INFORMAL HOUSING:
REDUCING DISASTER VULNERABILITY
THROUGH SAFER CONSTRUCTION

INFORMALITY AND DISASTER VULNERABILITY

Moving towards safer houses and stronger communities

WORLD BANK, DECEMBER 2011

(Funded by TFESSD under Component 2 of “Addressing Climate Change with Low Cost Green Housing”)
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1. INTRODUCTION

Background

This work was commissioned as one of three parts under a TFESSD\(^1\) Study, titled “Addressing Climate Change with Low Cost Green Housing.” The Study focuses on two aspects of Climate Change: One, the promotion of low-cost green technologies that are affordable to the middle and lower-middle income segments, and easily adoptable in the mainstream housing construction industry; and two, developing adaptive techniques for non-engineered construction, particularly in the slums and informal settlements to mitigate/ reduce the impact of natural hazards on low-income and poor households. The second aspect is the subject of this report.

Rationale

While the need for city governments and civil society groups to act to reduce greenhouse gases is well-established, the need to act to reduce vulnerability to climate change has relatively been slow to gain traction. This is critical to understand from several angles:

First, much of the housing backlog and current need for housing in developing countries is attributed to lower income segments of the population. Typically, these households live in non-engineered, ‘temporary’ or self-built housing that does not meet mandated safety standards, and is often located on dangerous lands. As a result, they are also the most vulnerable to natural hazards such as earthquakes, mudslides, hurricanes/ cyclones, and flooding. The increase in frequency of these events resulting from climate change makes their vulnerability all the more attention-worthy.

The second is the escalated risk associated with an urbanizing world: urban areas in developing country cities are commonly characterized by high population densities, old and deteriorated infrastructure, poor environmental conditions, concentrated poverty in informal settlements and slums, unplanned and often unregulated growth, and inadequately prepared local institutions, which makes them especially vulnerable. As a result, unlike the more developed nations where catastrophes typically happen when a major disaster strikes, in the developing countries, even small disasters result in disproportionate loss of life and property (see Box 1).

Third, a commonly cited problem attributed to disaster-related damage in developing countries is the ineffectiveness and lack of enforceability of building codes/regulations and zoning by-laws. The fact, however, remains that the inherent ‘illegality’ for most housing in informal settlements makes the ‘compliance’ issue redundant. In cases where regulations do apply, they often end up, and unintentionally so, hampering poor people’s efforts to improve their own safety (see Box 2 for an example in Mumbai). Be it the threat of eviction due to insecure tenure, or the risk of demolition for flouting regulations, they often serve as deterrents to building houses that are safer, even if only marginally so.

\(^1\)Trust Fund for Environmentally and Socially Sustainable Development
**Box 1. Vulnerability and risk: Developing versus developed nations**

“One marker for underdevelopment is the lack of a first response system. When you saw the television reports on the tsunami, you never saw ambulances arriving to help afterward. The main image of 9/11 in New York was that of first responders rushing in to save lives.

Another marker is a high death toll. There have been huge landslides in Malibu, though I don't recall any fatalities. There was a landslide in the Philippines a couple of months ago. About 1,000 died.

…a disaster in a poor country is far more lethal than an identical one in a wealthy place. The (2005) earthquake in Pakistan took an estimated 100,000 lives. The 1994 Northridge earthquake, which was similar in magnitude and depth, killed only 63. When Hurricane Ivan tore through the Caribbean in 2004, it killed about 2,000 Haitians. Within the United States, Ivan’s toll was less than 100.”


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**Box 2. Exacerbating vulnerability: The unintended impact of regulations in Mumbai’s slums**

Flooding is a major problem in Mumbai, particularly for the lower income residents of the city’s slums. In most cases, this is simply because the plinth level in many houses in the slums, especially the older houses, is lower than the ground level outside the house.

