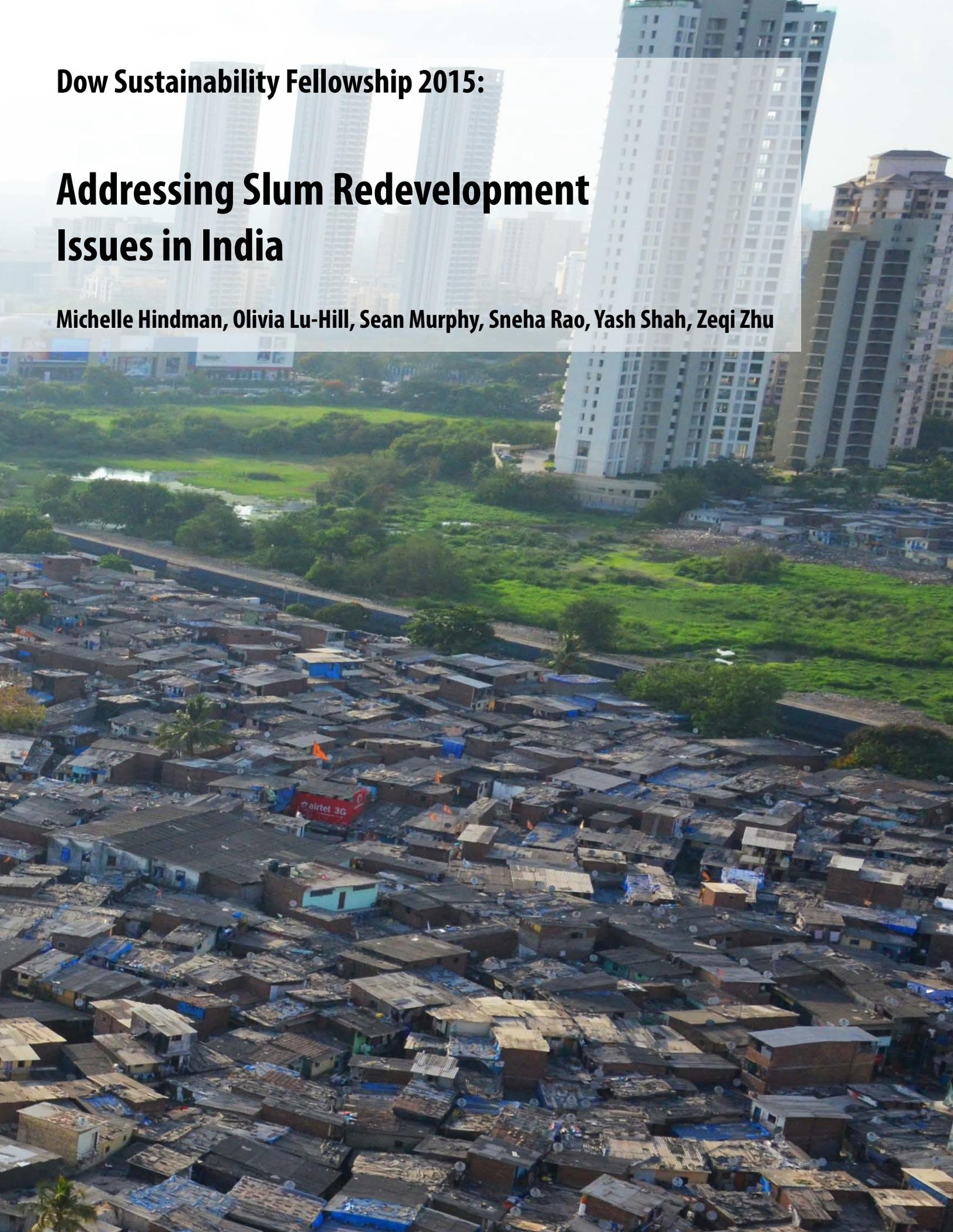


**Dow Sustainability Fellowship 2015:**

# **Addressing Slum Redevelopment Issues in India**

**Michelle Hindman, Olivia Lu-Hill, Sean Murphy, Sneha Rao, Yash Shah, Zeqi Zhu**



## Table of Contents

Acknowledgments.....	4
Executive Summary.....	6
Introduction.....	8
Section I: Background on Housing in India.....	9
Section II: Analysis from Field Research.....	26
Section III: Recommendations.....	31
Administrative Sustainability.....	32
Environmental Sustainability.....	35
Financial Sustainability.....	46
Cultural Sustainability.....	51
Conclusion.....	58
References.....	59



## ACKNOWLEDGEMENTS

We want to say a very big thank you to our collaborators and mentors in making this publication. It wouldn't have been possible without you.

Dr. Anne Wallin  
Dow Fellows Program Coordinator, 2015  
Dow Chemical



### Funding Partners:

Dow Sustainability Fellowship



International Institute of University of Michigan



### Advisors:

Dr. Vikramaditya Khanna  
University of Michigan Law School



Dr. Pavan Mamidi  
India Institute of Management, Ahmedabad



Dr. Ana Paula Pimentel Walker  
University of Michigan, Taubman College of Architecture and Urban Planning



Claudia Wigger  
University of Michigan, Taubman College of Architecture and Urban Planning

### University of Michigan Schools Represented

University of Michigan, Engineering School

University of Michigan, Gerald R. Ford School of Public Policy

University of Michigan, Natural Resources and Environment

University of Michigan, Taubman College of Architecture and Urban Planning





# Executive Summary

The main objective of this study is to develop recommendations to improve the Government of India's *Housing for All* policy. Apart from the recommendations to policymakers on institutional themes, we also provide recommendations to private sector real-estate developers for designing sustainable low-income settlements.

To help us achieve these objectives, we divided our study into three sections:

1. **Literature Review of Past Policies in India:** In our study of global interventions to improve the quality of life for slum households we categorized past policy approaches into broad categories of slum upgradation or slum redevelopment. We compared the features of three past federal policies in India namely *National Slum Development Program* (NSDP), *Basic Services for Urban Poor* (BSUP), and *Housing for All*. Through our literature reviews and qualitative interviews, we found that in-situ slum redevelopment policies such as *Housing for All* present more advantages than past policies. In Section I, we present the analysis of three available policy options based on program features, performance, and achievements.

2. **Stakeholder Meetings and Field Visits:** Since we found the in-situ component of the *Slum Rehabilitation Scheme* (SRS) to be closest to the slum redevelopment component in *Housing for All*, we targeted this policy in our field research. In our stakeholder interviews we gauged its potential to become an effective model for slum redevelopment in emerging cities in India. During our visit to Mumbai in May 2015, we met with key stakeholders, including government officials, lawyers, real estate developers, policy makers, and private equity investors to understand implementation challenges of SRS. We also met with advisory agencies and academic experts in Ahmedabad and Delhi to understand scalability challenges for SRS. In Section II, we use these insights to analyze lessons from twenty years of implementing SRS that could be applicable for the *Housing for All* policy.

3. **Recommendations:** In the final section, we synthesized our year-long research to distill four key recommendations to improve various types of sustainability of slum redevelopment. Our recommendations aim to use the field research from Mumbai to narrow down cities where in-situ redevelopment would be most administratively sustainable. We propose financing models for beneficiaries of these schemes which would ensure formalize property rights for the long term. We propose decentralized waste water and energy amenities to improve the environmental sustainability of housing and cities. Finally, we provide recommendations for architectural modifications which could retain the cultural sustainability of the communities. We aim to disseminate these four key recommendations to policy makers in India so that *Housing for All* is able to reach the goal of providing decent housing for every slum dweller by 2022.



# Introduction

In 2009, for the first time in human history, more people lived in cities than in villages<sup>1</sup>. This urbanization has been celebrated due to the associated rapid rise in productivity and thereby GDP growth, particularly, in the case of China and South Korea. However, there have been instances of urbanization without growth, such as in Brazil and certain African countries, where the quality of opportunities in cities, rather than the quantity of people, determines economic development<sup>2</sup>. Decent housing and the supporting urban infrastructure are fundamental drivers of improving quality of life.

In 2011, 377 million people (31% of the total population) in India lived in cities, but of these, 65 million (27% of the urban population) lived in extreme shelter poverty in areas called slums. This challenge is not unique to India, 863 million people around the world live in similar squatter settlements<sup>3</sup>. India and China have the highest number of slum dwellers, with 50 million plus inhabitants living in acute shelter poverty. The United Nations' *Sustainable Development Goals* recognize the sustainable growth of future generations is contingent upon active improvement in quality of life. The *Sustainable Development Goals* aspire to halve the proportion of people living in slums within each country by 2030. Given the very nature of informality, surveying the number of households defined as slums is challenging, but in India this implies improving quality of life of at least 6 million households.

Yet, India has a more ambitious target in mind; the government recently announced *Housing for All* policy which aims to provide every citizen access to adequate housing by 2022. It is estimated that the current shortfall of houses is 19 million, with 95% of this need being in the low-income segment (less than ₹2,00,000)<sup>4</sup>. This cannot be achieved by government interventions alone, hence the government has articulated its policy of incentivizing the private sector to participate in effective redevelopment of the entire slum community. The slum redevelopment component of this scheme proposes an efficient solution: the government aims to use land occupied by squatter settlements as a resource to subsidize housing for urban poor. This effectively solves the problems of land shortage while subsidizing the cost of housing for urban poor to as little as zero in some cases.

By involving the private sector and using real-estate as a financing tool, this component of the policy marks a stark departure from the previous policies which focused on piecemeal upgradation efforts in slums (*National Slum Development Program*) or used government machinery to create poor quality public housing (*Basic Services to Urban Poor*). Our research has found strong similarities between the federal *Housing for All* scheme's slum redevelopment component and the state policy implemented in Maharashtra (*Slum Rehabilitation Scheme*). This paper has used performance of in-situ redevelopment component of SRS as a proxy to predict the future performance of *Housing for All's* slum redevelopment component. We have then compared the features of three national schemes - NSDP, BSUP, and *Housing for All* - to develop an understanding of which policies have worked best in the Indian context.

# Section I: Background on Housing in India



## Snapshot of Indian Slums

The 2011 census presented the first quantitative picture of assets and amenities in informal housing units, which had until then been undocumented. This data presents important information about social, financial, and political attributes of slum blocks and of individual slum households. This context will be helpful in understanding the needs of slum households and the high levels of density in such areas.

The census estimates the number of slum blocks in the country to be 110,000. While the number of households in each of these slum blocks varies between 86,000 households in Dharavi<sup>5</sup>, to 1,300 households in Nochikuppam Chennai<sup>6</sup>, the level of public services in these areas remain visibly poor everywhere. There are several reasons for such low level of services, including a low tax base of urban local bodies, poverty debt traps, and a lack of informed voting.

*Among the slum blocks:*

- 58% have open or no drainage
- 43% must bring water from outside their communities
- 26% do not have access to clean drinking water
- 34% have no public toilets in their communities
- 2 electricity outages occur per day



*Image and Information Source: Indian Government Census, 2011*

*Box 1. Snapshot of Slum Blocks in India*

Local governments in India operate with very low tax bases, where eight of the largest twenty-one cities, are unable to finance even 50% of municipal costs<sup>7</sup>. As a result, informal districts of the city are worst-hit by low service levels. If the slum population is largely informal and tax non-compliant, local governments see little incentive to spend money on increasing their service levels. This is evident in visible open drainage lines, and lack of streetlights, roads, household toilets, and garbage collection services. This has led to major public health issues such as open defecation and the presence of unsanitary waste adjacent to houses<sup>8</sup>. Various studies correlating health outcomes to the built environment found that children living in urban slums in India have stunted growth compared to non-slum urban and rural children<sup>9</sup>. The health effects on slum residents have shown to vary by several factors including number of years living in the slum, presence of a separate kitchen, type and permanence of the shelter. The extremely dense housing also causes communicable diseases to spread rapidly.

In cities where the slum population constitutes about 40% of the total population of the city, one would expect the large slum representation to result in greater political demand for basic services. Unfortunately, large electorate numbers have not been able to translate that potential into a political advantage resulting in better service levels. A study of around 800 slums in Delhi, found that the slum population does participate in the electoral process (voter turnout was 58%) but the voter information level remains severely low, leading to voting on

the basis of caste lines or cash based voting. The political parties work with slum “Pradhans” who tend to be caste/ religious leaders, and form the informal power structures<sup>10</sup>. In slums with several ethnic or religious groups, each demographic portion of the slum may be led by its own Pradhan which makes it easier for people to resort to caste/ religion based voting. This dissociates politics from past performance and leads to the polarization of votes, often in conflict with the self-interest of the slum community.

Different scholars have drawn attention to the diversity that exists within each slum residence. We observed that in smaller Indian cities, typical slum dwellers were recent rural migrants, but in Mumbai and Delhi, families have lived in slums for years. The 2011 census data helps to quantify families’ income and assets, and captures their housing characteristics. Since there is a large divide in consumption and income statistics especially in the characteristic informal economy, an assessment of personal assets and visible housing characteristics will help policymakers understand their willingness to pay for various improvements.

## Market Failure as Institutional Reason for Slum Formation

*Among slum households:*

- 69% possess TV
- 63% have mobile phones
- 90% have electricity
- 94% have kitchens
- 44% have in house toilets
- 50% live in one room houses with an average family size of over four people



*Image and Information Source: Indian Government Census, 2011*

### *Box 2. Snapshot of Household Amenities across Slums in India*

While earlier studies highlighted slums as a problem that needed to be fixed, recent studies have drawn attention to how slums are a space for entrepreneurship and provide accessible affordable housing for urban migrants. There are multiple reasons for the growth of slums including rapid urban migration, urban governance<sup>11</sup>, and the housing demand-supply gap. In this paper, we focus our attention on the demand-supply gap.

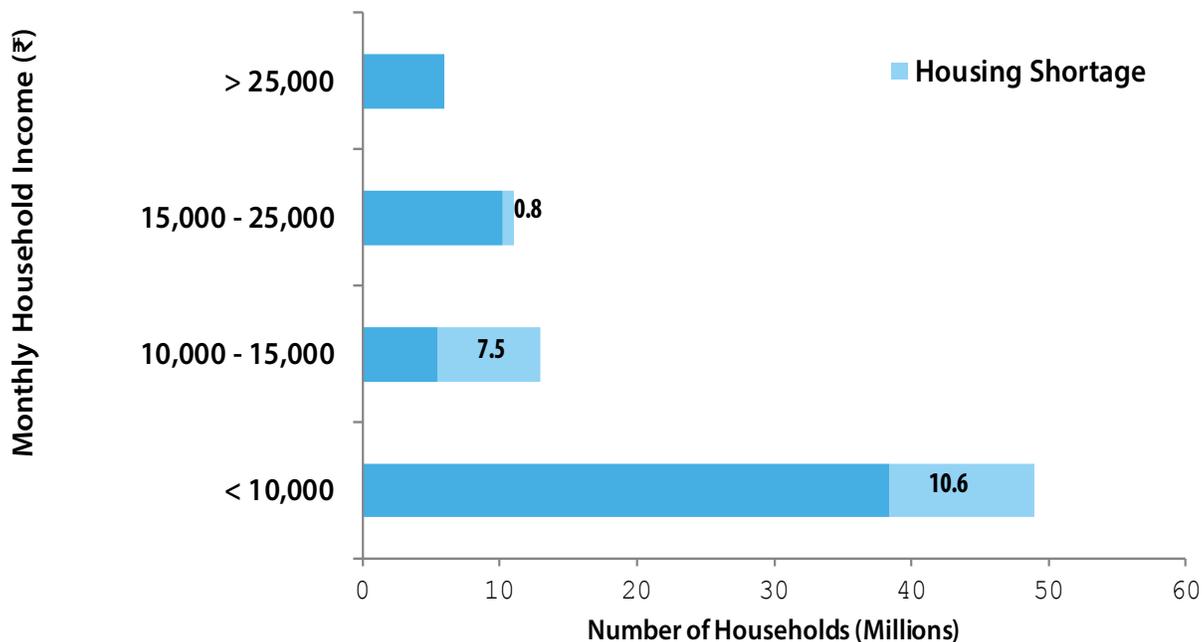
The gap between growing demand for affordable urban housing and insufficient supply has encouraged the formation of slums. Whenever the demand surplus is not met by formal sectors, this gap is typically filled by an informal dwelling such as a slum. While a slum is better than nothing, housing that is safe, clean, and secure is obviously preferred. The challenges that both the market supply and demand sides are facing have prevented sufficient affordable housing for the urban poor, stimulating slum formation.

## Demand side: Limited Access to Financial Resources for Slum Households

The traditional real-estate market in India has focused on serving the needs of the urban rich, households with monthly income greater than ₹60,000. At the base of the income pyramid, a typical double-income slum household can only earn up to ₹7,500 per month<sup>12</sup>. The Government of India reports there is a shortage of about 19 million homes in urban India, 56% of which are from Economically Weaker Section (EWS) households with monthly income less than ₹25,000<sup>13</sup> (Figure 1). In addition to the significant unmet demand, the urban poor lack the access to formal financial resources to help them purchase new homes or maintain a new life in a new housing unit. Therefore, most of the newly constructed housing units are not affordable.

