibliography

Almeroth-Williams, Tom. “Fixing India's Slum Rehabilitation Housing.” University of Cambridge. University of Cambridge, February 13, 2020. https://www.cam.ac.uk/stories/indias-slum-rehabilitation-housing.

Bela Bhatia. “Lush Fields and Parched Throats: Political Economy of Groundwater in Gujarat.” *Economic and Political Weekly* 27, no. 51/52 (1992): A142–70. http://www.jstor.org/stable/4399241.

Bhide, Amita, and Martina Spies. “‘Dharavi - Ground up’: A Dwellers-Focused Design Tool for ...” Commission for Development Studies at the Austrian Academy of Sciences, April 9, 2013. https://oead.at/fileadmin/Dokumente/kef-research.at/04_projekte/02_datenbank/p184_final_report_engl.pdf.

“CLIMATE MUMBAI (INDIA).” Climate Data. OpenStreetMap. Accessed May 5, 2022. https://en.climate-data.org/asia/india/maharashtra/mumbai-29/.

Echanove, Matias, and Rahul Srivastava. “This Is Not a Slum: What the World Can Learn from Dharavi.” World Policy Journal. Duke University Press, June 15, 2016. https://muse.jhu.edu/article/620753.

Eco India, Episode 1: How Bengaluru's Citizens Are Coming Together to Revive Its Lakes. Scroll.in, 2018. https://scroll.in/brandstudio/ecoindia/903765/eco-india-episode-1-how-bengaluru-s-citizens-are-coming-together-to-revive-its-lakes.

Freire, Paulo. *Pedagogy of the Oppressed*. New York: Continuum, 2000.

Gulankar, Akash Chandrashekhar, Mumbai, and Anushka Deepak. “Social Distancing Not a Choice in Dharavi, Asia's Biggest Slum.” Social distancing not a choice in Dharavi, Asia’s biggest slum. The Federal, April 22, 2020. https://thefederal.com/states/west/maharashtra/social-distancing-not-a-choice-in-dharavi-asias-biggest-slum/.

JMCmedia4. “Biofil Toilets Transforming Kampala Slums.” YouTube. YouTube, March 9, 2015. https://www.youtube.com/watch?v=hBi1Cnwp_-4.

Kumar Karn, S., and H. Harada. “Field Survey on Water Supply, Sanitation and Associated Health Impacts in Urban Poor Communities - a Case from Mumbai City, India.” *Water Science and Technology* 46, no. 11-12 (February 2002): 269–75. https://doi.org/10.2166/wst.2002.0749.

Mascarenhas, Trisha, and Jyotika Bindra. “Dharavi: Asia's Largest Slum or a Recycling and Circular Economy Goldmine?” Green Is The New Black, August 3, 2018. https://greenisthenewblack.com/dharavi-asias-largest-slum-indias-recycling-circular-economy-goldmine/#:~:text=With%2015%2C000%20factories%20dedicated%20to,in%20it's%20piled%20up%20trash.

Massachusetts Institute of Technology. “What Is Urban Upgrading?” History of urban upgrading. The World Bank Group. Accessed February 8, 2022. https://web.mit.edu/urbanupgrading/upgrading/whatis/history.html.

MMRDA. “Bandra Kurla Complex.” Mumbai Metropolitan Region Development Authority - Bandra Kurla Complex (BKC). MMRDA, 2013. https://mmrda.maharashtra.gov.in/bandra-kurla-complex-bkc-#:~:text=In%201977%2C%20the%20MMRDA%20was,pollution%20in%20the%20Mahim%20Creek.

Mollard, Manon. “Revisit: Aranya Low-Cost Housing, Indore, Balkrishna Doshi.” Architectural Review, July 12, 2021. https://www.architectural-review.com/buildings/revisit-aranya-low-cost-housing-indore-balkrishna-doshi.

Reuters, Reuters. In drought-hit Delhi, the haves get limitless water, the poor fight for every drop. India Today, July 7, 2019. https://www.indiatoday.in/india/story/in-drought-hit-delhi-the-haves-get-limitless-water-the-poor-fight-for-every-drop-1563827-2019-07-07.

Schapova, Polina. “The Kolis, One of the Oldest Fishing Communities of Mumbai, Face an Uncertain Future.” Firstpost. Firstpost, April 24, 2019. https://www.firstpost.com/long-reads/the-kolis-one-of-the-oldest-fishing-communities-of-mumbai-face-an-uncertain-future-6500251.html.

Shall, Scott. “Guerrilla Architecture and Humanitarian Design.” The Palgrave Handbook of Bottom-Up Urbanism, February 5, 2019. https://www.academia.edu/38291557/Guerrilla_Architecture_and_Humanitarian_Design.

Sharma, Kalpana. *Rediscovering Dharavi: Stories from Asia's Largest Slum*. New Delhi: Penguin Books, 2000.

Sharma, Kalpana. “Waiting for Water the Experience of Poor Communities in Bombay.” SPARC. Accessed February 8, 2022. https://www.ucl.ac.uk/dpu-projects/drivers_urb_change/urb_infrastructure/pdf_public_private_services/W_SPARC_Kalpana_waiting_water.pdf.

“Slums: Some Definitions - UN-Habitat.” UN-Habitat State of the World Cities . United Nations, 2006. https://mirror.unhabitat.org/documents/media_centre/sowcr2006/SOWCR%205.pdf.

"Slums: Some Definitions - UN-Habitat." UN-Habitat State of the World Cities. UN-Habitat, 2007. https://mirror.unhabitat.org/documents/media_centre/sowcr2006/SOWCR%205.pdf.

Staff, Scroll. Relocate Mahul residents in 12 weeks, do not move new families to area, Bombay HC tells Maharashtra. Scroll.in, September 23, 2019. https://scroll.in/latest/938257/relocate-mahul-residents-in-12-weeks-do-not-move-new-families-to-area-bombay-hc-tells-maharashtra.

Subbaraman, Ramnath, Shrutika Shitole, Tejal Shitole, Kiran Sawant, Jennifer O'Brien, David E Bloom, and Anita Patil-Deshmukh. "The Social Ecology of Water in a Mumbai Slum: Failures in Water Quality, Quantity, and Reliability." *BMC Public Health* 13, no. 1 (February 26, 2013). https://doi.org/10.1186/1471-2458-13-173.

Yadavar, Swagata, And, Soniya Agrawal, Nootan Sharma -, Tara Kartha -, and Monami Gogoi -. "Dharavi Is Not Just Fighting Coronavirus, but Also Dirty Toilets and Battered Image." ThePrint, May 22, 2020. https://theprint.in/india/dharavi-is-not-just-fighting-coronavirus-but-also-dirty-toilets-and-battered-image/426523/.