In the case of the older houses, this is because these houses were built several decades ago on what was previously a swamp, and the ground has gradually filled up over the years. As a result, what was originally the ground floor of many houses now resembles a basement, sitting several meters below the road level, and is perpetually flooded during the monsoons. In case of the “temporary” structures, the residents can invest in raising the house in a stilt-like manner. However, for houses built with concrete masonry, with common adjacent walls, there is no alternative other than manually remove the water when it comes in, or for the economically better-off, to fill the lower level and move up a floor.

Low plinths in the more recently built homes, however, exemplify a classic case of regulations unintentionally inhibiting people’s ability to improve their safety: there is a building height restriction (12 ft) by the municipality (probably with the intention of ensuring structural safety of the structures), which has forced residents to use lower plinths that offer little or no protection from flooding during the monsoon. Defiance of the 12 ft height restriction comes in the face of heavy penalties and/ or bribes, and/ or the risk of demolition by the authorities.
Fourth, the conventional approach by governments and donors to formalize the informal communities—through the delivery of better housing and/or infrastructure through in-situ upgrading, resettlement, or public housing schemes—is, in effect, a ‘lottery’ for the fortunate few. In the meanwhile, for the vast majority of the poor, informal housing continues to be the only option available in the foreseeable future. This ‘all-or-nothing’ approach benefits a few ‘lottery-winners’, in effect, leaving the rest to fend for themselves. This is essentially a ‘gap’ in the development sector which translates into higher exposure for poor communities on one hand, and on the other, a greater financial burden on the government for recovery and rehabilitation.

This raises the fifth and final point: despite the rhetoric about community-centered reconstruction, post-disaster efforts rarely take the local communities’ needs or skills into consideration. People in informal settlements build the way they do because of very basic practical reasons, primarily economic choice: typically, the materials are affordable and the skill-set for using those materials is readily available. The house plans, however spontaneous, are a direct outcome of the modular dimensions of the materials, not vice versa (for example, the length of a bamboo pole, the dimensions of a tin sheet, and so on). Introducing alien materials or technologies, or methods that hike up the construction cost, are unlikely to gain acceptance.

The aim should be to make people’s lives safer in a way that is easy for them to accept, and sustain, rather than pushing unnecessarily ‘innovative’ ideas that will crumble before the next disaster. Rather than dealing with impacts of extreme events, disaster-related initiatives should focus on preparedness aspects as part of adaptation: this involves reducing people’s vulnerability to the low-magnitude events that are more common, so that every natural hazard does not become a ‘disaster’.

There are limits on how much can be done to make these houses safer. This is attributed to a range of factors: for example, the transient nature of the housing being addressed which impacts the level of investment in the house, and locational factors (hazardous areas such as flood plains or steep unstable slopes). It is important to recognize these limitations in order to make realistic recommendations that people will adopt voluntarily. That said, the housing in these settlements is extremely heterogeneous: ranging from, say, a simple cardboard shack to a much more substantial concrete-block house; and from settlements located in high risk locations to those in relatively low risk areas. This heterogeneity presents a potential to provide safer housing options not for all, but for many.

Today’s growing concerns with climate change and greater frequency of natural hazards, together with the growth of the urban population and the informal sector, make a compelling case to engage in integrating adaptive techniques for self-built and non-engineered housing for low-income households that are relatively more resilient to natural hazards into the broader urban agenda.
Applicability of the research

This component of the Study essentially serves as a “pilot”, to develop and disseminate safer construction guidelines for a specific risk profile. While these guidelines will be quite specific to the local conditions and climatic/geographic context, it is expected that the underlying methodology for developing the profile—which is equally, if not more, important—could then be used as a model for other communities, cities and countries with different disaster risk profiles and climatic contexts.

This phase of the Study focuses on Mumbai, India. Findings from Mumbai present an opportunity to further a “South-South” dialogue and sharing of experiences across other emerging economies. The premise is that as countries begin to address the housing backlogs in an environment-friendly manner, simple construction techniques that adapt non-engineered buildings to better respond to natural hazards can go a long way in reducing the vulnerability of lower income communities.

Why Mumbai?