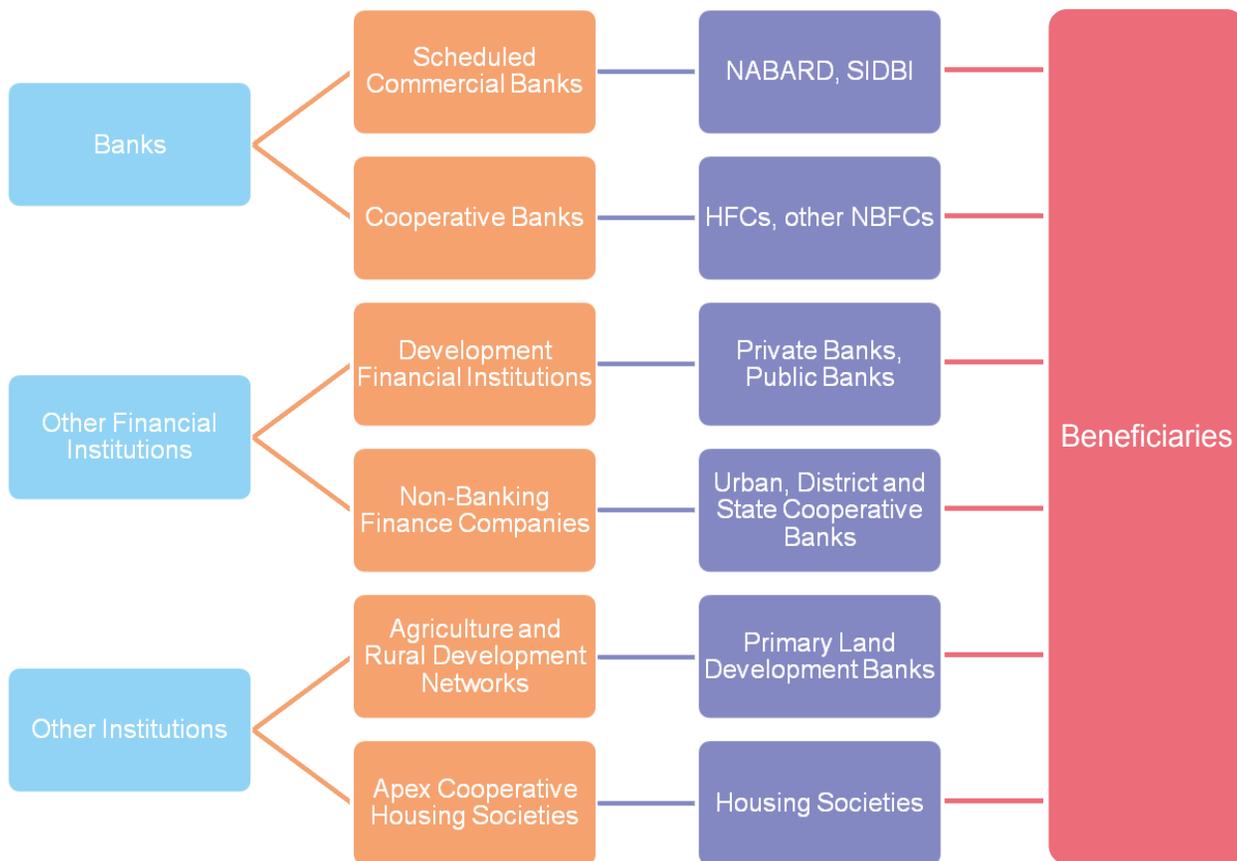
Housing finance companies (HFCs) have traditionally served only the mid-to-high income and formal sectors (Figure 3). Thus, slum dwellers are largely left out. Traditional companies have been hesitant to play in the informal sector to a great extent due to the high per capita costs of serving this section, aggravated in the informal sector by the perceived difficulty in assessing risks of the client. According to Ministry of Labor and Employment, 65%-70% of the workers in urban areas are working in the informal sector<sup>14</sup>. Since they are paid in real cash, and they lack collateral, formal records of identification, address and salary, they remain under served by HFCs.

As Figure 3 shows, different types of financial institutions have targeted different areas.



Source: Report of the Technical Urban Group (TG-12) on Urban Housing Shortage 2012-17. Ministry of Housing and Urban Poverty Alleviation, 2012

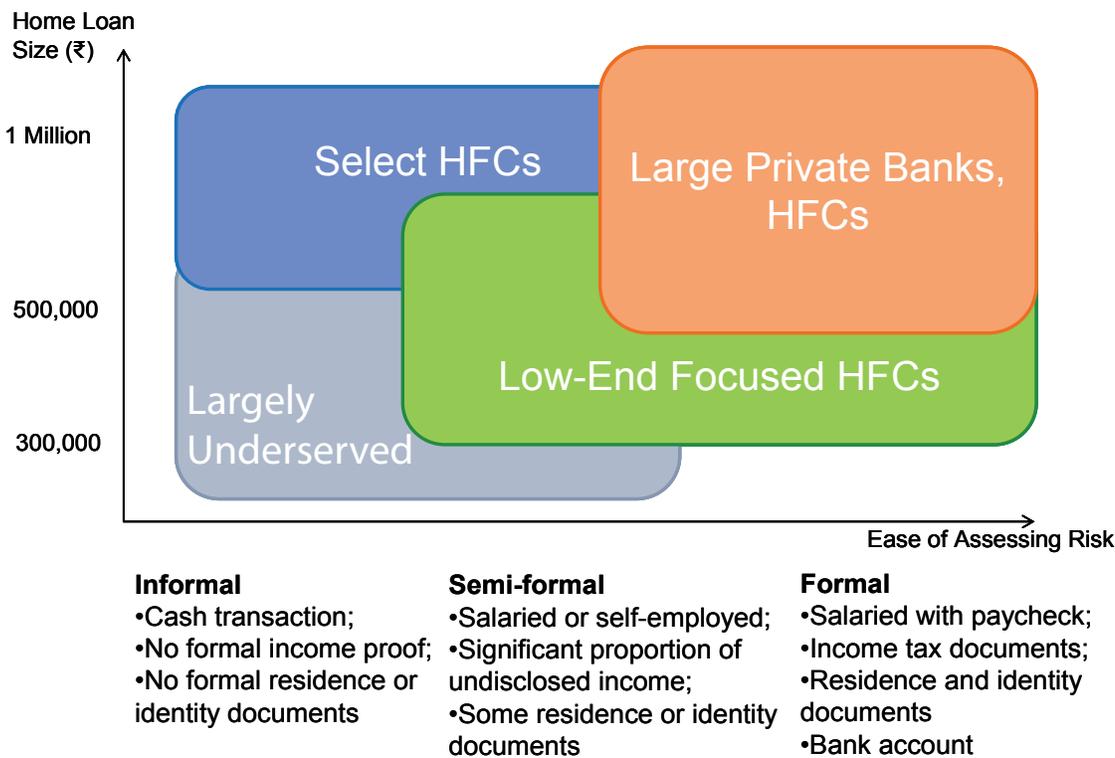
Figure 1. Urban Income Pyramid and Housing Shortage



Source: *Housing and Housing Finance*. Asian Development Bank. 2013

Figure 2. Housing Finance Market in India

Two important metrics that financiers consider when making loan decisions are (1) the size of the loan, and (2) the difficulty in assessing client's risks. Larger private banks and HFCs are focusing on high-volume easy-to-measure-risk market, which is traditionally preferred by investors. The rest of the market, either featured by lower lending amounts, higher uncertainty in assessing risk, or both, is shared by other later entered or specialized HFCs. In the largely under served market, there are now devoted start-ups like the Micro Housing Finance Corporation that have identified this high-risk low-volume segment as a large business opportunity. Existing organizations with superb track records in associated business have additionally of late entered or reported their aim to enter this business sector, seeing both a business opportunity and cross-efficiencies. However, in the short term, it is anticipated that there will still be a deficit of credits accessible to the slum dwellers in urban India.



Source: *Micromortgages: A Macro Opportunity in Low Income Housing Finance*, Monitor Inclusive, Markets. 2010

Figure 3: Housing Finance Company Market Map in India

## Supply Side: Issues in Providing Affordable Housing for the Urban Poor

A well-established pricing rule indicates that a household can afford a home priced below a forty-month income. Therefore, these slum households could only afford to buy a unit cheaper than ₹4,00,000. However, current private developers fail to provide decent housing at this price, instead a typical 269 sq. ft. unit costs between ₹5,00,000 and ₹7,00,000<sup>15</sup>. The supply of affordable housing is limited by a lack of available urban land, rising construction costs, and regulatory constraints.

### Lack of available urban land

In the past 15 years, India's urban population density has increased 45%<sup>16</sup>. It is further estimated that 40% of population will live in urban areas by 2026<sup>17</sup>. With increasingly densified urban population, there exists a huge demand for land. Careful urban planning benefits the urbanization process. However, excess control over land development creates an artificial urban land shortage, as this could lead to urban sprawl and corruption in land licensing. Lack of transparent land transaction records also add up the search time and costs for developers. Additionally, a lot of non-marketable state-owned entities are located in the heart of cities, further limiting the amount of available land for housing.

## Lack of Available Urban Land is Driving Up Land Cost

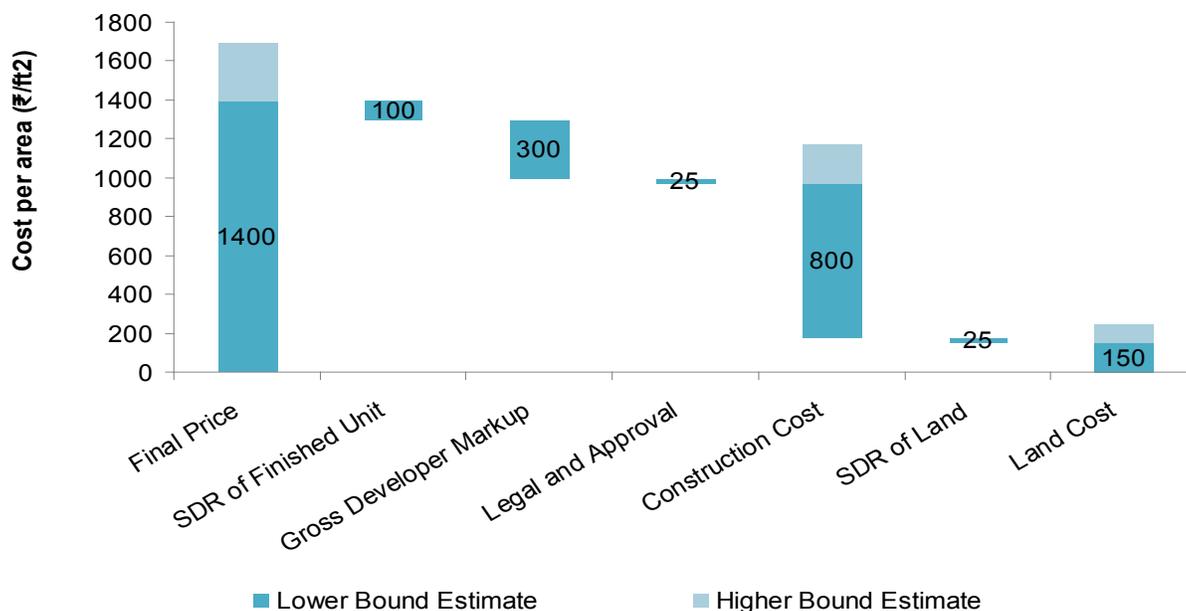
Constraint	Details
Excess control on the development of land creates artificial shortage	<ul style="list-style-type: none"> <li>• Tend to sprawl out urban development towards the periphery</li> <li>• May lead to rampant corruption as few stakeholders with large influence</li> </ul>
Lack of marketable land parcels	<ul style="list-style-type: none"> <li>• Nonmarketable state-owned entities often incompatible with real land value</li> <li>• Lack of monitoring provides proliferation of slums and squatter settlements</li> </ul>
Titling issues and lack of transparent information	<ul style="list-style-type: none"> <li>• Incomplete registration form creates great disadvantages to land buyers</li> <li>• Lack of transparency in transaction information hinders land acquisition</li> </ul>

Source: *Affordable Housing in India*, Jones Lang LaSalle. 2012

Table 1: Lack of Available Land is Driving up Land Cost

### Rising construction costs

In the upscale housing market, the largest driver of cost in private development projects is land costs, particularly in the city-center. In the slum redevelopment projects, where land costs could be as little as none, then the largest driver of the final project cost is construction costs. However, the estimated construction cost for this housing is about ₹800 per sq. ft.<sup>18</sup>, accounting for more than half of the final price. The construction cost has increased about 80% in the past decade. With climbing material costs and labor costs resulting from labor shortage, private developers alone may not be able to deliver affordable housing to the market.



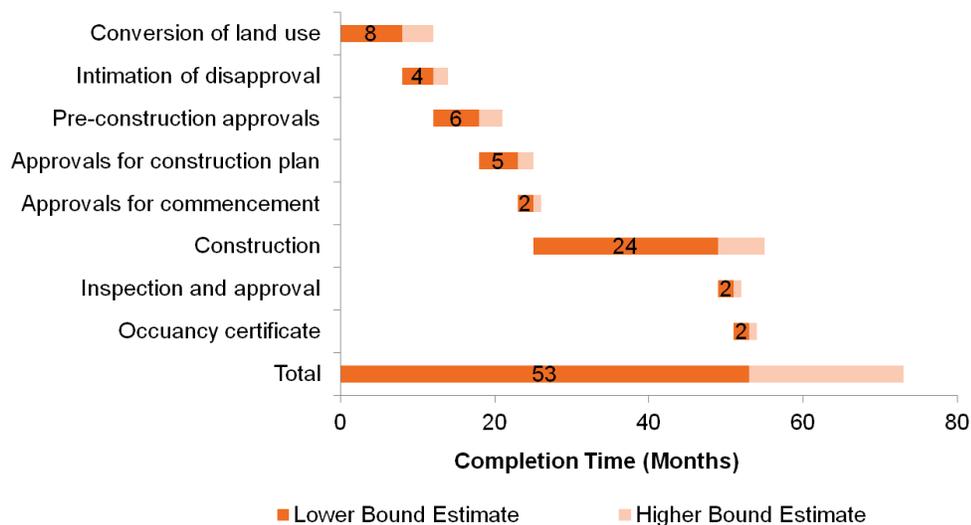
Note: SDR stands for Stamp, Duty and Registration

Source: *Affordable Housing in India*. Jones Lang LaSalle. 2012

Figure 4: Estimated Cost of Affordable Housing

## Regulatory constraints

The lengthy procedure of land development is especially determined by the efficiency of urban local bodies, which are in charge of city planning, delivering utility administrations, and controlling development through approvals. In fact, India is ranked 183 out of 189 economies in dealing with construction permits by the World Bank<sup>19</sup>, which shows the challenges real estate developers face in India. Statutory approvals are estimated to add about 1.5 to 2 years to the pre-construction process. Development projects in urban areas are subject to a long approval process regarding different aspects from both state and central level, which brings about postponement in tasks. In the end, development costs are escalating, and are eventually absorbed by the households or the purchaser (Figure 5).



Source: CREDAI-Jones Lang LaSalle Real Estate Transparency Survey, Jones Lang LaSalle, 2011

Figure 5: Estimated time in affordable housing construction process

## Approaches to Slum Free Cities

Globally, there have been several interventions which have aimed to provide adequate housing solutions for all. They can largely be categorized into two groups: slum redevelopment and slum upgradation. The former rebuilds a slum from scratch, and the latter enables the slum dwellers to make improvements in their households while municipalities upgrade the level of service to the slum.

**Slum Redevelopment:** The first slum redevelopment policies emerged in the United Kingdom and United States to redevelop industrial London and New York City, which were interspersed with squatter settlements. In the U.K., the Slum Clearance Compensation Act of 1956 guided the policies to deal with slums that had sprawled through the industrial cities of London, Glasgow, and Liverpool. The policy encouraged local councils to initiate mass slum clearance, demolish poor quality housing, and replace with new buildings. This resulting social housing was primarily financed by the state and was one of the most expensive programs of the time.

As a result of this program, by 1979, 1.5 million dwellings had been demolished and more than about 3.70 million people (15% of the total population of Britain) had been relocated<sup>20</sup>. At the time, scholars criticized the policy for relocating public housing to town outskirts and for shifting low-rise housing to high-rise flats. Recently, studies have shown that most of these families were happy to move from squalid insanitary housing to a house which offered better amenities such as hot running water, electric lights, and heating<sup>21</sup>. While the improvement in quality of life for slum dwellers was huge, the next wave of policies focused on minimizing the social cost of relocation. This led to the consideration of in-situ redevelopment policies.

In in-situ redevelopment, the implementing agency would provide a temporary accommodation for slum-dwellers until construction was completed. Then, beneficiaries were moved back onto their original land, into improved housing with better amenities. This process enables continuation of livelihood and maintains social ties. The success of this policy depends on three key outcomes:

- 1. Ensuring decent quality of housing:** Quality of housing is extremely important to ensure that beneficiaries move back into the housing. Creating quality housing at low costs, as is demanded by such schemes, poses a challenge for developers. Low quality housing is often has large issues, such as water leakages in walls, while medium quality housing fulfills basic needs yet may have insufficient lighting. Creating poor quality housing leads to inefficient outcomes for the scheme, as quality dictates beneficiary acceptance rates. This can lead to beneficiaries returning to live in slums resulting in abandoned housing. Therefore, ensuring incentives are present in the scheme to ensure quality housing is an important consideration.
- 2. Ensuring timely redevelopment:** During redevelopment, slum dwellers live in temporary accommodations, often times far away from their areas of livelihood. During this interim period, beneficiaries are relocated to off-site housing, buildings are constructed at the former slum site, and permits certify compliance with government standards. However, this time is often lengthened by legal delays and obtaining the necessary consent. Every additional day of delay in the project is a loss of income for a daily-wage earning low-income household.
- 3. Ensuring identification of beneficiaries:** While moving people from one area to another, there are instances where beneficiaries are incorrectly identified. This happens because redevelopment policies ask for residents of informal housing to prove how long they have been living in a particular area. The survey methods which identify these beneficiaries face several challenges such as non-transparent beneficiary list, delayed survey results due to manual survey techniques, and corruption.

Thus, an effective implementing agency can reduce the time of redevelopment and enhance the quality of housing is pertinent in this scheme. While the construction of public housing has been carried out by relatively effective local governments such as the U.S. and U.K., in developing countries the capacity of local government varies from city to city. Hence, the private sector are often looked to as a potential partner for implementation of redevelopment schemes.

**CASE STUDY:****U.S. Housing Act of 1949**

Today, squatting is a problem seen largely in the developing world. Yet, a mere 70 years ago, industrial London and New York City were interspersed with squatter settlements. In fact, New York's Chinatown was one of the first slums in United States<sup>22</sup>. The goals of United States' Housing Act of 1949, has parallels with the goals Housing for All policy enacted by Government of India in 2015. Recent evaluation studies of policy interventions from 1960's in developed countries' can provide a window for policy makers in developing countries to find a solution to the challenge of slum settlements. It aimed to provide a decent home to every American family by 1955 by redeveloping slum areas and construct 810,000 units of public housing. Federal government incentivized local government to use their powers of eminent domain to clear and then sell parcels of land in blighted urban areas for either public housing projects or for urban redevelopment. It also provided federal grants and loans to create public housing with low rental rates and construction cost caps. These two features of the scheme were most controversial, because of the social cost it caused (racial segregation and large scale relocation of 300,000 families). All of this led to substantial delay in achievement of the goal, and it took 20 years to complete construction of all housing units<sup>23</sup>.

**Achievements of the program:**

- Efficient land use: 57,000 acres (90 square miles) of pure residential area was redeveloped to create public amenities and places for commercial use. 35 % was used for residential redevelopment, 27 % was used for streets and public rights-of-way, 15 % was used for industrial purposes, 13 % was used for commercial purposes, and 11 % was used for public or "semi-public" spaces (23 A Study).
- Economic Growth: Recent studies have shown a strong positive correlation between economic outcomes and years of participation in the program, in any given region. For example, 5 years of participation in the program is associated with 1% higher family income. A \$100 per capita difference in grant funding was associated with a 2.6 percent difference in the 1980 median income and a 7.7 percent difference in 1980 median property value<sup>24</sup>. Thus, mandatory investment in urban redevelopment along with construction of housing can lead to overall investment in the built-environment and improved quality of life for slum residents.

**Lessons from United States Housing Act of 1949:**

- Provide spaces for Livelihood: High-rise public housing buildings were criticized by multiple scholars for turning horizontal slums into vertical slums and were chided for offering a spatial solution for a social problem.
- Construction of quality housing units by effective agencies: Local governments did experiment with getting private sector companies to build social housing, but the quality was not up-to-par with public housing buildings. Government agencies which faced more public scrutiny tend to deliver higher quality results.
- In-Situ Redevelopment will minimize relocation: While, slum clearance did result in a large scale relocation, it also focused on using the cleared-up-land for building more public housing in the area. In that way, the government tried to minimize relocation. The strategy for clearing and redeveloping the land mass had positive correlations with overall economic development of the area. However, such calculations do not consider the social cost of relocation, which is why the future slum interventions around the world aimed at minimizing this.

## Slum Upgrading

By the mid-1980s, the World Bank targeted slum areas in developing countries by providing a package of basic services, including clean water supply and adequate sewage disposal, to improve the wellbeing of the slum community. The largest of these interventions occurred in Indonesia, where the World Bank ran the ambitious Kampung Improvement Program for twenty-five years. In the Indonesian capital, Jakarta, the World Bank's activities affected over 5 million people in fifteen years and involved some 300 local government units around the country, emphasizing the provision of water, sanitation, shelter, and roads<sup>25</sup>.

In the 1990's, Hernando de-Soto's influential work in Peru showcased the importance of providing security of tenure for slum residents and thereby unlocking the land capital's potential for eligible slum dwellers. De Soto, correlated the success of small business in the U.S. to effective use of land as collateral, and made the case for access to private property and thereby to credit markets. He referred to the land occupied by squatters as "dead capital" and began the task of registering property titles to transform slum communities. From 1990 to 1995, 300,000 titles were registered in Lima. By 1998, the value of each plot's title had typically doubled<sup>26</sup>. The combination of these two strategies became known as "Slum Upgrading", formally defined as a package of services which involve provision of clean water supply and adequate sewage disposal along with a clear property title to the land slum dwellers are occupying.

One of the biggest challenges of slum upgradation projects is scaling up these pilot projects. In the context of developing countries, not only does scaling-up projects require effective local government agencies, financial ecosystems for low-income housing, and legal systems. Measuring outcomes for slum upgrading projects is challenging because of the piecemeal nature of its upgradation, and a focus on quantity of people reached rather than quality of projects. Cost-effectiveness is also challenged when projects are unable to make an efficient use of land. In cities such as Rio de Janeiro, Brazil, where high-rise buildings stand next to one-story favelas, the ineffectiveness of land utilization is especially apparent, as multi-storied houses are a more effective use of space. Further, upgradation efforts sometimes involve construction of community assets, such as community toilets, which if not maintained, will be underused.

There are advocates for either upgradation and redevelopment approaches. The World Bank promotes upgradation as a better strategy to develop squatter settlements because it preserves investments by the slum dwellers for their homes. However, governments around the world look to redevelopment in response to needs of urban poor which are not satisfied by piecemeal upgradation efforts and demand a significant improvement in quality of life.

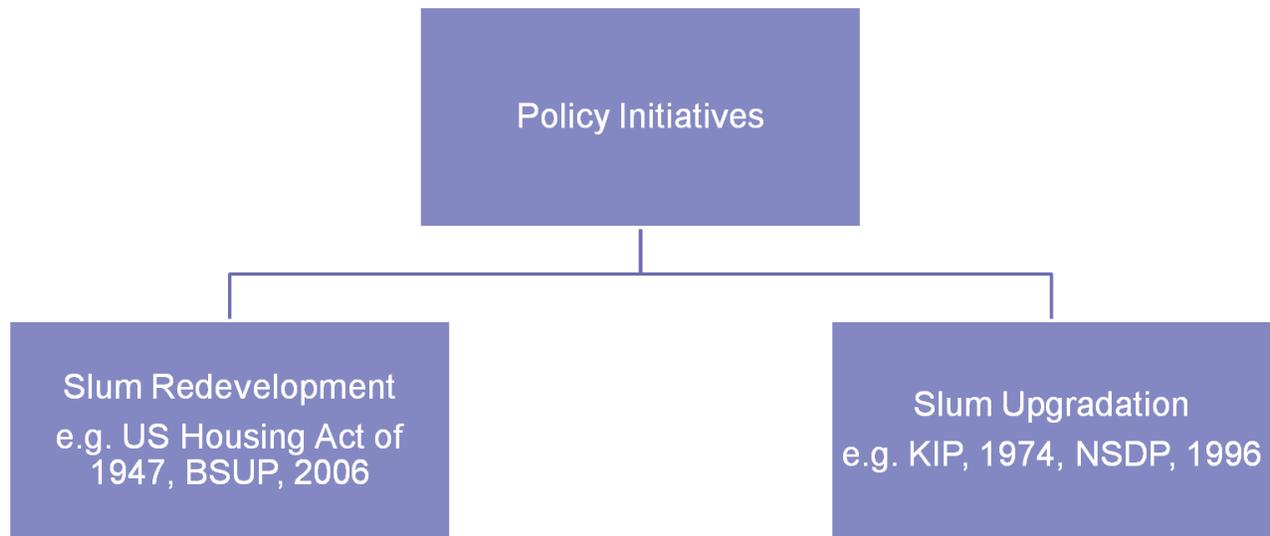


Figure 6. Policy Interventions

## Evolution of national schemes in India over time

### National Slum Development Programme (NSDP)

The 1996 slum upgradation initiative, National Slum Development Programme (NSDP), started with the aim to upgrade 47,124 slums throughout India. It identified a target slum in each city which it planned to develop as a “model” slum. In this scheme, improvements in physical amenities - such as water supply, storm water drains, community baths and latrines, wider paved lanes, sewers, streetlights, etc. - are provided to the entire slum community. NSDP provided both loans and subsidies to states for slum rehabilitation projects on the basis of their urban slum population. Beneficiaries were provided loans to make improvements to housing while governments invested in providing community amenities. In the implementation of this scheme, however, NSDP was only able to disburse about 70% of its allocated funds, indicating difficulties in the administrative process. The performance of the program varied by state, yet overall, projects often lacked proper monitoring and supervision, resulting in a trend of time-delays and misused funds. NSDP spent approximately ₹30.9 billion and affected 45,786,396 people<sup>27</sup>.

### Basic Services to Urban Poor (BSUP)

BSUP was started as a part of larger scheme called JNNURM, a large scale urban renewal program for urban India. BSUP aimed to provide basic services to urban poor in 63 of the largest cities in India by population. While the original intent of this program was to provide security of tenure at affordable prices and improved housing, water supply, and sanitation, it ultimately became a housing construction program subsidized and implemented by the government.

Government agencies estimated the housing unit cost as ₹3,00,000 and decided to provide a housing subsidy of approximately 88%, with the remaining 12% contributed from the end beneficiary<sup>28</sup>. BSUP failed to take into account the limited capacity of government for implementation of such a project. Limited local government capacity resulted in poor monitoring during the construction process leading to poor quality housing. In the case of Bhopal, the housing was so poorly constructed, with dark alleys and leaking pipes that slum residents refused to move in, and in this case overall take-up rates by original inhabitants was less than 30%.

BSUP has underperformed due to poor quality housing and lack of transparency of costs in the implementation of the scheme. Project delays and poor bidding specifications resulted in escalation of the costs, as the projects progressed and total costs far-exceeding initial estimates by the government. For example, in Shabari Nagar Bhopal the initial cost of beneficiary share was estimated to be ₹35,000 but by the time construction was completed, the cost had escalated to ₹57,000<sup>29</sup>. As a result, these housing units became unaffordable for most beneficiaries, and the intended target populations were not reached. BSUP spent ₹ 268 billion to construct 1,028,503 housing units.

## Housing for All:

In June 2015, the Cabinet of India approved the Housing for All scheme, with the goal to provide housing to every Indian household by 2022. It plans to include 300 major cities in India in its first two phases by 2019. After 2019, it plans to extend this scheme to remaining cities in India. One of the major components of the program is to utilize in-situ slum rehabilitation, through which the government has devised a strategy to incentivize private developers to use land as a resource. The policy also includes a small slum upgradation component to involve beneficiary-led individual housing construction.

For slums which are tenable – able to be maintained and not at high risk – the government recommends an in-situ redevelopment policy irrespective of the tenure status of the slums. It plans to operationalize this policy through private sector partnerships. State or

### Four main components of the *Housing for All* policy :

- Slum rehabilitation will use land as a resource to involve private developers
- Public-Private Partnerships to create affordable housing.
- Affordable housing through the Credit Linked Interest Subsidy
- Beneficiary-led individual house construction or enhancement.

Source: Indian Ministry of Urban Development

urban local bodies will provide slum areas with additional floor space index which will result in verticalization of the sprawl. The freed up land area from the verticalization can be used by private developers for commercial resale. This will allow private builders to construct houses for eligible slum dwellers free of cost. In places where such cross-subsidization isn't possible, the government will share the financial burden through viability gap funding (60-75%). The process will involve a transparent bidding process from private developers<sup>30</sup>.

The success of slum redevelopment policies are measured by three key outcomes: identification of beneficiaries, timely construction, and quality of housing. As the policy had just been enacted, it isn't possible to measure its performance, rather, we can examine its features to determine if administrative design was intended to ensure these three outcomes. By linking private sector Transfer of Development Rights (TDR) incentives with the number of beneficiaries who are provided with housing, the program has ensured that targeting is done in a better manner. Selecting private developers through a transparent bidding process may ensure better quality housing. Finally, to ensure timely construction, the Ministry of Urban Development has launched the Technology Sub-Mission which recognizes and implements modern, innovative, and green technologies and building materials for faster construction of quality houses. Such industrial construction practices are 30% cheaper and 40% faster than conventional construction methods<sup>31</sup>, and the construction cost savings can be passed on to the beneficiary.

National policies in India have moved from slum upgradation, to ex-situ slum redevelopment, to in-situ redevelopment in a short, twenty year span. In-situ redevelopment promises to fulfill the aspirations of the new urban India through better quality housing, faster construction, and enhanced beneficiary identification.

### Upgradation (NSDP) (1996-2002)

#### Advantages:

- **Minimal Social Cost:** Laying down amenities without uprooting existing houses avoids disturbing livelihoods.

### Public Housing (BSUP) (2006-2012)

#### Advantages:

- **Cost-Effective:** Huge subsidies from government help create affordable housing stock for low-income slum dwellers.

### In-Situ Slum Redevelopment (Housing for All) (2015-Present)

#### Advantages:

- **Quality of Construction:** Private sector must ensure good quality of construction to win future project bids.
- **Targeting:** As private sector has an incentive to create housing for poor, beneficiaries are accurately identified
- **Minimal Social Cost:** In-situ slum redevelopment ensures the livelihoods of slum dwellers are not disrupted long term
- **Efficient use of tax-payer's money:** Housing for All aims reduces dependency on tax payer's money by providing free of cost housing to slum dwellers.

## Upgradation (NSDP) (1996-2002)

### Disadvantages:

- **Inefficient use of tax-payer's money:** Upgradation is typically thrice as expensive as redevelopment, as they require higher upfront costs and amenities require a lot of maintenance.
- **Dissatisfied stakeholders:** Urban residents unsatisfied by piecemeal upgradation; Limited funding results in cheap upgrading solutions (e.g. community toilets) which have low take up rates, furthering informality; Upgradation creates community assets which historically have seen low usage: Community toilet usage averages 6% due of lack of maintenance.

BSUP evolved as a response to rising aspirations of middle class, unsatisfied by minor upgradations

## Public Housing (BSUP) (2006-2012)

### Disadvantages:

- **Dissatisfied stakeholders:** Non-in Situ redevelopments in BSUP saw low take up rates – for example 30% and 10% take-up rates of flats in Bangalore and Hyderabad (Compared to 100% take-up rate in SRS projects) - creating a stock of unoccupied houses; An in-situ BSUP housing project in Pune saw a decrease in access to livelihood, education and health, which shows the importance of timely and good quality of construction in addition to location.
- **Slow pace of implementation:** Due to limited government capacity and slow approval process, in BSUP only 33% of approved projects were constructed. Lack of engineers at the ground level with Urban Local Bodies (ULB's) to monitor the projects: ratio of 1 engineer to 4 ULB's.
- **Low Transparency:** Extended construction time by 2 years leads to doubling of costs, which are borne by end beneficiary and make projects unaffordable.

## In-Situ Slum Redevelopment (Housing for All) (2015-Present)

### Disadvantages:

- **Legal delays due to lack of cadastral records:** Cadastral maps in most cities in India haven't been updated, and present challenges when private players would need to awarded TDR incentives for their redevelopment projects.
- **Non-Robust Property Valuation :** While Mumbai has a pretty robust property valuation framework, other cities do not have similar assessment of property rates due to under-reporting of true property

*Housing for All* evolved as a response to low-quality houses being built in BSUP, which saw low-take up rates by target population

Based on our analysis of these three schemes, we were excited by the potential of Housing for All for slum redevelopment in urban India. We wanted to develop recommendations for a policy which will have a massive impact on the lives of 13.7 million households in India. To study possible recommendations of the policy, we began by looking for precedents of the scheme elsewhere in India, which will provide us a window for implementation of Housing for All.

The in-situ redevelopment component of the Slum Rehabilitation Scheme (SRS) in Maharashtra has strong parallels with Housing for All's slum redevelopment component in areas of financing, agency implementation and government provided incentives. The in-situ slum redevelopment model of SRS is entirely funded through private development and involves no payment from either the end user or government. Floor space index (FSI) and land based incentives of SRS have been successful in Mumbai where real-estate prices are at a premium because of the high density and overcrowding. High land cost in urban area is a key assumption which is built into the subsidization of free housing for slum dwellers.

After 20 years of implementation of this scheme in Mumbai, it has created a functioning market for slum redevelopment. There are niche real-estate developers and financiers who specialize in engaging with slum-dwellers and redeveloping the areas. Market-based reforms have incentivized these developers to use innovate construction practices which reduce cost and time, without compromising on quality. This has also led to the emergence of a private-equity class which has started seeing these projects as viable investment opportunity. Studying the evolution of 20 years of SRS will allow us to capture valuable lessons for implementation of the slum redevelopment component of Housing for All.

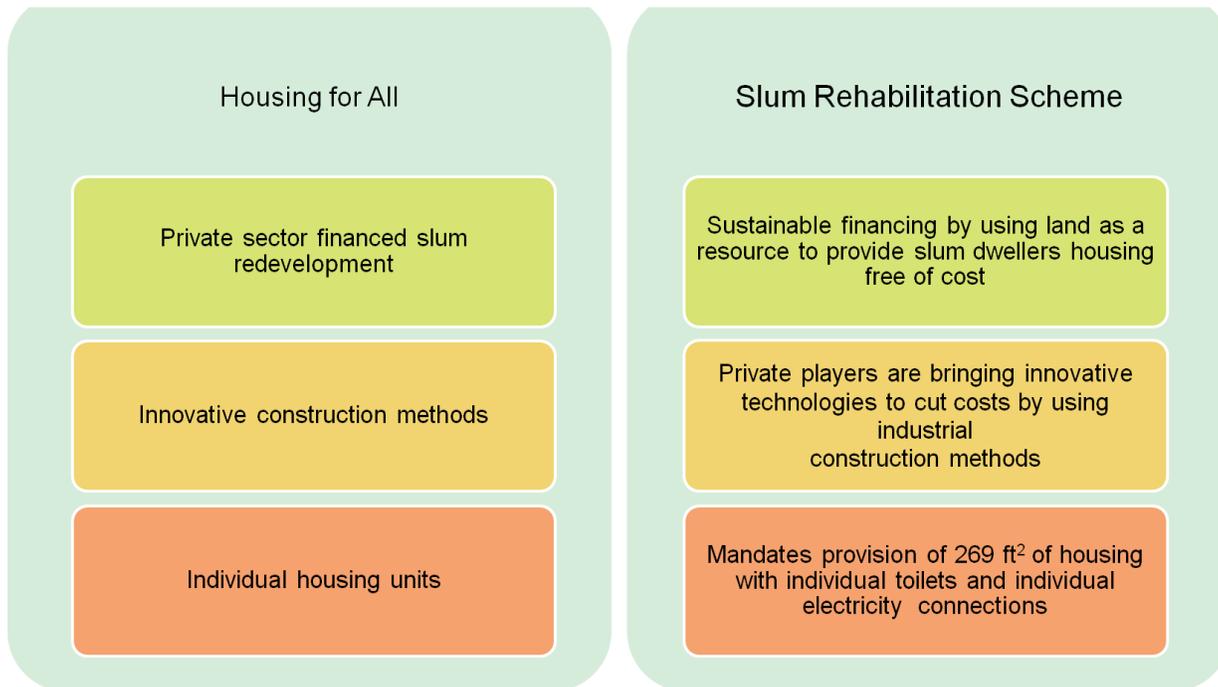


Figure 7. Comparison of Housing for All and SRS

## Section II: Analysis from Field Research



Having found potential in Housing for All's slum redevelopment component of the policy and finding parallels between Slum Rehabilitation Scheme (SRS) and Housing for All, we conducted field research in India, visiting Mumbai to see first-hand the implementation of SRS. In this section, we provide a context for the various housing options in city of Mumbai, and the perceptions from various stakeholders about performance of SRS.

## Observations from Field Research

### Analysis of Public Housing and informal settlements in Mumbai

There are three main types of housing in Mumbai's slums: Chawls, Zopadpattis, and Pavement dwellings<sup>32</sup>. These differ primarily in the security of tenure but also in formality of the physical structure, the ratio of public and private space, and the dwelling's relation to the street. During our field visit to Mumbai, we gained an understanding of these informal residences and of the nearby SRS redevelopment projects.

#### SRS Buildings

Current SRS buildings are typically tall buildings around 23 stories with each apartment unit 269 sq. ft. The unit areas are predetermined by the government and are equally allocated to all slum relocated tenants, who enjoy full tenure security. Apartment complexes usually have a central atrium or courtyard, elevators, and enclosed common stairs. There are typically fences outside the complexes to create more of privacy and separation between the street and the residents. The ground floor consists of street-level storefronts, which have been allocated to the slum dwellers who previously had stores in the slums. Apart from the first floor, all spaces are used for residential purposes and have standardized layout and floor height.