Mumbai was selected for a variety of reasons:

One, Mumbai’s slum population constitutes 60 percent of the city’s total population—and is likely to keep growing with increasing urbanization. With Mumbai’s population soaring anywhere between 15 and 20 million people, this translates into 8-12 million people currently living in slums or informal housing in very densely populated settlements. The houses in these settlements are typically non-engineered and/or self-built, and in most cases, do not meet basic safety standards.

Two, Mumbai’s slums offer a rich palette of housing typologies, and hence the opportunity to analyze a range of options and solutions, and objectively identify the ones that are viable. ....... On the other hand, the characteristics of Mumbai’s slums present many similarities to slums in other large cities both within and outside of India (Delhi, Nairobi, Lagos, Manila, to name a few), which will make this work more replicable/scalable, and lessons drawn from this exercise more transferrable to other cities and regions.

Three, the spate of serious flooding in the city in recent years has affected thousands of people, and brought the city to a standstill on numerous occasions.

While flooding disasters in Mumbai affect the poor and the wealthy alike, the problem is much more grave for the poor who live on the margin, and for whom, rebuilding the house—even if only a shanty—undoes the gains they might have made over several years. Also, it is not presumptuous to say that these are also the households the live in the most flood-prone areas with some of the worst/non-existing infrastructure, as a result of which, they suffer not just during the more serious flooding events, but also during periods of relatively mild rainfall.

Relocation/resettlement does not work, or at least not fast enough.....Attempts to relocate people living on hazardous land prone to flooding are almost always futile. This is because Mumbai’s notoriously short supply of housing leaves no other option for the poor to accommodate themselves. The pace of population growth has outpaced the speed with which the city creates housing—whether is be the private sector or the government.
Informal Housing: Reducing Disaster Vulnerability Through Safer Construction

And finally, there is a growing emphasis on slum upgrading and low-income housing across the board in India—e.g. the Rajiv Awas Yojna (RAY) initiative being among the more recent large-scale programs being funded by the central government. This study presents a new and cost-effective approach that could complement the more project-oriented slum improvement or resettlement efforts, one that offers good value-for-money, and is based on sound and simple methods which can be implemented by the people themselves, and therefore more sustainable from the viewpoint of vulnerability and risk reduction.

This report presents low-cost low-tech construction improvements for incrementally-built informal housing in Mumbai that make it both more climate resilient and climate responsive. The report is divided into three parts:

Main Report - This presents the context, rationale, and the key conclusions and recommendations of the Study....

Book 1: Situation Analysis - This constitutes Book 1, which comprises a full documentation of the field analysis—starting from a broad-brush overview of Mumbai’s informal housing down to surveys of individual houses. It presents the various typologies to be addressed and concludes with the key findings with respect to problems in building design and construction in each typology....

Book 2: Building Guidelines - This constitutes Book 2, which presents recommendations for improvements in each housing typology. It presents step-by-step information on the existing materials palette, how to select and use each material better, how to assemble the building structure, and how to maintain the house. These are presented together with the costs, so as to allow the user to make an informed decision on what sort of house to build, bearing in mind the trade-off: spending a little more upfront versus spending regularly on repairs. .......

This work is an attempt to draw attention to housing interventions that, although not ‘ideal’ in terms of safety, will:
- Move poor and vulnerable communities living in informal settlements up a notch in the ‘safety’ spectrum, and thus address this current ‘gap’ in development practice.
- Provide an intermediate best-cost solution for informal housing as a transitional stage towards “formal” housing.
- Mitigate loss of life and property resulting from smaller but more frequent hazardous events.
- Reduce externalities of unsafe structures on the surrounding communities.

Fundamental to underlying approach of this study is acknowledgement of the fact that people in informal settlements build the way they do because of very basic practical reasons, primarily an economic choice: the materials are affordable and the skill-set for using those materials is readily available. The house plans, however spontaneous, are a direct outcome of the modular dimensions of the materials, not vice versa (for example, the length of a bamboo pole, the dimensions of a tin sheet, and so on). This is the starting point for developing the guidelines. Introducing alien materials or technologies, or methods that hike up the construction cost, are unlikely to gain acceptance.

2Incrementally- or self-built housing in this context is defined as one where the owner self-manages the construction, perhaps with the help of a petty contractor/builder. Interventions to build more disaster-resistant construction could, therefore range from minor home improvements in informal sector housing which makes it more disaster resistant, to more substantial upgrading efforts.
The aim is to make people’s lives safer in a way that is easy for them to accept.

To this effect, the study to develop low-cost, disaster-resistant housing solutions for non-engineered self-built construction in informal settlements is based on the following guiding principles:
The solutions should be scalable: easily applied and replicable, with a marginal cost differential.
The target audience includes family units engaged in self-built informal housing and petty builders. Technical ideas must be developed while ensuring that they are easily acceptable, and communicated using simple user-friendly means that can be understood easily;
2. CONTENT AND OUTPUT OF THE STUDY

Site Selection

While slums in Mumbai have been the subject of much study, little documentation exists on current construction practices. This study involves a qualitative survey using a ‘purposive’ sampling of ten informal housing settlements in different parts of the city of Mumbai to ascertain patterns of use, spatial layouts and methods of construction. Below is a list of the settlements included in the sample:

2. Kunchi kurve Nagar, Kalina – a tightly knit tribal community in the western suburbs.
3. Qureshi Nagar, Kurla – a slum in an eastern suburb of Mumbai, along a railway line; many residents in the slum engage in the specialized activity of processing animal fat.
4. Shiv Krupa Society, Govandi – a settlement in an eastern suburb of Mumbai. Most houses have toilets provided through a municipal sanitation program.
5. Behrampada, Bandra East – a dense settlement located in a western suburb of Mumbai which houses various industrial activities; the slum is multi-storied with several community spaces on higher floors.
6. Darukhana, Reay Road – a settlement located along the water’s edge of the eastern Waterfront within the ports of Mumbai.
7. Bharat Nagar, Bandra Kurla Complex – an old resettlement colony close to the business district of bandra Kurla complex with very high property prices; the area is presently undergoing redevelopment.
8. Versova Fishing Village, Versova – a fishing village located in the western suburbs of Mumbai, currently undergoing small scale redevelopment.
10. Wasi Naka Resettlement and Rehabilitation Colony, Wasi Naka – a recent resettlement colony for people affected by infrastructure projects in Mumbai.

Each settlement is distinct in terms of occupational patterns, demographic make-up and location. However, the survey reveals a consistency across all settlements in the palette of materials used for construction, the quality of the labor pool available, and the sources of materials and costs associated with construction. These construction practices and methods can be synthesized into distinct typologies which form the basis for recommendations for safer homes that are adaptable by a variety of settlements in Mumbai.

As part of the detailed site studies, the team carried out the following –

• Interviews with local community leaders;
• Interviews with select residents to ascertain occupation, income, household composition, costs of construction and length of tenure;
• Photo-documentation and measure drawings of homes in the communities;
• Detailed discussions with local petty contractors and tradespersons;
• Public workshops in one pilot community (Shivaji Nagar) organized by the local community leaders to solicit input from residents in a public forum.
• Dissemination workshops in select settlements.

Outputs of this study include two reports:

Book 1: Situation Analysis
Book 2: Building Guidelines
Book 1: Situation Analysis

Book 1 presents a baseline analysis of informal housing in Mumbai, with a focus on the types of construction methods and practices. The core emphasis is on identifying building systems, materials used, the associated costs and the issues and opportunities that these present.