In May 2015, our team toured a 17-acre slum redevelopment project located in Bhoiwada, Parel, Mumbai. Sanctioned by the Slum Rehabilitation Authority (SRA), and built in collaboration between Larsen & Toubro and Omkar Realtors & Developers, nine 23-storey buildings were under construction to replace approximately 4,000 slum households. Directly adjacent to the SRA apartments, luxury residential towers rose on the reclaimed land to offset the total costs of development. Beyond producing standardized apartments to meet the regulations established by SRA, buildings are often constructed with prefabricated concrete which help to reduce construction costs by an estimated 30% and construction time by 40%. Buildings are equipped with elevators, fire doors, and a fire sprinkler system fed by harvested rainwater. Each apartment contains a kitchen supplied with municipal drinking water, two rooms for sleeping and socializing, and separate shower and wash rooms which drain to an on-site septic system before discharging into the city's sewer network.

#### Chawls

Chawls are public housing buildings constructed between 1920 and 1956 by factory owners and landowners to accommodate migrant workers. As Chawls were originally created primarily for male migrant



workers, they consisted of one-room apartments with a small cooking space and common toilet facilities on each floor for all of the workers. Eventually, these small living spaces became home to the families of the workers. Apartments in Chawls are typically 81 sq. ft., and each unit has one or two rooms which open into a common corridor. Buildings usually consist of two to four stories and either have a central courtyard or are adjacent to busy streets. As a result of a lack of building maintenance, structures have greatly deteriorated overtime and are often unsafe. Today, they are still commonly used to house families throughout Mumbai and have high tenure security. All of the units have common exterior corridors, courtyards, and staircases joining the units which provide ample space for social interaction. In these places you can usually see people sitting, children playing, and clothes hanging. From the street, the life within these Chawls is seen in people on hallway porches or the character of each space created by personal modifications. The overall building formation of the Chawls has contributed to a close-knit social life for its residents, and this **“social network”** is one of the reasons that keep residents from moving out of the Chawls<sup>33</sup>.

### Zopadpattis

Zopadpattis are generally informal neighbourhoods created through ad-hoc construction techniques. They are the type of slum in India most commonly depicted by media. Mumbai’s most infamous slum, Dharavi, home of the film “Slumdog Millionaire”, is an example of a Zopadpatti. These dense informal developments are usually one to two stories and are created on empty private or public plots in the city where residents enjoy medium tenure security. They often span several miles, house thousands of families, and are the most predominant type of settlements formally recognized as slums. Zopadpattis are the site of a mixture of residential, commercial, and religious activities. Due to their informal construction, many spaces are mixed-use or fall under multiple categories of space. These neighborhoods are dense with very narrow alleys, usually inaccessible by car or motor vehicle. There are no official maps of these areas so way finding within them is often difficult for non-natives.



### Pavement Dwellings

Pavement dwellings are similar to Zopadpattis in their use of ad-hoc construction techniques, however, these structures typically have even less formality and permanence. Pavement dwellers, the people in the clusters of families who live in these settlements, are not formally recognized as “slum dwellers” due to the informal and temporary nature of their dwelling structures. Compared to other slum dwellers, pavement dwellers’ living conditions are the most exposed and transient. They are usually found squatting temporarily on the side of a road and are subject to being pushed off their land at any time. As the least permanent type of settlement, pavement dwellers unfortunately can not get a voting card and can therefore not ask for a ration card, which makes them even more vulnerable than the ‘conventional’ slum dwellers. Moreover, without this voting card, they are rarely considered as eligible for rehabilitation and frequently see their shelters destroyed.



## Analysis from Key Stakeholder Interviews

### Lessons from implementing SRS scheme in last 20 years

Through meetings with key stakeholders in India, we found four main challenges in SRS: illegal subletting, litigation, social acceptability, and sustainability.

**Litigation:** Real-estate developers expressed concerns over dispute redressal mechanisms from the Slum Rehabilitation Agency (SRA). The nature of informal settlements leads to complicated and disputed land rights, hence real-estate developers are cautious of these uncertainties and litigation risks. As such projects operate in already low profit margins, if a project becomes legally disputed, it disincentivizes other private sector developers to engage in future slum redevelopment projects. Similar concerns were expressed over the complicated Stamp Duty Registration process which can take up to a year. The litigation delays can add to the developers cost to temporarily relocate slum dwellers.

**Illegal Subletting:** In the current SRS model, eligible beneficiaries are provided with free housing and full ownership rights from the day they occupy the houses<sup>34</sup>. Housing for slum dwellers financed by developers' resale of commercial units on high-valued land is one of the crucial features of this model. Recognizing the unaffordability of improved housing, SRS greatly incentivizes slum dwellers to participate in redevelopment projects with free housing. However, during conversations with various stakeholders, we found that free housing can lead to additional complications. The SRA claimed that at least half of these free redeveloped units are being illegally subleased. In the long run, this is counterproductive to the goal of creating slum free cities. Further, by reviving government provided housing in a sense removes the feeling of home ownership and control.

**Social Acceptability of High-Rises:** The high-rise apartment buildings characteristic to SRS are likely undesirable in other cities where the norm is G+3 housing (as opposed to G+23 in SRS). It will be important to optimize housing density with community acceptance of the infrastructure. Furthermore, densifying sprawling slums into apartment buildings can impact community dynamics, daily social interactions, and lifestyles. Future projects can minimize behavioral and social disruptions by promoting public spaces that allow the community to effectively share and communicate.

**Environmental Sustainability:** We also found concerns among urban planners about adding additional housing on an already over-constrained municipal systems. Without investing in adding capacity to existing civic infrastructure for the city, such policies could put undue burden on the city's civic amenities, in particular, utilities directly provided to households, such water and electricity.

The challenges in implementation of SRS from last 20 years provide a great learning opportunity slum redevelopment component of Housing for All. We use multidisciplinary approaches to envision the future of Housing for All and recommend ways to ensure its sustainability when scaled to other cities in India.

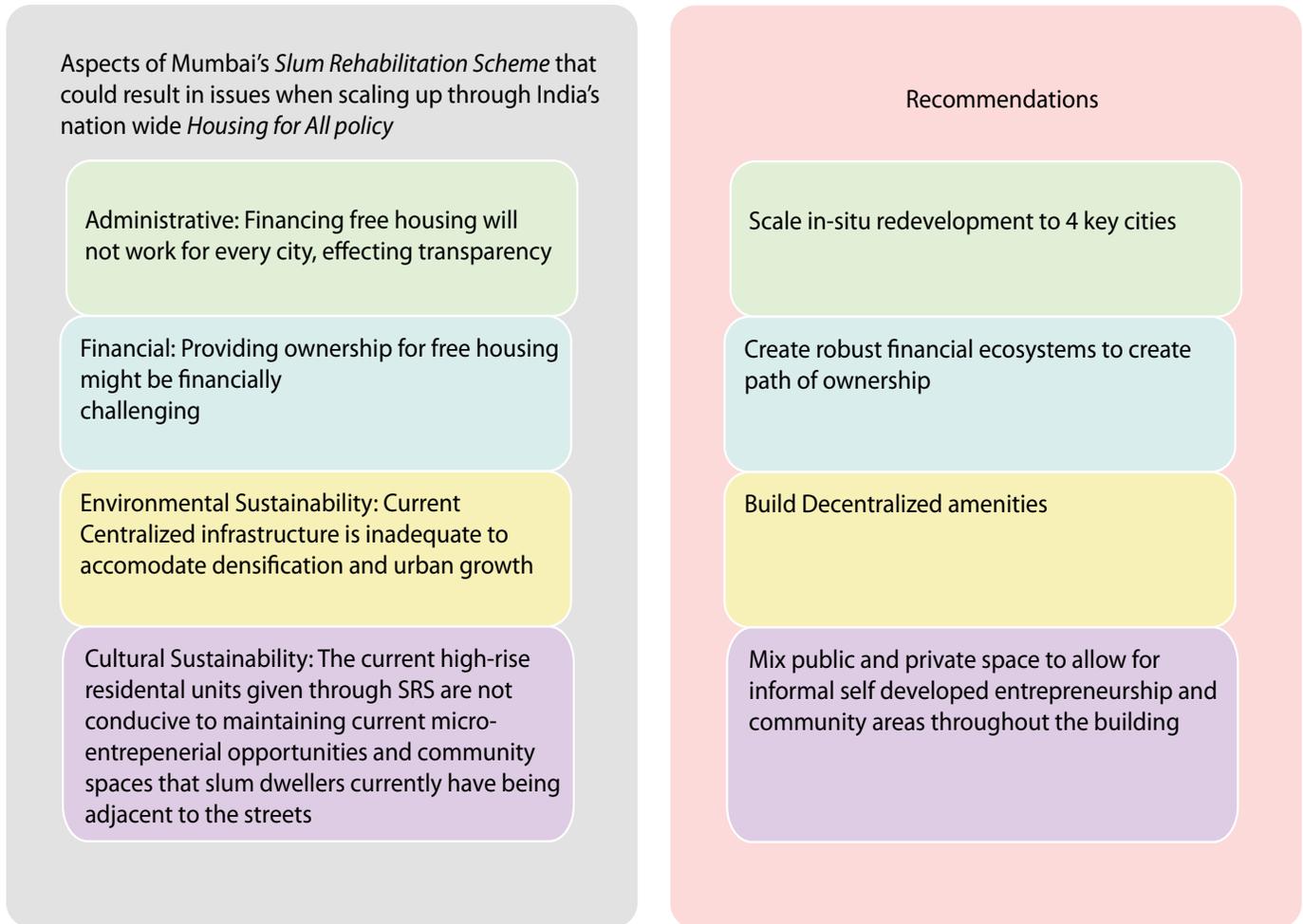


Figure 8. Lessons from Implementation of SRS

# Section III: Recommendations



In this section, we propose recommendations to improve the efficiency and success of slum redevelopment in relation to four topics: Administrative, Environmental, Financial, and Cultural.

- **Administrative sustainability** will evaluate which cities have the most appropriate context for applying Mumbai's *Slum Redevelopment Scheme* directly for nationwide *Housing for All* policy.
- **Environmental sustainability** will evaluate types of decentralized infrastructure and alternative technologies which will benefit low-income settings.
- **Financial sustainability** will evaluate tenure rights which would truly enable translation of informal housing into formal housing in the long term.
- **Cultural sustainability** will evaluate certain architectural changes to replicate lifestyles on the street into the building and to increase diversity and commercial and social interactions between tenants.

### **Administrative Sustainability:**

#### **Replicate in-situ slum redevelopment model of SRS in the national *Housing for All* scheme**

Mumbai's *Slum Redevelopment Scheme* capitalizes on the city's high real-estate value to subsidize slum redevelopment. SRS's unique financing model and incentives for private developers work well in a compact mega-city, but are they translatable to other cities in India? To investigate, we examine key factors which have enabled the model's success and compare these across other cities in India to identify where the policy can be replicated with minimal alteration. Cities implementing slum housing policies which do not have these key factors would likely need additional provisions and adjustments to the structure of SRS.

In our analysis we find that the in-situ slum redevelopment component of *Housing for All*, subsidizing housing to slum dwellers via private investment, could be directly applied to 4 cities, yet adjustments to incentives may be required.

#### **Factors imperative to make in-situ redevelopment successful**

Through interviews with real-estate financiers, we have identified four main attributes of the SRS model in city of Mumbai which enable in-situ redevelopment scheme to work well.

1. Land Scarcity: Surrounded by water, Mumbai cannot grow outward like most cities, therefore the land is very densely populated.
2. High slum population and land coverage: Growing populations and urban migration have resulted in occupation of large percentages of the city by squatter settlements<sup>19</sup>.
3. Real Estate Cost: The land transferred from the government to the developers replaces the need for a government subsidy; in fact the government gains from the 25% premium paid by developers and leverages the capacity and expertise of the private sector in real estate development.

Thus, to determine which cities in India the SRS model would be directly applicable to, we must examine demand (growth) and supply (density), as well as financial incentives. These factors are qualities of the city itself, and are therefore not adjustable by policy. Financial

incentives, Floor Space Index (FSI) and Transferable Developmental Rights, are customizable by the implementation agency and can be used for compensatory purposes, when extending the scheme to a city that does not have similar features to Mumbai in these three areas. In Mumbai, the demand-supply gap is extremely high, resulting in high real estate prices. Therefore, in other cities, if the density is high and growth is high, we should consider that city sufficiently similar to Mumbai. As a proxy for the above attributes, we examined the following quantitative variables: city density, city growth rate and slum population percentages, and real-estate cost.

City	Density (people/km <sup>2</sup> ) (2011) <sup>A</sup>	City Growth Rate (2001-2011) <sup>A,B</sup>	UA <sup>†</sup> Growth Rate (2001-2011) <sup>A,B</sup>	Slum Population (2001) <sup>B</sup>	Monthly Rent <sup>‡</sup> (₹) <sup>C</sup>
Mumbai	20,694	4%	12%	19%	62,874
Delhi	7,423	11%	18%	33%	33,850
Bangalore	11,371	96%	49%	8%	24,716
Hyderabad	7,772	97%	34%	17%	20,191
Ahmedabad	11,954	58%	41%	13%	23,596
Chennai	3,937	8%	32%	18%	26,755
Kolkata	2,423	-2%	6%	21%	27,364
Surat	13,666	83%	63%	15%	10,069
Pune	4,388	23%	34%	21%	23,367
Kanpur	2,956	8%	8%	15%	27,119

Sources: A- India Census 2011, B- India Census 2001, C- Expatisan

Table 2. Urban Characteristics for the top 10 cities in India by Population

In Table 2 we identified the top ten cities by population in India according to population to compare city governments dealing with issues and policy challenges of the same scale. In the second and third column the urban density and growth rates are compared within each city and entire urban agglomerate. These were calculated using census data from 2001 and 2011. Using 2001 census data, the most recent available, the Indian government has estimated the total slum population of each city, shown in the fourth column. Here, they defined a slum as “a compact area of at least 300 population or about 60-70 households of poorly built congested tenements, in unhygienic environment usually with inadequate infrastructure and lacking in proper sanitary and drinking water facilities.”<sup>35</sup> To standardize real-estate prices for comparison across cities, data from a crowd-sourced cost-of-living database, was used. The monthly rent estimate shown in the last column is for a 900 sq. ft furnished accommodation in an “expensive” area<sup>36</sup>.

The data shown in Table 2 makes clear that in terms of population density and real-estate prices, Mumbai is unlike any other city in India. Due to its geography, as Mumbai’s population grows residents are forced to move vertically rather than radiate outward. This is not the case for inland cities, which have plenty of room to expand horizontally. Surat, which is also a

coastal city and is boarded by the Tapi River, has a density 34% less than Mumbai. The standardized monthly rent estimates are quite striking, with Mumbai having the most expensive real-estate in India. The next most expensive city, Delhi, has housing prices 46% lower and prices in the remaining top 10 cities are all more than 50% cheaper.

The growth rate and slum population data listed in Table 1 provides greater insight into our question. Most cities saw growth rates over the past decade that were significantly greater than Mumbai's (excluding Kolkata and Kanpur), and five cities (Delhi, Hyderabad, Chennai, Kolkata, and Pune) had slum population percentages within 10% or greater than that of Mumbai (likely an underestimate as this data is outdated). In the future, land scarcity and providing affordable housing will pose significant challenges and opportunities. From this, we can assume at minimum, four cities - Delhi, Hyderabad, Chennai, and Pune - meet both the demand (growth) and the supply (slum density) requirements. In these places, a fully subsidized, in-situ slum redevelopment policy, quite similar to SRS (Housing for All) would likely see the same success as in Mumbai. However, because real-estate prices are lower than in Mumbai, additional incentives and/or adjustments for FSI and TDR may be required.

In this back of the envelope analysis, and in our field research in India, we have found it challenging to acquire complete, reliable, usable, and up-to-date data. Not only does this lack of information result in delayed and prolonged redevelopment projects, but it makes the policy and city planning more difficult and less effective. For city governments to create suitable schemes for creating affordable or subsidized housing, it is imperative that they have an accurate and complete picture of those in need of assistance. Because eligibility of slum dwellers for SRS depends on proof of tenure from the 2000 census, people who have taken up residence in Mumbai's slums post-2000 are not considered in the planning process for slum redevelopment projects. Ideally, these policies would provide assistance to all people in need of affordable housing, but to do so would require recognition of all current slum dwellers as residents with tenure rights. This would require mass gathering of data, surveying and mapping all of those currently living in slums. A recent survey of the largest twenty-one cities in India found that none of those cities had a digital cadastral map. Improved information technology, such the ability to collect household and geo-location data with a mobile device, has the potential to expedite this process prior to project implementation.

## **Environmental Sustainability: Decentralized Infrastructure for Sanitation and Energy Amenities**

Public services have traditionally been implemented and managed by municipalities as comprehensive centralized systems. Slums often lack access to these services because of three primary reasons: high investment costs of providing services to complex informal settlements, a lack of resources to meet growth and demand, and an unwillingness from low-income groups to pay taxes and fees. Decentralized systems, being more cost efficient, have the potential to solve these problems by creating partially self-sustainable communities that would reduce the burden on conventional utilities. We will focus on the use of decentralized infrastructure for improving access to energy and sanitation in slum communities.

### **Decentralized Sanitation: Localize Anaerobic Digestion Wastewater Treatment Facilities**

#### **Why should we integrate decentralized plants with slum redevelopment?**

Attempts to improve sanitation through the installation of shared toilets in certain Indian slums have had limited success, largely due to low usage rates. For this reason, we propose installing individual toilets in slum upgradation projects. However, given the fact that even in high-income areas many households are not connected to a municipal sewer system, and that access decreases the further a household is from the city center, it is infeasible to connect sewage from slum redevelopment projects to existing city infrastructure. Therefore, we propose the use of decentralized, on-site sewage treatment. This not only avoids logistical infrastructure constraints, but also keeps any recoverable resources, such as manure, and associated employment opportunities within the community.

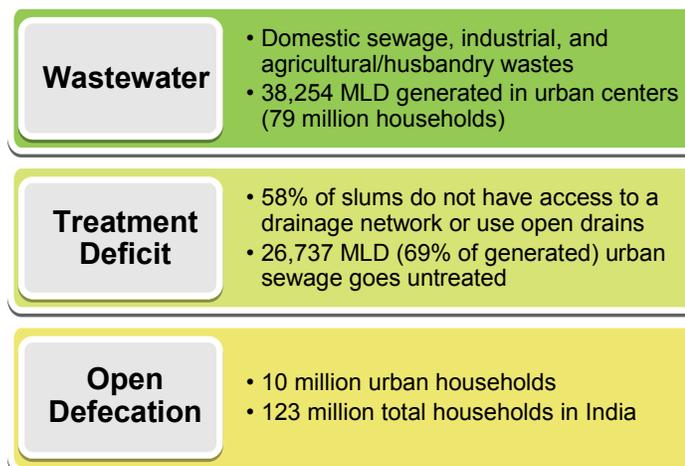
Decentralized anaerobic digesters are recommended to address the country's sanitation deficiencies and to develop sanitary urban communities. A cost-benefit analysis of centralized (sewerage connection) and decentralized (septic tank and biodigester) systems is presented to evaluate the environmental and financial sustainability of each approach. A review of India's sanitation policies summarizes the strengths and weaknesses of past and current implementation strategies.