Housing Typologies in Mumbai’s Informal Settlements
Three predominant types of construction systems were identified - dry, wet and hybrid. These typologies are based on materials used, the methods of assembly, the time involved for construction and the associated costs. In general, the following are the distinguishing characteristics for each construction system:

A. Dry building system -
Materials require little to no water for assembly
Homes may be built within accelerated time frames
Construction costs are low
Materials are easy to salvage/replace in case of damage to the house
The typical choice of construction for a household new to a slum community

B. Wet building system -
Materials require the use of water for assembly
Time frame for construction is typically longer than that for dry building systems
Construction costs are higher than for dry building construction system
Materials are not easy to salvage/replace in case of damage to the house
The typical choice of construction for households with established presence in a slum community

C. Hybrid building system –
Combination of Dry and Wet systems
Materials require some water for assembly
Hybrid systems are faster and cheaper to build than wet systems, but are more expensive and time consuming than dry systems
Usually an outcome of incremental expansion, with wet on the ground level and dry on the top
Dry components are easy to salvage/replace
The typical choice for households with established presence in a slum community, but with limited means; also a typical choice for households seeking to expand their homes vertically.
Within each of these categories there is a wide range of housing types. However, only those sub-types were selected which have potential for improvement; others were considered outside the scope of this work.

Dry construction ranges from the very basic shack (with two poles and a bamboo sheet on a pavement) to a much more substantial 2-3 storey unit. This study does not include the pavement house because of limited potential to make any significant improvements to it. Similarly, anything taller than a 2-storey house is not taken into consideration, partly because it would not be prudent—from the safety standpoint—to make rule-of-thumb recommendations for such a structure that is not adequately engineered.

Similarly, in wet or hybrid construction, there are several settlements where houses go up to 5 storeys. These are structurally unsafe to begin with, hence not recommended, and not covered in this study.

After eliminating the sub-categories that go beyond the scope of this work, five sub-categories of construction were identified and studied in detail. These five, illustrated in Box 3, also represent the majority of slum housing in Mumbai. [note: put updated graphic....]

Key Findings
In general, the study highlighted the following broad issues:
Vulnerability of houses to flooding
Poor structural stability due to incorrect building methods, suboptimal/incorrect use of materials and irregular / reactive maintenance practices.
Poor access to light and ventilation in the slum houses
Availability of alternative material in abundance like waste material (eg. PET bottles) and material that is comparatively cheaper than mainstream materials and which are easier to replenish (eg. Bamboo)

While the issues and challenges are many, there are also distinct opportunities as revealed by the surveys. In particular, residents of informal housing use recycled building products procured from second-hand markets or from large construction sites. The team also identified good construction practices that are currently being implemented by local contractors or residents that can enhance the life-cycle of materials and the micro-environment of each home.

Materials: Materials for both wet and dry construction systems are readily available in Mumbai. This study provides extensive suggestions for choice and optimal use of all conventional materials along with specific focus on reused material.

Construction: The assembly details provided in this study are based on common building practices, known to the typical petty builder in Mumbai. Often, cost-considerations result in the exclusion of many of these simple and effective practices. However, it was found that with simple measures that are easy to implement and require little technical knowledge beyond what is available, major improvements can be made to the construction quality, and hence the durability of the structure. The cost of these measures is negligible when compared with recurring maintenance costs and vulnerability of life and property.

Costs & Decision Making: The true cost of not adopting these methods may not be fully apparent to the typical slum home builder who finances the construction through savings or borrowed money. The study provides cost comparisons between the different construction systems.

New Possibilities: There is a significant amount of waste generated in the city, especially in the form of post-consumer plastic waste such as PET bottles. There are also other materials like bamboo which are easy to replenish, but are not used for building houses.
Box 3. Housing typologies prevalent in Mumbai’s informal settlements

**TYPE A1:**
DRY BUILDING SYSTEM

**TYPE A2:**
TWO STOREY, DRY BUILDING SYSTEM

**TYPE B:**
TWO STOREY, HYBRID

**TYPE C1:**
ONE TO TWO STOREY WET CONSTRUCTION

**TYPE C2:**
WET CONSTRUCTION, COMMERCIAL
Book 2: Building Guidelines

Book II is structured as a manual that provides guidelines for improving construction of houses in informal settlements. It is designed as a quick reference for house owners and contractors in informal settlements. For the house owners and occupants, it serves as a guide for construction and maintenance of the house; for the contactors, it presents ways to explore new possibilities with existing as well as alternative materials.