#### **Overview of Sanitation Policies**

Improved sanitation effectively limits unhygienic and unsustainable behaviors and decreases the risk of human exposure to pathogens and infectious diseases. The burden of providing sufficient access to sanitation and wastewater treatment facilities is common among developing countries and the inability to do so can ultimately inhibit economic growth and prosperity. Deficiencies in sanitary practices and infrastructure are most severe in India, where 626 million people (i.e., 59% of people reported globally, and one-twelfth of the world population) resort to open defecation<sup>37</sup>. Even when residents of large cities (70% of India's total urban population) have access to toilets serviced by municipal wastewater treatment systems, the sewage treatment capacity is 31% of the sewage generated<sup>38</sup>. Therefore, much of the remaining domestic wastewater flows untreated to land and water bodies, polluting

three-quarters of the nation's surface waters. To address the immediate need for action, the Government of India has initiated numerous strategies to improve environmental and public health, improve the quality of water, sanitation, and hygiene (WASH), and eliminate the "traditional behavior" of open defecation.

A series of government led WASH campaigns have achieved varying levels of success, from which effective hygiene development practices can be concluded and improved upon in progressive policies. The 1986 *Central Rural Sanitation Programme* was characterized as a supply-driven and infrastructure-orientated approach, but was limited in its ability to improve personal hygiene behaviors. Restructured in 1999 as the *Total Sanitation Campaign* (TSC), the program emphasized Information, Education, and Communication through a demand-driven and people-orientated approach<sup>39</sup>. To improve response to the TSC, the *Nirmal Gram Puraskar* incentive was created to award fully sanitized and open defecation-free communities with recognition and monetary prizes. Charged with the growing popularity of the TSC and its incentives, the policy was renamed in 2012 as *Nirmal Bharat Abhiyan* which proposed to accelerate rural sanitation coverage using cost effective, ecologically conscience, and sustainable technologies. The *National Urban Sanitation Policy* placed greater focus on developing community-driven, totally sanitized, healthy and livable cities and towns<sup>40</sup>.



Source: Census, Central Pollution Control Board

Figure 9: Summary of the wastewater and sanitation deficiencies in India and its cities.

To achieve the overarching goals of the policy, the *Nirmal Bharat Abhiyan* campaign was revitalized in October 2014 as *Swachh Bharat Abhiyan* (*Clean India Mission*). The primary objectives of this most recent national effort are to eliminate open defecation, to provide municipal solid waste management services, and to generate awareness and encourage behavioral changes in personal hygiene. The *Swachh Bharat Abhiyan* campaign is divided into two sub-missions: the *Swachh Bharat Mission-Gramin* continues to build upon the success of former rural sanitation programs and is implemented by the Ministry of Drinking Water and Sanitation; and the *Swachh Bharat Mission-Urban* concentrates on urban sanitation and is implemented by the Ministry of Urban Development (MoUD). This review will focus on the urban policies, hence simply referred to as the *Swachh Bharat Mission* (SBM).

Sanitation facilities shared between two or more households (or the public) are a convenient method of increasing access to sanitation in urban areas, however, they are not considered improved forms of sanitation by the World Health Organization due to concerns

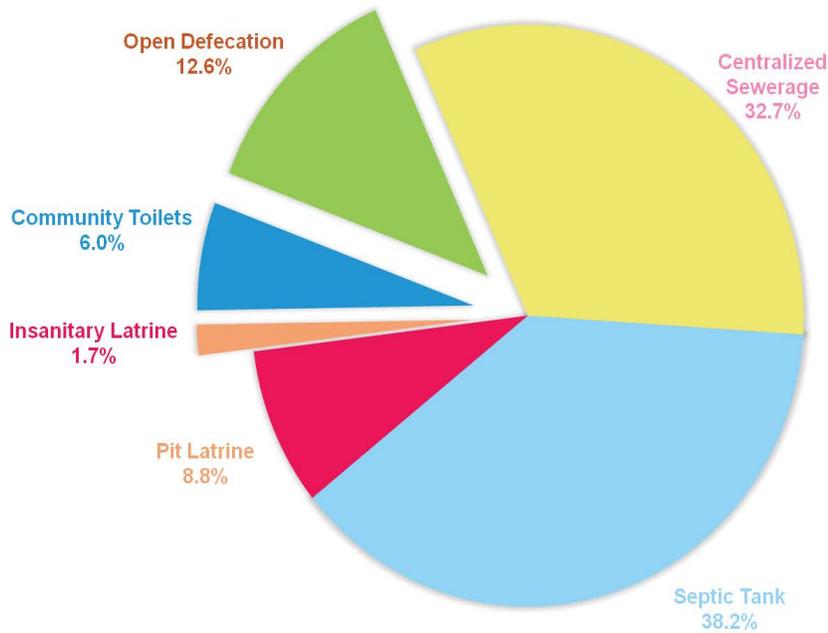
of cleanliness and accessibility (e.g., available overnight, or used by children)<sup>41</sup>. In urban India, private household toilets are generally preferred over shared facilities, thus it has been a focus of Slum Rehabilitation Authority buildings to provide each household with a toilet. To construct and upgrade the necessary toilets and treatment facilities, work is largely conducted at the local level as a collaborative effort between the municipal leaders, known as the urban local body (ULB), and members of resident associations, ward committees, and civil society. ULBs are encouraged to seek public-private partnerships with contractors and developers to increase the private sector investment and efficiency in delivering urban infrastructure and services<sup>42</sup>. The ULBs are responsible for notifying the general public and identifying SBM beneficiaries through awareness campaigns and house-to-house surveys. Households will be targeted to receive benefits regardless of whether they live in authorized or unauthorized settlements (i.e. slums).

## Centralized versus Decentralized Wastewater Infrastructure

### Centralized Systems

Under Swachh Bharat Mission (SBM) guidelines, all newly constructed and renovated sanitation facilities are required to connect into an existing sewerage system when accessible within 30 meters. In underdeveloped or newly industrialized countries, however, the availability of a centralized drainage network is often limited, and in India, implementation of conventional sewage treatment has been relatively unsuccessful due to a variety of financial and logistical issues. ULBs unable to self-generate capital resources and dependent on government funding, are challenged with the high costs required to build, operate, and maintain adequate wastewater infrastructure<sup>43</sup>. In particularly dense cities, expanding municipal water and sanitation services to unplanned communities or areas with narrow streets may be difficult without construction permanently displacing slum dwellers<sup>44</sup>. Furthermore, the Western approach to centralized collection and conveyance is partly based on exceptionally high water usage and therefore may be unsuitable in developing countries. The per capita domestic water use in India ( $46 \text{ m}^3 \text{ p}^{-1} \text{ yr}^{-1}$ ) is approximately one-fourth the domestic water usage in the United States<sup>45</sup>. The low and intermittent wastewater flow rates in developing countries may increase maintenance demands to address issues with clogging and production of corrosive hydrogen sulfide gas.

Although conventional sewerage systems are a comprehensive method of collecting, conveying, and treating wastewater for an urban environment, investment may not be economically feasible or sustainable. Extending centralized sewage treatment to typical households in Asia without current connection, costs an estimated  $\$11.95 \text{ p}^{-1} \text{ yr}^{-1}$  while an alternative septic tank intervention would cost  $\$9.10 \text{ p}^{-1} \text{ yr}^{-1}$  over the system's 30-40 year design life (Table 3)<sup>46</sup>. Annual per capita costs for improved sanitation interventions were calculated based on investment costs (e.g., planning, hardware, construction, and education) and recurrent costs (e.g., operation, maintenance, regulation, and monitoring). Centralized sewage is generally the most expensive system to build and operate in low-income and developing communities, however, actual cost will vary in practice and per capita costs for centralized systems can be expected to decrease with increasing population and density<sup>47</sup>.



Source: India Government Census 2011

Figure 10: Percent of urban households in India by access to type of toilet facility. Emphasized are forms of unimproved sanitation.

### Decentralized Systems

If no sewage system or septic tank exists within the immediate vicinity of the proposed SBM toilet, onsite treatment must be constructed. Decentralized wastewater treatment systems (DEWATS), such as biodigesters, constructed wetlands, lagoons, or septic tanks, –operate at or near the point of waste generation to manage individual households, small communities, or public areas. Managing wastewater onsite localizes the water resource, thereby limiting potential imbalances of resource distribution and reducing the inefficiencies and costs of conveyance. The localized scale also requires less infrastructure and thereby simplifies construction and cuts capital costs.

An exceptional treatment system will efficiently manage “waste streams” as “resource streams” through use of sustainable design and innovative technology to recycle the energy and nutrients freely and continuously available from wastewater. Byproducts of the treatment process may include: renewable energy in the form of combustible and carbon-neutral biogas; biosolids enriched with nutrients and minerals for land application in agriculture; and decontaminated, non-potable water to recharge groundwater or reuse for irrigation. The wastewater nutrients (nitrogen, phosphorus, and potassium) recovered as fertilizer from a small community of 840 people would have an annual value of \$284<sup>38</sup>. Practicing resource recovery can reduce downstream pollution while improving the independence, productivity, and sustainability of the human community.

Decentralized systems are disadvantaged by two major factors: land and education requirements. DEWATS are generally land intensive, wherein the footprint of the facility is locally confined by the features of the site and depends on the quantity and strength of wastewater. In densely populated environments, such as India’s mega-cities, the high cost of land and limited open

space may significantly challenge the implementation of an onsite system. However, many decentralized practices can be sited underground in concrete vaults and utilize shallower pipes of smaller diameter as compared to conventional sewerage drains<sup>49</sup>. Secondly, onsite systems rely on its beneficiaries' efforts, involving responsible household and community members to operate, maintain, and manage the facility – either through a small business or without formal compensation<sup>43</sup>. During the construction and startup phase, the ULB or acting authority should establish system efficacy and resiliency, train members with essential servicing skills, inform the community of good personal hygiene practices, and provide a working knowledge of the sanitation system to improve the likelihood of success.

Regardless of the type of treatment or the system configuration, household toilets are expected to be maintained by the homeowner, while community and public facilities must include a five-year maintenance contract according to SBM guidelines. Any additional maintenance and technical assistance is typically available through private businesses. The policy further suggests that wherever possible, public and community toilets be equipped with solar panels to ensure an uninterrupted power supply for lights or pumps, thereby reducing the cost to operate. Provisions should be made when designing public and community facilities to separately accommodate men, women, and the disabled (e.g. ramps, braille signs, etc.). Focus groups led by India's state governments will specialize and seek to prioritize vulnerable households, such as those with children, pregnant women, and senior citizens. Furthermore, the focus groups will provide access to temporary toilets on construction sites and grant migrants, pavement dwellers, and the homeless access to onsite, public, or community toilets as a preventative measure against slum development. All toilets constructed through the program must be supplied with a municipally-treated drinking water source and should include a hand washing station.

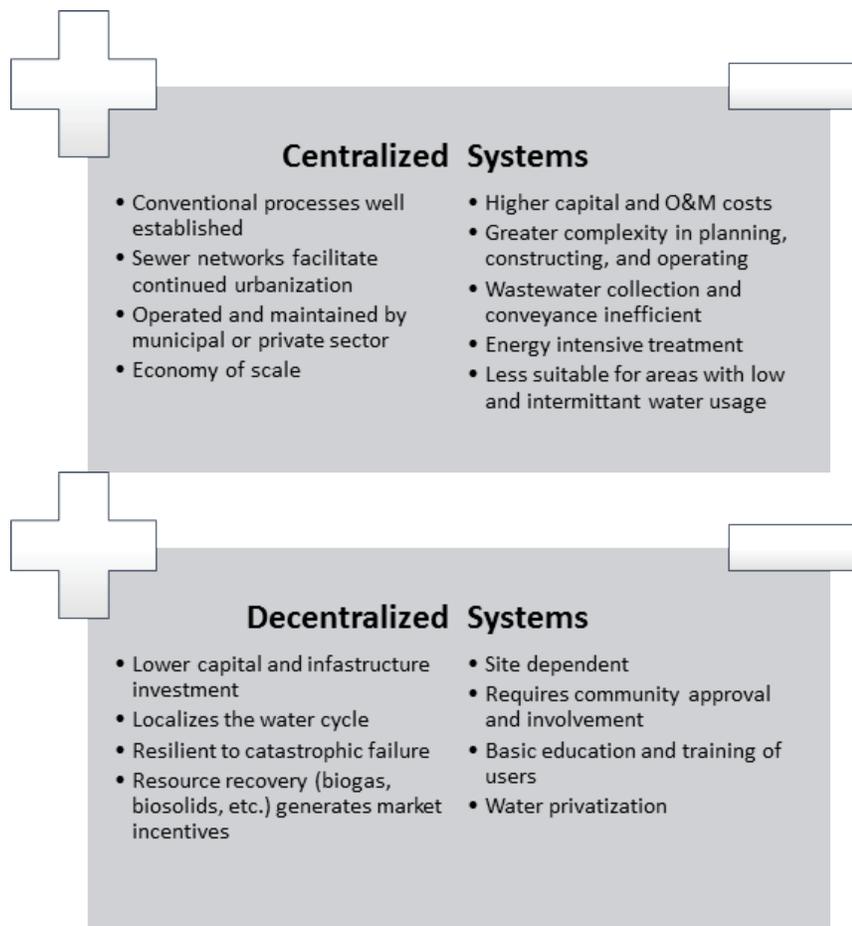


Figure 12. Pros and Cons of Centralized and Decentralized Wastewater Systems

As of June 2015, the *Nirmal Gram Puraskar* incentive program registered more than 12,000 gram panchayats (self-governed villages or small towns) as open defecation-free and having provided complete toilet coverage. Unfortunately, this progress represents only 5% of all gram panchayats in India<sup>49</sup>. Swift and sustainable efforts by ULBs are required in order to meet the mounting demand for sanitation facilities. Incorporating resource recovery technologies can generate useful wastewater treatment by-products, and when combined with sustainable recycling practices, can stimulate the growth and independence of local commerce. Areas without access to centralized sewerage networks or communities in which the centralized infrastructure is inadequate, should consider decentralized wastewater treatment systems as potentially cost effective alternatives.

Specifically, we propose using anaerobic bio-digesters as an onsite sanitation facility. These ecologically-friendly and cost-effective waste treatment facilities can improve environmental and public health while producing marketable recycled byproducts. Recent developments have improved efficiency of anaerobic bio-digesters and increased capability to operate in a wide range of conditions. This technology's principal biological process is detailed and a case study is presented to exemplify the technology's value as an onsite sanitation facility.

	Decentralized		Centralized
	Biodigester	Septic Tank*	Sewer Connection*
Design Volume** (m <sup>3</sup> )	46.5	168.2	--
Design Life (years)	30	30	40
Initial Investment Cost (per person)	\$104.00	\$104.00	\$154.00
Biodigester Inoculum***	\$2.68	--	--
Recurring Annual Costs (per person)	\$84.50	\$169.00	\$324.00
O&M	\$8.45	\$16.90	\$97.20
(% of Annual Cost)	(10%) <sup>†</sup>	(10%)	(30%)
Education	\$16.90	\$8.45	\$16.20
(% of Annual Cost)	(20%)	(5%)	(5%)
Disposal <sup>‡</sup>	\$6.90	\$90.00	\$6.90
(% of Annual Cost)	(8%)	(53%)	(2%)
Contingency and Misc. Recurring Costs	\$52.25	\$53.65	\$203.70
(% of Annual Cost)	(62%)	(32%)	(63%)
<b>Total Annual Cost per Person Reached<sup>#</sup></b>	<b>\$6.37</b>	<b>\$9.10</b>	<b>\$11.95</b>

\* Sewer connections costs include partial treatment of sewage (Hutton & Heller, 2004)

\*\* Design Population of 840 people; (Indian Standard, 1986; Singh 2014)

\*\*\* (Dhaked, Bingham & Singh, 2010, Col. M. Katta, personal Communication, May 2015)

+ Assuming biodigester maintenance is equal to half the cost of annual septic tank maintenance.

Table 3: Cost Comparison Between Centralized and Decentralized Sanitation Interventions

## SECTION III: RECOMMENDATIONS TECHNICAL CASE STUDY: Anaerobic Biodigester

Over the past two decades, the Government of India Defence Research and Development Organization (DRDO)<sup>50</sup>, Biotechnology Division in Gwalior, has been formulating an innovative anaerobic digestion technology to address the pervasive sanitation insufficiencies across the country's diverse climatic and geographic regions. The DRDO biodigester is a decentralized wastewater treatment system that removes disease-causing microorganisms (pathogenic bacteria, viruses, and protozoa) from fecal waste, and utilizes the metabolic processes of beneficial microorganisms (methanogens, acetogenic and acidogenic bacteria) to convert waste into methane-rich biogas. The system is capable of operating in temperatures at or above 10°C and was originally sanctioned to support military stationed in the Himalayas' Siachen Glacier where the frozen conditions and remote location complicated wastewater treatment or its transportation to a waste management facility. The biodigester has since been implemented throughout India, from the northern mountains in Ladakh, to the nation's capital, and as far south as the islands of Lakshadweep; toilets have been installed in homes, schools, and even passenger coaches on the Indian Railway. The anaerobic biodigester is energy efficient, simple to maintain, and unique in its ability to deplete biodegradable waste at low temperatures.

Biodigesters have at least three significant improvements over traditional septic tanks. First, the DRDO biodigester achieves 99% reduction of organic waste, whereas a septic tank biologically digests an estimated 30% of solids and will gradually accumulate sludge. Septic systems therefore need recurring fecal sludge management which increases the maintenance costs and logistics to collect, transport, and treat septage<sup>51</sup>. There is little to no accumulation of sludge in a biodigester because of the insignificant yield in biomass from the completely anaerobic process and due to the efficient conversion of organic waste into gaseous carbon dioxide and methane. Secondly, a biodigester facility requires 40–70% less volume than an equivalently designed septic tank of similar capacity<sup>52,53</sup>. Finally, anaerobic digestion technology has the potential to recover resources such as water, nutrients, and energy from the waste stream.

The two main components of the biodigester are the "microbial consortium" and the fermentation tank. The microbial consortium is cultivated from generalist species and adapted to decompose night soil at cold temperatures<sup>54</sup>. Adding microorganisms sampled from Antarctica and cold-climate environments may improve the organic degradation efficiency and biological resiliency of anaerobic biodigesters operating at low temperatures<sup>55</sup>. During the startup phase, each fermentation tank is seeded with up to 40% by volume of the engineered inoculum, costing an estimated 5 to 8 rupees (US\$0.08 – \$0.12) per liter<sup>56,57</sup>. The fixed-dome tank is typically constructed of fiber reinforced plastic, stainless steel, concrete, or green infrastructure alternatives such as precast ferrocement<sup>58</sup>. Units may be modular and designed for a single family, or scaled to support a community of families. The tank is buried underground, allowing the minimum temperature requirements to be maintained by geothermal energy, where a five meter depth is expected to sustain 15°C in the biodigester<sup>59</sup>.

Biogas resulting from anaerobic digestion is a mixture of methane (55–70%), carbon dioxide (35–40%), water vapor (2–7%), and trace gases (< 2%). It has an average energy content of 6kWh per cubic meter when combusted directly, or 2kWh of electricity when converted in a biogas powered electric generator<sup>60</sup>. This renewable energy can power small electrical appliances and engines, or fuel cooking stoves and gas lamps. It can also be mechanically recycled to heat the digester itself or to mix the contents in order to improve biodegradation efficiency. Necessary safety precautions should be taken to prevent the flammable biogas from leaking and when storing the biogas under pressure.

## Summary of Anaerobic Digestion

Anaerobic digestion is a naturally occurring biological process carried out in the absence of oxygen to decompose organic matter into carbon dioxide, methane, and water. Anaerobic digestion ideally occurs at mesophilic (20–40°C) or thermophilic (40–60°C) temperatures, and while higher temperatures typically correlate with greater methane production and treatment efficiency, the process remains possible at psychrophilic (0–20°C) conditions. Roughly half of the global population lives in climates with an average annual temperature of 20°C or colder<sup>61</sup> and by optimizing the anaerobic digestion system to operate within lower temperatures, energy, that would otherwise be used to heat the digester, can be saved.

To accelerate biodegradation, the fermentation tank has several chambers to increase the hydraulic retention time. Performance can be enhanced by adding an immobilization matrix within the anaerobic digester to increase the surface area on which microorganisms can grow in an adherent layer known as biofilm. The greater concentration of microbial biomass facilitates interspecies syntrophy, improves biodegradation efficiency and methane production, and can thereby reduce the tank volume. In an anaerobic digester operating at 10°C and utilizing an immobilization matrix, biogas yield was 20% greater than the control and the average bacterial and methanogenic populations were measured to be at least two orders of magnitude greater on the matrix than in the mixed liquor sludge<sup>62</sup>. Designing a system that uses locally available resources as immobilization matrices for biofilm growth can be a sustainable and cost effective method to improve biodigester performance and efficiency.

Parameter	Value	Units
Community Population	840	people
Domestic Wastewater	40	g BOD <sub>5</sub> (organic waste) / person / day
Organic Waste	110	g organic (household and kitchen) waste / person / day
Total Organic Waste	150	g / person / day
Biogas Production (25 day HRT at 10°C)*	6.97 x 10 <sup>-5</sup>	m <sup>3</sup> biogas / g organic waste / day
Total Community Biogas	8.8	m <sup>3</sup> biogas / day
Cook stove Energy Consumption†	0.4	m <sup>3</sup> biogas / hour
Biogas Energy Conversion‡	2	kWh / m <sup>3</sup> biogas
Total Electricity	17.6	kWh / day

Sources: \*Ramana and Singh, †Lohri, ‡Vögeli et al.

Table 4. Energy potential of DRDO anaerobic digestion biogas for an example Mumbai slum redevelopment apartment building

## Recommendations to Housing for All for Sanitation

Constructing decentralized sanitation facilities can prevent the environmental pollution and health risks associated with open defecation common among slum households. Upgrading existing septic tanks into biodigester facilities, and increasing dependence on resource recovery technologies, can reduce maintenance and costs, produce energy and nutrient resources, and improve water quality.

## Decentralized Infrastructure: Rooftop solar energy

### A Snapshot of India's Energy Usage

In 2009, India had the third largest energy demand in the world after China and the United States. As World Energy Outlook 2011 shows, India's energy demand more than doubled from 319 million tons of oil equivalent (Mtoe) in 1990 to 669 Mtoe in 2009<sup>63</sup>. Notably, India's per-capita energy consumption is still much lower than developed countries and even of some developing countries. Its 2009 per-capita energy consumption was 0.58 (toe/capita), compared to the world average of 1.8, OECD of 4.28, China of 1.7 and Africa of 0.67<sup>64</sup>. The low per-capita energy consumption indicates that India's energy demand still has a long way to reach saturation. With a growing economy and a 1.24 billion population aspiring for a better quality of life, India's energy demand growth is inevitable.

India's energy sector is increasingly unable to deliver a secure supply of energy amid growing demand and fuel imports. In conjunction with a rising subsidy level and systemic failure to ensure proper revenue collection along the value chain, the financial capacity of energy sector players is significantly undermined. Lack of sufficient capacity to make timely and adequate investments gives reason to fear that India is heading towards energy crisis.

### Background on India's Energy Infrastructure- Issues with Reliability and Access

In July 2012, two consecutive blackouts knocked out three of India's five major power grids, leaving over 600 million people - more than half of the country's population - without electricity for two days<sup>65</sup>. The outage trapped miners, interrupted critical health services in hospitals, shut down airports and water treatment plants, and halted hundreds of passenger trains. Often cited as the world's worst power outage, this blackout brought to light India's mounting struggle to meet its energy needs.

Amid chaos that would have left North Americans reeling, Indians took the outage in stride. Commuters grumbled about delays, young activists cursed government policies, the elderly bemoaned the humidity, but for the most part, people remained calm. The reason for this is two-fold. First, daily, localized power cuts are common and already frustrate the lives of people on the grid, lasting anywhere from an hour or two in cities, and up to twenty hours in rural areas. As a solution to the unreliability of electricity big businesses and more affluent homes often have backup diesel generators, however, those less well-off must sit and wait without electricity. Secondly, 400 million Indians or 32% of the population live entirely without electricity. Comprising 45% of rural areas and 7% of urban areas, un-electrified India has been forced to build a lifestyle around the use of firewood, candles, kerosene lamps, and gas stoves<sup>66</sup>.

### India's Economic Growth and Aging Electricity Network

Building a modern industrialized economy and bringing light and power to its entire population without increasing carbon emissions poses a genuine concern for the Indian government. India will need to add around 15 gigawatts each year over the next 30 years to keep up with rising demand of electricity<sup>67</sup>.

A common trend among developing nations is as standard of living increases, so to do carbon emissions and other pollutants. According to the World Bank, from 1980 to 2010 China's capita GDP grew from US\$193 to US\$4514, during which its emissions per capita grew from 1.49 tons per year to more than 6 tons per year<sup>68</sup>. Similar to China's capita GDP growth, according to IMF, India is projected to have similar per capita growth, estimated as US\$8475 by 2019. However, due to India's large population and mostly coal-based energy generation, India's current growth could have tremendous environmental repercussions.

On the other hand, government also must increase supply of electricity to the current grid infrastructure. Losses faced by India's state utilities over the past five years were about 1.5% of the country's GDP<sup>68</sup>. According to World Resources Institute, India faces transmission and distribution energy losses about of 27% which is the highest in the world. To meet the demand for increased electricity consumption and address environmental concerns, less carbon intensive technologies offer a solution. In housing redevelopment projects, the available rooftop area presents the opportunity to provide decentralized electricity for the community.

### **Background on India's Solar Energy Market**

India's solar market could be worth billions of dollars over the next decade; pundits forecast a \$6 billion to \$7 billion capital equipment market and close to \$4 billion in annual revenues from solar photovoltaic (PV) over the next decade.

The current government administration realizes the importance of solar energy for the country's energy mix and envisions the country as a key global solar market. India has bolstered their solar energy industry through the *Jawaharlal Nehru National Solar Mission (JNNSM)* which is committed to creating 100 gigawatts of solar capacity by 2020.

The government aims to achieve 40 gigawatts of this target capacity from rooftop installations on both residential and industrial complexes, which is predicted to play a prominent role in meeting energy demands across segments. A study conducted by The Energy and Resources Institute estimates realistic market potential for solar PV in urban settlements of India as about 124 gigawatt<sup>69</sup>. This market potential is based on current context where solar has already achieved grid parity for commercial and industrial consumers, and is quickly becoming attractive to residential consumers in many states. As a result, multiple state governments have taken necessary steps to kick-start implementation of rooftop solar PV projects.

## Implementation Challenges

*“77% of people felt the proportion of total expenditure on electricity in the redeveloped buildings were significantly greater compared to their previous electricity expenditures in slums”*

*- Paula Cadavid: Moving in-Selling Out: The outcome of slum rehabilitation in Mumbai*

*Solar energy prices are dropping – As per 2015 report by Central Electricity Regulatory Commission of India, ₹7.04 is the cost of electricity generated by solar panels which is already less than utility electricity cost in many states of India.*

*One of the most daunting tasks faced by solar developers in India’s rooftop solar industry is identification and aggregation of spaces with the potential to support solar panels.*

*-Jafar Khan, Senior Engineer, Azure Power*

## Application of Solar Power to the broader context of the *Housing for All* policy

Under *Housing for All*, the Indian government plans to construct at least 19 million houses in urban areas by 2022. *Housing for All* and JNNISM has a potential to complement each other in achieving the target set by each policy. A simple back-of-the-envelope calculation shows that if all the buildings constructed under *Housing for All* adopt solar technology, there is a minimum potential of 10 MW installation across India. Slum redeveloped buildings have approximately 14,000 sq.ft. of unused rooftop space with a potential for 50 KW per building of solar panel installation. Apart from reducing carbon emissions, adopting solar technology will also reduce electricity bills of low-income households. In Mumbai, estimated savings per year from such installations in an average SRS building is ₹2,35,790 and carbon emission savings of 1,821 metric tons CO<sub>2</sub> over a twenty five year lifetime of the project. This is equivalent to 4,406 trees planted<sup>72</sup>.

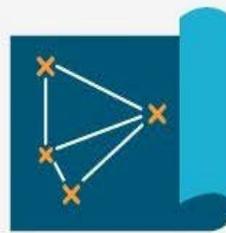
### Everyone Benefits



*Customers gain access to convenient, affordable, and reliable electricity.*



*Investors get access to bankable investments in a new, high-growth market.*



*Developers and energy providers undertake sustainable, scalable projects.*



*Governments reach their electrification targets.*

Image Source: Bridge to India

## Financial Sustainability: Ownership Rights to be Earned in the Long Term

Housing is a fundamental human need that contributes to an individual's physical, psychological, and social well being. However, slum dwellers are deprived from basic civil amenities and fail to have fair opportunities to enjoy economic growth. The huge unmet demand for housing in the slum households presents an untapped opportunity for institutional innovations. For the majority of targeted cities that cannot offer strong land-based incentives to private developers like in Mumbai, other forms of public-private partnership should be customized. A typical financial incentive to developers is to collect rent from public redevelopment housing to offset costs.

As mentioned in a previous section, giving out free housing to slum households under SRS results in issues of illegal subletting, illegal sales of housing, and people returning to slums. To address this spiral effect of slum redevelopment, we recommend innovative financial ecosystems in this section. We recommend that eligible beneficiaries should (1) receive subsidized leasehold rights for the first ten years, and (2) have access to formal financial resources to choose between a title deed by paying the remaining principal, or continuing leasehold title by paying unsubsidized rents at the end of the interim or sooner.

### Path to Homeownership through Redevelopment Housing

Renting offers convenience, as renters typically do not have to pay for unexpected repairs and can enjoy the benefits of fluidity. However, renting deters occupants from investing in home improvement. Moreover, it does not allow households to build up equity in their homes, which retains them to accumulate assets.

To encourage renters to save, the U.S. Housing and Urban Development Department (HUD) initiated the Family Self-Sufficiency Program in 1990. The five-year program was designed to help residents in public housing to become more economically independent by requiring participants to regularly meet their case managers to ensure they are fulfilling development goals, such as returning to school or looking for better jobs. As the participants begin to earn higher salaries, they were able to put extra income into saving accounts as opposed to being charged with higher rents. In 2011, a HUD study showed that the enrollees' annual income increased 67% and they left the program with \$5300 savings on average<sup>73</sup>.

A similar concept could be applied in India, but with adjustment to local conditions. The implementing agency could appoint case managers in each redevelopment neighborhood. These case managers, functioning as the front officers of the program, should be in charge of appraising the eligibility of renting households, setting development goals with the households, and ensuring the households are on track to fulfill their goals. Goals should be customized to each household, encouraging them to develop saving habits, receive better education, build parenting knowledge, seek better employment opportunities, and establish small businesses. Overall the program aims to formalize the livelihoods and economies of these communities.

The payment structure needs to be carefully designed. In India, a slum redevelopment housing unit of 269 sq. ft. typically costs about ₹3,00,000 excluding land costs. With ₹1,00,000

from the government, households could only have a ₹2,00,000 principal in the beginning. A 2011 MoHUPA study showed that household willingness to pay for rent is less than 30% to 40% of their gross income<sup>74</sup>. Throughout our interviews in India, we found an average ₹500 per month willingness to pay for rent among redevelopment households in Mumbai. However, deciding the amount of these monthly installments requires additional surveys among the communities.

In the first ten years of the transition period, as the economic environment among the households are becoming more formal, residents are expected to receive higher incomes. Regardless, the rent should remain flat, rather than be on a sliding scale based on income in typical public housing pricing schemes. However, the households should be encouraged to put the extra earnings into an escrow account. Meanwhile, former slum households could enjoy improved purchasing power from enhanced and safer living conditions and savings from avoided health expenditures.

By the end of the transition period, the households may still require access to affordable financial resources to be able to make the buying or renting decisions. Given that existing financial institutions do not target slum dwellers, we recommend improvements to the financial ecosystem so that the beneficiaries of the scheme could access the formal financial market. We recommend (1) the traditional Housing Finance Companies (HFC) to reach the slum households, and (2) Micro-Finance Institutions (MFIs) that focus on the low-income group be better designed to scale-up across the country.

In India, four ways exist in demonstrating land rights.

1. A title deed that has the highest legal sanction
2. A leasehold that shows the holder rights to use the property for a certain number of time
3. A license to cooperative societies, members register with the cooperative for right to the property
4. A stamp paper signifying sale of a property that has no legal validity

The first three ways can be used to receive bank finance.

### **HFC: Reaching the Slum Households**

The traditional HFCs require innovation to serve the needs of the slum households with low income and informal documents. Large home loan lenders usually depend upon the proof of wage and expenditure documentation when making lending decisions. Poor people typically have no collateral and therefore no chance to take out a loan, save money, or invest for the future. For this particular income group, surveying requires a more field-based methodology for cash flow checks: utilizing surrogates, triangulation, and building up learning about client subsections to increase assessment reliability (Table 5)<sup>75</sup>. For HFC business practitioners to succeed in this slum household sector, one needs to put resources into complete and creative customer risk evaluation techniques to better understand the slum households. The loan officers, the front-end of this appraisal process, are crucial for truly understanding the local situation while remaining legitimate and trustworthy. Hence, local hiring and regular training is recommended.

It's the person that matters	
Procedure	Details
Understand a customer's stability	<ul style="list-style-type: none"> <li>• Visit to home to understand applicant's current housing situation, stability and duration of stay</li> <li>• Interview neighbors to verify duration, understand habits, etc.</li> <li>• Check credit and banking history (if applicable)</li> </ul>
Understand a customer's source of income	<ul style="list-style-type: none"> <li>• Visit the applicant's business to observe daily business flows, speak with customers and estimate revenues and costs</li> <li>• Understand the business model and its key strengths and weaknesses, fluctuations in cash flow, risks, etc.</li> <li>• Talk to suppliers, competitors, etc. to triangulate and benchmark estimates</li> </ul>
Standardization	<ul style="list-style-type: none"> <li>• Building a database of informal sector customers' income by profession in different localities</li> </ul>

Source: : *Building Houses, Financing Homes. Monitor Inclusive Markets. 2010*

Figure 13. HFC Customer Risk Assessment

### Micro-finance: Improve Design to Scale up

A large population of the urban poor is cut off from the traditional HFCs. Aside from innovative HFC lending mechanisms, scaling up micro-finance is more effective in delivering housing funds for the urban poor. Micro-finance has proved to be one of the most powerful engines in the global effort to empower the poor, alleviate poverty, and drive economic growth. The key feature of micro-finance is to provide people the opportunity to take one's future into one's own hands.

Housing micro-finance, also known as incremental financing, is considered as the application of a micro-finance-based approach to housing finance. While many slum households are unable to access mortgages, housing finance makes it possible to address housing needs progressively towards a larger housing vision. In addition, micro-entrepreneurs often use their homes as productive assets in generating income. Thus, a quality home not only enhances living conditions, it is also an investment for conducting business more efficiently.

There are few examples of fruitful housing micro-finance models in India. However, there is sufficient experience and lessons from past and existing endeavors at giving funds to low income households through small scale accounts or different channels<sup>76</sup>. In order to scale up and provide sustainable housing micro-finance in India, the following difficulties must be overcome when designing lending mechanisms:

(1) *Land title and collateral*: The financial industry recognizes the trouble of formal financial institutions to expand the degree of financial intermediary unless the land title conditions are improved. This is where both state and central governments can play a significant role in facilitating the improvement of the urban poor's living conditions.

(2) *Reaching the poorest*: The challenge lies in reaching the poorest of the poor, typically with monthly income below ₹5,000. The difficulty in lending to this income group lies in their volatile income and vulnerability to small economic shocks that could adversely affect payment. Complicated land title and collateral issues may add to the difficulty of this business.

(3) *Funding*: Funding poses, perhaps, the largest constraint for MFIs in delivering housing micro-finance. MFIs started only a decade ago to offer housing micro-finance loans to customers which have successful payment records. Some MFIs find it hard to meet the high housing finance demand with constrained resources.

(4) *Loan Amount:* Even among the MFIs that currently serve the slum dwellers, very few offer loans that could cover the entire cost of a new housing unit. This constraint is mainly due to the MFI's own funding issues and risk of defaulting. When the loan from MFI is not enough to cover the complete cost, beneficiaries may still resort to informal sources of credit; however, moneylenders tend to charge prohibitively high rates of interest. In Mumbai, the monthly interest rate could easily go up to 30%. As low-income households tend to pay off the biggest liabilities first, this makes them often prioritize private moneylender's loan. That being said, if a MFI is not able to provide sufficient amount to its borrowers, it may in return lead to the defaults on the MFI loan at the time of repayment.

(5) *Awareness:* Housing micro-finance would require some degree of awareness-building amongst its clients. Slum dwellers are used to thinking about more immediate terms, which has historically made them repay loans on a short-term basis for durations up to a year. For a larger amount of housing loans, MFIs often issue loans that last at least three years. In the urban area where social networks are fluid and migration is frequent, this awareness challenge that MFIs are facing is significant.

To overcome these above-mentioned challenges, we hereby recommend:

- There is first a need to formulate a framework that would help identify the right beneficiaries for slum redevelopment projects, which would require new methods in recognizing informal proof of income. In addition, flexible payment mechanisms should be carried out, as slum households typically have volatile income flows.
- The most practical option for MFIs is to discover approaches for securing longer term funding. In addition to cooperative banks, a local commercial bank could also function as an intermediary and the Central Nodal Agencies could guarantee the bank's loans to qualified MFIs and receive a favorable interest rate.
- To raise awareness between slum households in thinking and making investments in the longer term, MFIs must spend time and effort in engaging their borrowers to build up an extended perspective of their finances. We encourage MFIs to actively recruit front officers from local communities, especially women and young adults, as a means to broadly empower the slum communities.

*Team Observations:*

*Through our interaction with different stakeholders, including private developers, government officials, funders, and low-income households, we captured the development and current state of the existing housing financial ecosystem, especially in Mumbai. As the business model matures, it is becoming more viable and healthy for funding agencies to invest in the real-estate developers in slum redevelopment schemes. For the end beneficiaries of this scheme, the slum dwellers, housing finance has been provided by specialized Housing Finance Companies (HFCs) targeted at providing housing finance for both formal and informal lower-income households. Many market facilitators have also begun to collaborate with multiple players in the market. For example, Monitor Inclusive Markets started in 2006 to engage with the private developer, the government, and the financial sector to deliver more low-income housing to the market. During our field visit, the stories we heard from those who moved into new houses are uplifting, while a large population still lives in slums. The relationships between beneficiaries and financial institutions still face significant challenges in sustained growth.*

*The market failure in affordable housing cannot be solved solely from the supply side. Even if developers provide a sufficient and sustainable supply of housing, the market would still be insufficient without a similarly strong purchasing power from the low-income urban customers. In recognizing this insufficient demand, the MoHUPA has created the Credit Linked Subsidy Scheme component of Housing for All to provide favorable home loans to the urban poor. To date, 152 primary lending institutions have signed MOUs with Central Nodal Agencies to serve eligible households at the interest rate of 6.5 % for a tenure of 15 years, which is less than the prevailing mortgage rate of approximately 14%.*

**Housing for all – What needs to be done?**

In short, from the financial sustainability perspective, we recommend that the government should (1) grant leasehold rights during the interim period while incentivizing households to work toward an ownership, and (2) encourage innovative lending mechanisms from Housing Finance Companies and Microfinance Institutions to ensure that housing finance is accessible to large sections of slum population at the end of the transit period. Whenever slum dwellers are able to make individual housing choices, the informal economy could truly convert into formal economy, and long-term financial sustainability could be achieved.

## Cultural Sustainability:

India's informal settlements are dotted with small shops, spaces of micro-entrepreneurship, and spaces for community gathering. We aim to maintain economic and cultural sustainability through architecture, verticalizing these public spaces and integrating them within the buildings. By increasing business and commercial areas within the apartment building, income opportunities increase and a stronger sense of community can be established. This in turn should increase resident retention rates, thus improving the redevelopment project's effectiveness.

There are often trade-offs slum dwellers must consider when electing to allow, or not allow, the private redevelopment of the land and when deciding to move from a ground level structure to a high-rise apartment apart from the street. Through successful redevelopment, slum dwellers acquire provision to basic infrastructure, and possibly access to capital in the form of property, while on the other hand, they may forfeit the economic opportunities, social networks, and certain freedoms to develop their own habitat. Although residents benefit from more hygienic conditions and safer structures, they often lose their means of subsistence, which, in India, is usually dependent on their close proximity to the street level. In Dharavi for example, a majority of the structures adjacent to public streets double as living quarters, areas of manufacturing and sale, and sometimes, places of community gathering. Providing a slum dweller with an isolated residential unit separated inside of an apartment building, removes them from many of the economic opportunities and interactions in public spaces they had before. Additionally, the displacement (including temporary) from low-rise to high-rise residences can have a negative impact on social networks (Echanove and Srivasta).

Source: *The High Rise & The Slum: Speculative Urban Development in Mumbai* by Matias Echanove & Rahul Srivastava For the Oxford University Press Reader on Urban Planning and Economic Development, 2010

*"They say they will redevelop Dharavi, but look at what they're doing. These high-rise buildings mushrooming all around us. People who move in are selling and leaving their flats already. They need money because they cannot continue with their livelihoods in these buildings. People living in these high-rises don't know their neighbors anymore."*

*- Letter of the Committee to the Chief Minister of Maharashtra concerning the Dharavi Redevelopment Project <sup>77</sup>*

Many previous studies have tried to address this issue by promoting the preservation of one storey informal settlements. Maintaining many of these informal settlements would help to further preserve the culture, but it does not provide the people access to better infrastructure and shelter, which may prevent individuals from achieving a healthier life and a longer life expectancy. Additionally, with India as one of the most populated countries in the world and the demand for urban real-estate increasing, it is simply not realistic to preserve every informal settlement in Mumbai. According to the World Bank, 54% of Mumbai's population (11 million people) live in slums. In order to provide shelter and basic infrastructure as well as maintain the economic and social opportunities presented by living adjacent to the streets, we propose specific architectural conditions which start to incorporate ways that create and develop public space and micro- entrepreneurship opportunities within the redevelopment buildings.

## Past approaches to low-income high-rise buildings

There have been various studies which have attempted to solve it. We begin by analyzing the types of slum housing in Mumbai and to generate recommendations, we analyze some of the past approaches which have dealt with low-income high rise housing.

There has been much academic research conducted on how to design for the redevelopment and rehabilitation of slums. However, many past proposals for slum upgradation projects have failed to include a critical viewpoint- that of the slum dweller, in the design stage. Recently, more approaches have been pushing to allow for a plan that would allow for more self-directed development, sustaining community spaces and culture.

### Case Study: Sky-ville Human-scaled community spaces in high-rises<sup>78</sup>

Architects: WOHA

Project Name: Skyville

Location: Singapore

Project Opening Year: 2015

Skyville designed by WOHA provides a contemporary twist on public housing projects in South East Asia. The complex housing 960 dwellings emphasize connection to outdoor spaces and parks. The main idea was the addressing of such large projects to break the enormous scale of their projects into humane pieces while still accounting for the overall need for dense urban developments. In Skyville, they developed the concept of sky villages, which are 11 story neighborhoods oriented around communal gardens with residences on four angled sides. Each “sky village” has 80 apartments looking onto and sharing use of its high-rise garden, increasing interactions among neighbors. The design opts for open covered balconies overlooking the communal garden space to provide access to all dwelling units and serve as a shaded space for people to meet. The idea behind these skygardens and community spaces are to break down the scale of development and encourage interaction within the tower. Thereby creating the experience of intimate neighborhood settings within a high-density urban development.

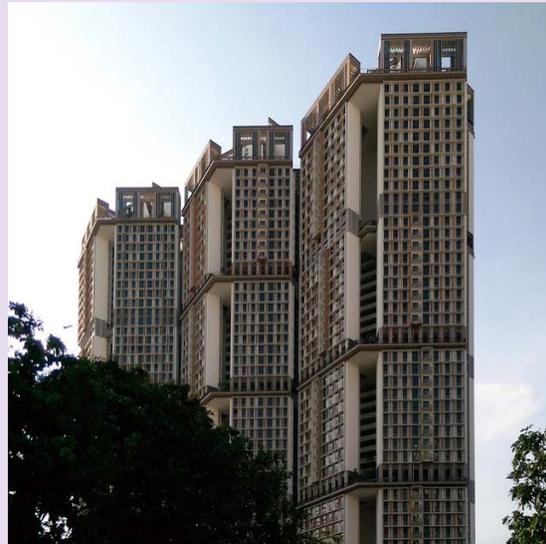


Figure 22: Interior and exterior photograph of Skyville  
Image and information source: urbanarchnow.com

## SECTION III: RECOMMENDATIONS **Case Study: Quinta Monroy- Self-Driven Development**<sup>79</sup>

Architects: Elemental  
Location: Tarapacá, Chile  
Project Opening Year: 2003

The Quinta Monroy project in Tarapacá, Chile was designed by the New York based architectural firm Elemental. The main premise behind the design was to create social housing that was seen as an “investment not an expense” The idea was to challenge the notion that social housing, unlike private housing, often decrease in value over time. Elemental identified a set of design conditions which allow a housing unit to increase it’s value over time without having to increase the current public subsidy provided for it. The idea was to create enough density in order to pay for the site, which was expensive due to the location, thus keeping the current site was to maintain the job network and opportunities for the current residents and strengthening income opportunities for it’s residents and allow for increase of property value over time. The second driver was to create a space for the extensive family to develop, this manifested itself in collective space with restricted access created by twenty families. Perhaps the most striking aspect of this project’s housing design is that only 50% of the houses are created within a unit’s volume, the rest of the house was to eventually be self-constructed allowing for each unit to expand within its structure. The part of the house constructed consisted mostly of the infrastructure and amenities for the house because those are often hard and expensive to expand upon through self-directed renovations. Due to the fact that the constructed part was only 50% of the theoretical development of the house, the main challenge was in fitting amenities such as a kitchen and toilet designed for a 72 sq. m house inside of a 30 sq. m building. Therefore the aim of the houses were to create a framework in order to avoid any possible negative effects of self-construction but also facilitate the process of self-expansion. The idea behind designing for self-expansion was to encourage tenants to take ownership of their houses and therefore feel more tied to its development, making it more likely for them to stay.

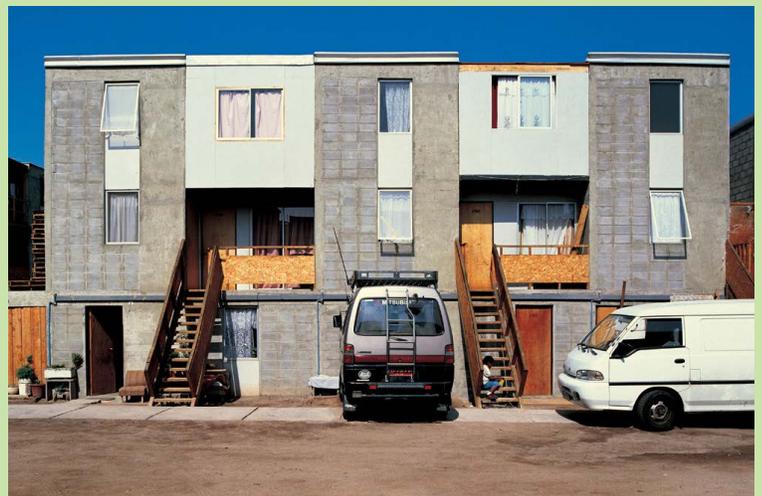


Figure 23: Quinta Monroy before and after occupancy  
Image and information source: [www.archdaily.com](http://www.archdaily.com)

## Case Study: “Re-inventing Dharavi” 2015 Architectural Competition<sup>80</sup>

Dharavi is one of the most widely studied informal settlements in the world. Situated in Mumbai it represents all the pressures that are faced by informal settlements in large developing cities. In 2015 the Urban Design Research Institute (UDRI) proposed an international competition called “Re-inventing Dharavi” as a challenge for fresh thinking in response to the current proposal for developers to provide housing through vertical through the SRS scheme, which verticalize the slums and allow for new developments on the freed up space. “Reinventing Dharavi” aimed to advocate for a more equitable development of its home city which would not only address the increased amenities, such as toilets, of current redevelopment schemes but also the fabric of the community from micro-entrepreneurship as well as current outdoor places of social interaction. The winners of the competition this year, an architectural firm from Mumbai, Plural, proposed the creation of a Dharavi Community Land trust that would redistribute the land ownership rights of the slum to the community, who would then create a redevelopment plan in line with their vision. This proposal also resolves one of the major issues surrounding slum upgradation - the complexities in understanding land ownership and who in an informal settlement has the right to an upgraded flat. An honorable winner of the competition, a Dutch design firm, Felixx Landscape Architects and Planners + Studio Oxl Architects, calls to bring local stakeholders together to co-create a plan for the city- allowing for the redevelopment process to occur through “street led upgradation”.

*“Dharavi’s design is not an accident; it responds to the social ties and economic needs of the community” -theguardian.com*



Figure 24: Renderings of Felixx Landscape Architects and Planners +Studio Oxl Architects proposition for the “Re-inventing Dharavi competition

Image and Information Source: “Best Ideas to Redevelop Dharavi Slum Developers India”, [www.theguardian.com](http://www.theguardian.com)

## Verticalizing the streets of Urban India

To replicate communal spaces, we recommend architectural methods that include areas for circulation and commercial/social interaction in external corridors, sky-parks, and common public spaces every few floors. Including areas for micro entrepreneurship and utilizing precast flat slab construction in the redevelopment can increase economic sustainability of the resident community and the building itself.

### Areas for micro entrepreneurship throughout the building

When relocated into a redevelopment, many of the slum households lose access to ground and open spaces which they use for their work. Although there are ground floor shops in SRS projects, the buildings are unable to accommodate all spaces of micro-entrepreneurship held previously by residents. Furthermore, due to the increasing demand for housing, Slum Redevelopment Scheme (SRS) buildings are often dense and vertical, therefore it has been a challenge to create similar street type storefronts in these tall buildings.

To create economic sustainability within the redevelopment, we propose open areas for stalls and shops throughout the building (see Fig. 13). Smaller stores can potentially be located on the walkways between buildings, but also within the larger communal areas every fifth floor. By distributing shared and public spaces throughout the building, tenants are able to work and live in the same area. Common spaces should include flexible stalls which can be easily changed to accommodate diverse business opportunities, from a two person barbershop, to a tea stall, to a grocery. It is also our hope that because the residents won't need to commute very far to work, there will be greater income opportunities at home and original SRS beneficiaries are less likely to sublease or move away from their apartment.

### Central core for circulation and shops

The central core will allow for internal circulation, which will increase views between floors and create a stronger sense of connection within the building's community. As previously mentioned, SRS buildings are tall vertical developments with the ground floor dedicated to micro-entrepreneurship and with regular divides of space between apartment units in the floors above. The circulation for these SRS apartments usually consist of elevators and common staircases on the periphery. Apart from the ground floor, there is no mixed-usage between residency, shops, and circulation. There are large differences between the diversity and complexity of mixed residential and micro-entrepreneurial spaces created within a slum and within an SRS building.

One aspect of slums that is not currently incorporated into the buildings is the amount of public space that the residents can interact in. Due to their close proximity to neighbors in slums as well as to public streets, there are always visible connections between people, creating a general sense of safety and community. As discussed in Section II, open spaces in slums allows for the informal small shops and businesses as well as areas for communal gathering.

### Create external corridors and remove public-private space thresholds

Similar to the facade of Chawls, apartment buildings should have an external corridor along the outside of the building in addition to the internal corridors. In current designs, walls shut off buildings from the streets and there is no visible connection to the people and life inside the building. It is the hope that these external corridors will be a place for people to hang dry clothes, sit and sip tea and yell down to the street to invite life into the building, creating

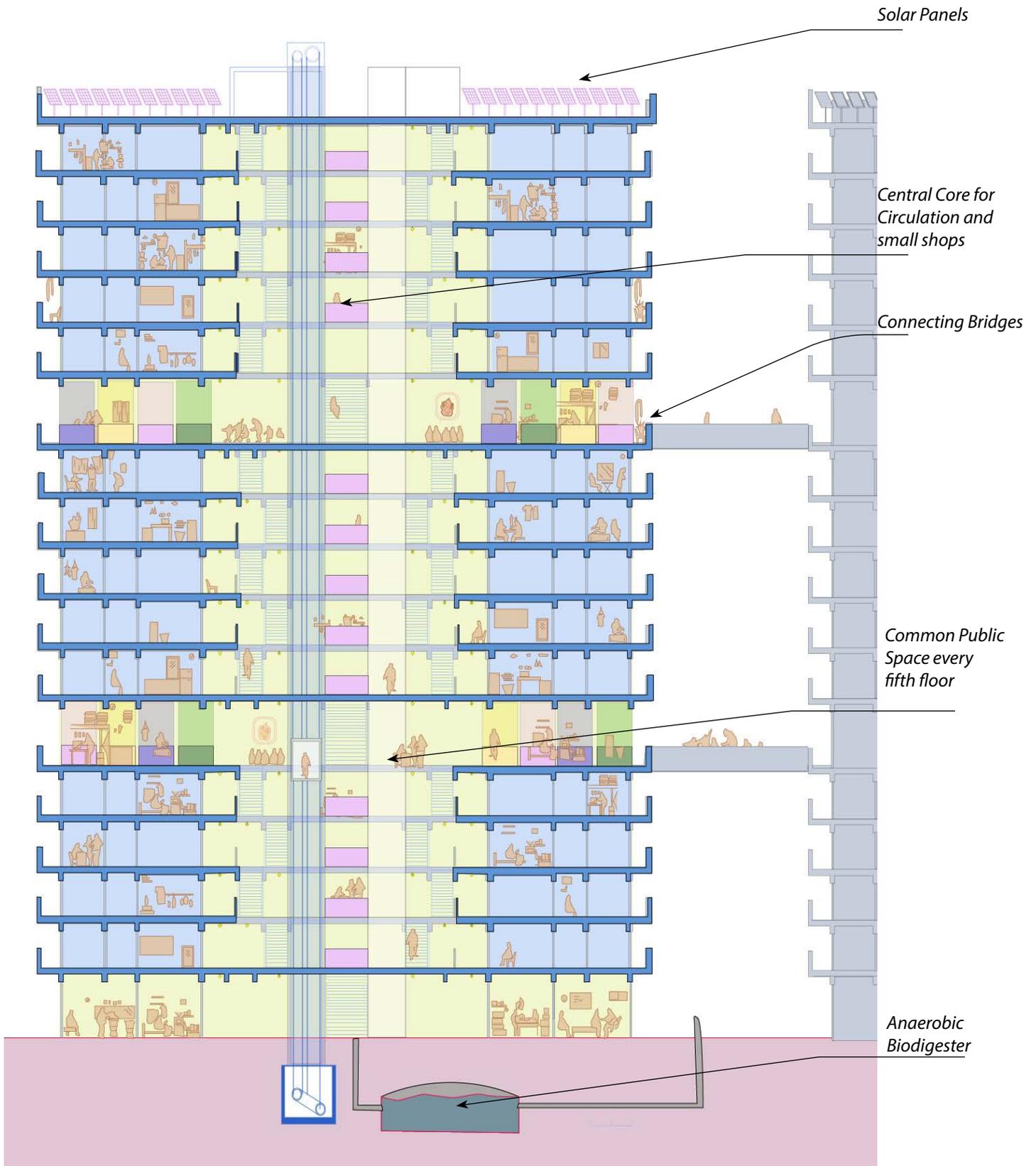


Figure 13. Diagrammatic of section of proposed architectural recommendations to SRS housing

an overall a stronger sense of community. By redefining the public-private threshold within the building from the lobby to the residential areas, the central core becomes an open space to allow public traffic within community and entrepreneurial spaces of the building.

### **Connected Bridges**

We recommend connecting clustered buildings via pedestrian bridges as a way for the community to maintain its connections with each other. One of the biggest commentaries on vertical high rises for low-income households has been the loss of their most important asset - social connections. Physical connections between buildings can help to minimize the loss of these social connections.

### **Increase common public space every fifth floor**

We recommend creating evenly distributed public spaces , which can be used for shops as well as sites of public gathering, such as for religious purposes. For ground + 23 levels floor buildings in Mumbai, these public spaces should be included on every fifth floor. Every fifth floor because that is around the maximum number of floors people would be willing to travel up and down stairs without an elevator. Five floors its also around the maximum height that lines of communication could reach through shouting down or looking up between floors. Throughout India, people of all classes gather to pray during different religious festivals and community activities, such as weddings and funerals. The densification of large cities means that there is decreasing public space for people to gather, therefore, by regularly interjecting floors with common public space throughout the building, it is likely that the current cultural traditions surrounding gathering and business will continue.

### **Precast flat slab construction**

Pre fabricated construction usually comprises of manufacturing the many of the building components off site, for example walls and structural members are assembled together to form wall pieces instead of the traditional on-site framing and construction. There are many benefits to prefabricated construction including usually less energy need and pollution generated from the construction as well as higher quality construction due to the fact that the materials are assembled in a controlled environment like a factory. Prefabricated construction such as, precast flat slab construction, also allows for minimal columns because many of the walls are self supporting. This has the potential to increase flexibility in the arrangement of interior walls, allowing for residents to expand or divide up their space to meet their individual needs.

### **Summary**

Through incorporating some existing areas of social interaction in informal settlements in Mumbai, as well as past approaches to public housing and slum redevelopment, we propose to maintain the social, semi-public, entrepreneurial atmosphere of the streets in newly developed dense vertical redevelopments.

## Conclusion

Economic and urban development is an interdisciplinary challenge dependent on social inclusion, smart investment, good governance, and environmental responsibility. Efficient implementation will require strong partnerships between governments, investors, and private developers to affect the global and household quality of life. The policies and practices that provide low-income families with quality homes and access to essential services, need to be action-orientated, forward-thinking, and sustainable. To address the growing needs and deficiencies in slums of India, our team proposes several sustainable models to improve including recommendations in four different categories, administrative, infrastructural, financial and architectural.

**Administrative:** We propose to replicate Mumbai's in-situ Slum Redevelopment Scheme in cities of similar land and population characteristics such as Delhi, Hyderabad, Chennai, and Pune. In these places, a fully subsidized, in-situ slum redevelopment policy, quite similar to the Slum Redevelopment Scheme, Housing for All, would likely see the same success as in Mumbai.

**Infrastructural:** We propose to construct and retrofit apartment buildings with decentralized infrastructure such as solar energy and anaerobic digestion sanitation. Solar energy proves to be a potential solution for slum redeveloped buildings because of good solar resource in India. Our analysis estimated savings up to ₹2,35,790 over a twenty five year lifetime of the project. On a national policy level Housing for All, energy analysis resulted in identifying potential of 10 MW worth of solar panel installation across India. Decentralized Sanitation can prevent the environmental pollution and health risks associated with open defecation common among slum households. Upgrading existing septic tanks into biodigester facilities, and increasing dependence on resource recovery technologies, can reduce maintenance and costs, produce energy and nutrient resources, and improve water quality.

**Financial:** We propose to offer long-term ownership rights and improve access to formal financial resources. We recommend that the government should grant leasehold rights during the interim period while incentivizing households to work toward an ownership, and encourage innovative lending mechanisms from Housing Finance Companies and Microfinance Institutions to ensure that housing finance is accessible to large sections of slum population at the end of the transit period. Whenever slum dwellers are able to make individual housing choices, the informal economy could truly convert into formal economy, and long-term financial sustainability could be achieved.

**Architectural:** We recommend prioritizing community space and spaces for microentrepreneurship within building design to increase social and business opportunities. Through incorporating some existing areas of social interaction in informal settlements in Mumbai, as well as past approaches to public housing and slum redevelopment, we propose to maintain the social, semi-public, entrepreneurial atmosphere of the streets in newly developed dense vertical redevelopments.

## References

1. "Urban and Rural Areas 2009." United Nations - Department of Economic and Social Affairs. United Nations, June 2010. Web. 5 Sept. 2015.
2. Henderson, Vernon. "Urbanization and Urban Growth." *The Political Economy of Development in Kenya* (2004): n. pag. 27 Oct. 2004. Web. 18 Sept. 2015.
3. "State of the world's cities 2012/2013.": Sustainable Development UN. UN Habitat - For a Better Urban Future, 2012. Web. 10 Sept. 2015.
4. Report of the Technical Urban Group (TG-12) on Urban Housing Shortage 2012-17, Ministry of Housing and Urban Poverty Alleviation, September 2012
5. "India National Report": India: National Report Progress of Implementation of the Habitat Agenda (1996-2000), United Nations. Ministry of Urban Development and Poverty Alleviation, Government of India, 2001. Web. Sept.-Oct. 2015.
6. "Slum Upgradation Programs." *Ojvensha*. 3 Apr. 2014. Web. 15 Nov. 2015.
7. ASICS. *Annual Survey of India's City-Systems*. Bangalore, 2014. Print.
8. Buckley, Robert, Mahavir Singh, and Jerry Kalarickal. "Strategizing Slum Improvement in India: A Method to Monitor and Refocus Slum Development Programs." *Global Urban Development*. , Nov. 2007. Web. 08 Sept. 2015.
9. Agarwal, Siddharth, and Shivani Taneja. "All Slums Are Not Equal: Child Health Conditions Among the Urban Poor." *Indian Pediatrics* 42 (2005): 233-244. Print.
10. Jha, Saumitra, Vijayendra Rao, and Michael Woolcock. "Governance in the Gullies: Democratic Responsiveness and Leadership in Delhi's Slums." *World Development* 35 (2007): 230-46. Elsevier. 2007. Web. May 2015.
11. Fox, Sean. *On the Origins and Consequences of Slums*. London, 2008. Web.
12. "Global Report on Human Settlements 2003: The Challenge of Slums." United Nations, 2003. Web. Sept. 2015.
13. Nair, Shalini. "Govt's Flagship Project 'Housing for All' to Be Unveiled by PM Modi Soon, Income Cap up to Rs 6 Lakh." *The Indian Express*. *The Indian Express*, 18 June 2015. Web. 22 Nov. 2015.
14. Ministry of Labour and Employment. Government of India, Web. 22 Oct. 2015.
15. "Decoding Housing for All by 2022." KPMG. KPMG & NAREDCO, 2015. Web. 14 Oct. 2015.
16. "Urban Population." World Bank. World Bank, 2015. Web. 16 Oct. 2015.
17. "Population projections for India and states 2001-2026." Report of the Technical Group on Population Projections Constituted by the National Commission on Population (2006): Office of the Registrar General & Census Commissioner, India, May 2006. Web. 3 Nov. 2015.
18. Mayank, Himadri, Mitali Nanavaty, Somdutta Chakraborty, Subhankar Mitra, and Ashutosh Limaye. "Affordable Housing in India." Jones Lang LaSalle. 2012. Web. 11 Nov. 2015.
19. World Bank. 2016. *Doing Business 2016: Measuring Regulatory Quality and Efficiency*. Washington, DC: World Bank. DOI: 10.1596/978-1-4648-0667-4. License: Creative Commons Attribution CC BY 3.0 IGO
20. Wooderson, Hannah. "Reform & Revolution 9 - 1950s Slum Clearance." *24dash.com Latest Housing News*. N.p., 9 Mar. 2010. Web. 23 Aug. 2015.
21. Carter, Harold. "From Slums to SLums in Three Generations; Housing Policy and the Political Economy of the Welfare State, 1945-2005." *Discussion Papers in Economic and Social History* 98 (2012): Web.
22. Baker, Kevin. "The First Slum in America." *The New York Times*. *The New York Times*, 29 Sept. 2001. Web. 23 Sept. 2015.
23. *A Study in Contradictions: The Origins and Legacy of the Housing Act of 1949* Alexander von Hoffman, *Housing Policy Debate* · Volume 11, Issue 2 299 © Fannie Mae Foundation 2000
24. Collins, William J., and Katharine L. Shester. 2013. "Slum Clearance and Urban Renewal in the United States." *American Economic Journal: Applied Economics*, 5(1): 239-73.
25. World Bank. 1995. *Indonesia - Enhancing the quality of life in urban Indonesia: the legacy of Kampung Improvement Program*. Washington, DC: World Bank. Web. 22 Oct. 2015
26. Soto, Hernando De. *The Mystery of Capital*. New York: Carnegie Council on Ethics and International Affairs, 2002. 2002. Web. 30 Aug. 2015.
27. Indiastat. *National Slum Development Programme (NSDP) (1996-2006) India Growth Statistics Details Figures*, 2006. Web. 18 Sept. 2015.
28. "Jawaharlal Nehru National Urban Renewal Mission." Ministry of Housing and Urban Poverty Alleviation Government of India, Dec. 2005. Web. Sept. 2015.
29. Mahadevia, Darshini, Abhijit Datay, and Aseem Mishra. "Foisting Mass Housing on the Poor: Lessons from Social Audit of BSUP." *CUE Working Paper Series* 21 (2013): CEPT. Oct. 2013. Web. Sept. 2015.
30. "'Housing for All by 2022" Mission – National Mission for Urban Housing." *Pmindia.gov.in*. Government of India, 17 June 2015. Web. 27 Sept. 2015.
31. Woetzel, Jonathan, Sangeeth Ram, Jan Mischke, Nicklas Garemo, and Shirish Sankhe. "Tackling the World's Affordable Housing Challenge." *McKinsey&Company*. *McKinsey&Company*, Oct. 2014. Web. 05 Oct. 2015.
32. Yang, Ruochen. "Analysis of Mumbai - Jijamata Nagar." *Slideshare*., 14 Nov. 2012. Web. 22 Oct. 2015. (Yang Ruochen, 2012)
33. Karandikar, Priyanka N., "Chawls: Analysis of a middle class housing type in Mumbai, India" (2010). *Graduate Theses and Dissers-*

- tations. Paper 11777, 14 Nov. 2012. Web. 22 Oct. 2015.
34. Cadavid, Paula Restrepo. "Moving in – Selling Out: The Outcomes of Slum Rehabilitation in Mumbai." *EconPapers: CER-NA Working Paper Series*, 2010. Web. 17 Sept. 2015.
  35. "Explanatory Note." *Census of India: Census of India 2001 (Provisional) Slum Population* - Web. 15 Nov. 2015.
  36. *Expatisan: Cost of Living Index*. Expatisan, Web. 22 Sept. 2015.
  37. United Nations Children's Fund, & World Health Organization. (2012). *Progress on Drinking Water and Sanitation: 2012 Update*.
  38. Central Pollution Control Board. (2009). *Status of Water Supply, Wastewater and Generation and Treatment in Class-I Cities and Class-II of India*. New Delhi.
  39. Programme Evaluation Organization. (2013). *Evaluation Study on Total Sanitation Campaign Evaluation Study on Total Sanitation Campaign*. New Delhi.
  40. Ministry of Urban Development. *National Urban Sanitation Policy (2008)*. New Delhi: Government of India.
  41. United Nations Children's Fund, & World Health Organization. (2012). *Progress on Drinking Water and Sanitation: 2012 Update*.
  42. Ministry of Urban Development. (2014). *Guidelines for Swachh Bharat Mission*. New Delhi.
  43. Central Public Health and Environmental Engineering Organization. (2013). *Manual on Sewerage and Sewage Treatment Systems*. New Delhi.
  44. United Nations. (2014). *The Millennium Development Goals Report*. New York. (United Nations, 2014)
  45. Gleick, P. H., Ajami, N., Christian-Smith, J., Cooley, H., Donnelly, K., Fulton, J., Srinivasan, V. (2014). *Freshwater Withdrawal by Country and Sector*. In *The World's Water (8th ed., pp. 227–235)*. Island Press.
  46. Hutton, G. & Haller, L., (2004). *Estimating the costs and health benefits of water and sanitation improvements at global level*. Geneva.
  47. Dajani, J. S., & Gemmell, R. S. (1971). *Economics of wastewater collection networks*. WRC Research Report No. 43. Urbana.
  48. Hophmayer-Tokich, S. (2006). *Wastewater Management Strategy: centralized v. decentralized technologies for small communities*.
  49. Ministry of Drinking Water and Sanitation. (2015). *Monitoring Status of ODF GPs*. Retrieved August 15, 2015
  50. Defence Research and Development Organization, & Federation of Indian Chambers of Commerce and Industry. (2012). *About Bio-Digester*. Retrieved March 9, 2015
  51. Ministry of Urban Development. (2013). *Advisory Note on Septage Management in Urban India*. New Delhi.
  52. *Indian Standard. IS: 2470 (Part I). Code of Practice for Installation of Septic Tanks (1985)*. New Delhi: Bureau of Indian Standards.
  53. Singh, Lokendra. "Eco-Friendly Bacterial Effective Solution for Toilet." 2014: Web.
  54. Singh, Lokendra. "Production of Biogas from Night Soil at Psychrophilic Temperature." *Bioresource Technology* 53.2 (1995): 147–149. Print.
  55. Dube, S., Singh, L., & Alam, S. I. (2001). *Proteolytic anaerobic bacteria from lake sediments of Antarctica*. *Enzyme and Microbial Technology*, 28(1), 114–121.
  56. Dhaked, R. K., Singh, P., & Singh, L. (2010). *Biomethanation under psychrophilic conditions*. *Waste Management*, 30(12), 2490–2496.
  57. Col. Ratta, M. "Grandeur Business Solutions Biodigester." Personal interview. May 2015.
  58. Saral. (2015). *Saral Precast Solutions*. Pune: Vaichal Group.
  59. Ramana, K. V., & Singh, L. (2000). *Microbial Degradation of Organic Wastes at Low Temperatures*. *Defence Science Journal*, 50(4), 371–381.
  60. Vögeli, Y., Riu, C., Gallardo, A., Diener, S., & Zurbrügg, C. (2014). *Anaerobic Digestion of Biowaste in Developing Countries*. Dübendorf: Swiss Federal Institute of Aquatic Science and Technology.
  61. Small, C., and J. Cohen. "Continental Physiography, Climate, and the Global Distribution of Human Population." *Current Anthropology* 45.2 (2014): 269–277. Print.
  62. Dhaked, Ram Kumar et al. "Immobilization of Anaerobic Bacteria on Rubberized-Coir for Psychrophilic Digestion of Night Soil." *Anaerobe* 11.4 (2005): 217–224. Print.
  63. "World Energy Outlook 2011." International Energy Agency, 2011. Web. 22 Sept. 2015.
  64. International Energy Agency. Web. 23 Sept. 2015.
  65. "600 Million in India Lose Power in World's Largest Blackout." *Mashable*, 31 July 2012. Web. 27 Sept. 2015.
  66. "Energy Home." *Energy Home*. The World Bank, n.d. Web. 22 Aug. 2015.
  67. "India Tries to Electrify without Creating an Emissions Disaster | MIT Technology Review." *MIT Technology Review*, 07 Oct. 2015. Web. 22 Sept. 2015.
  68. Kohli, Namrata. "The Loss of Power - The Economic Times." *The Economic Times*, Web. 22 Nov. 2015.
  69. The Energy and Resources Institute. Web. 18 Sept. 2015.
  70. Gregory, Mark. "India Struggles with Power Theft." *BBC News*. BBC, 15 Mar. 2006. Web. 12 Oct. 2015.
  71. Gokarn, Subir, Anuradha Sajjanhar, Rohan Sandhu, and Siddhartha Dubey. "Energy 2030." *Brookings India* (2013): Dec. 2013. Web. 11 Oct. 2015.

72. Shah, Yash. "Sfuri Analysis." Sfuri, July-Aug. 2015. Web. Nov. 2015.
73. Lalith de Silva, Imesh Wijewardena, Michelle Wood and et al. "Evaluation of the Family Self-Sufficiency Program: Prospective Study". U.S. Department of Housing and Urban Development. February 2011. Web
74. MoHUPA. Guidelines for affordable housing in partnership (Amended). Ministry of Housing and Urban Poverty Alleviation, Government of India, New Delhi (2011)
75. Deb, Anamitra, Ashish Karamchandani, and Raina Singh. "Building Houses, Financing Homes (India's Rapidly Growing Housing and Housing Finance Markets for the Low Income Customers)." Monitor Inclusive Markets. First Initiative, July 2010. Web. 4 Oct. 2015.
76. Aparna Krishnan, Minakshi Ramji and Yusuke Taishi. "A Report on Low Income Housing in India: Challenges and Opportunities for Microfinance." Centre for Micro Finance at the Institute for Financial Management and Research (IFMR). Chennai, India. 2007. Web.
77. Open letter of the Committee of Expert to Hon. Shri Ashok Chavan, Chief Minister of Maharashtra concerning the Dharavi Redevelopment Project, July 7, 2009. Web. 20 Nov., 2015 <[www.dharavi.org](http://www.dharavi.org)>
78. Choe, Jonathon. "The New Generation of Public Housing." Urban Architecture Now. 9 July 2015. Web. 25 Nov. 2015.
79. "Quinta Monroy / Elemental" 31 Dec, 2008. ArchDaily. Web. 25 Nov, 2015 <<http://www.archdaily.com/10775/quinta-monroy-elemental/>>
80. Carr, Carlin. "The Best Idea to Redevelop Dharavi Slum? Scrap the Plans and Start Again." The Guardian. The Rockefeller Foundation, 18 Feb. 2015. Web. 22 Oct. 2015. 78.