Purpose and Audience
This Book does not intend to provide any one specific prescriptive formula for building a house in informal settlements. Rather, it is an analytical guide that seeks to do two things: first, to help low income home-builders make informed decisions on the type of house to build or improve, and how to do it better than most people currently do. The trade-off between the higher upfront cost of methods recommended here in relation to the benefits achieved in the longer run is clear: a safer and more durable house at a marginally higher—yet very affordable—cost, that extends the same materials closer to their optimal potential, and requires the same labor/ skillset that is currently available. To this effect, this Study makes a compelling case.

Second, it is hoped this manual, or possibly even the methodology used for the underlying research, will serve as a resource for (i) government, donors, and policy-makers by presenting a relatively cheaper and sustainable approach to slum improvement and disaster risk reduction, (ii) NGOs and microfinance agencies, as a guide on what sorts of ‘improvements’ to promote or finance, and to inform the development of construction-related technical assistance/ training programs for residents of informal housing.

While the applicability of this research and the findings extend beyond Mumbai to other large developing country cities where flooding is a problem, the underlying methodology for this research is one that can be adapted to slum settlement anywhere, particularly in light of the increasing disaster-related risks facing poor people across the globe.
Content and Structure

Part 1 addresses issues related to prevalent construction materials by providing recommendations on their selection, usage, and maintenance, so as to avoid repetitive and costly repairs.

Part 2 addresses issues related to the assembly of these materials in house construction—for example, the assemblies for foundations, plinths, floors, walls, and roofs—and suggests simple and cost-effective improvements to existing methods. (Note: Reinforced Cement Concrete (RCC) construction is not included in this report as this requires some level of professional engineering, and as such is not seen as the recommended mode of construction for self-built informal housing.) Possibilities of making the houses more climate-responsive through improved ventilation, lighting, and sanitation are also discussed.

Part 3 assimilates the recommendations in Part 2 into “ideal” prototypes for each housing typology: Dry, Wet, and Hybrid, with specifications and costs for ‘existing’ and ‘recommended’ construction methods for each.

Part 4 draws from outside experiences and presents new low-cost construction materials and methods to be explored by house owners and contractors as innovative alternatives to current practices.
3. CONCLUSIONS AND BROADER LESSONS

The work done under this study in Mumbai highlights the importance of a low-cost community-based approach to housing that, in addition to bringing more benefits to more people, is also cheaper to implement, and self-sustainable in the long run. The Mumbai Study highlights that the Climate Change-related risk exposure of low-income populations at the household/community level is an area that deserves more attention. This is because: one, most climate change mitigation or adaptation efforts do not adequately address disaster risk at the household level, thus leaving a gap in terms of better—yet affordable and practical—solutions in the short- and medium-term for lower income populations who are typically the most vulnerable. And two, this vulnerability can easily be mitigated, or at least reduced by a large extent, through simple and low-cost disaster-resistant retrofits and building systems that, even if not ‘ideal’ in terms of the conventional safety standards, will move the most vulnerable groups up a notch in the safety spectrum.

The building guidelines developed under this Study for self-built informal construction in Mumbai are aimed at helping people make their shelter more climate-responsive and disaster resilient. The housing in these settlements is of an extremely heterogeneous nature, ranging from a simple cardboard shack to a much more substantial concrete-block house, in locations ranging from high to low risk. This heterogeneity presents a massive potential to provide safer housing options - not for all, but for many.

Further, as the Mumbai study highlights, government assistance in the form of a supportive policy framework, financing for primary/secondary flood protection infrastructure, and better coordination with the local communities is an essential part of vulnerability reduction. This is particularly the case for flooding where the externalities associated with poor drainage go far and beyond the individual house to the community/neighborhood as a whole, and vice versa. Low-income communities typically cannot afford the high cost or offer the technical expertise that is required for this type of flood protection infrastructure.

Accordingly, regulations that inhibit people’s ability to reduce their vulnerability must be revisited and reformed. The example in Box 2 comes from the fieldwork carried out under this study: the low plinth level—which offers little or no protection from flooding during the monsoon—in many of the recently built houses in Mumbai’s slums is the direct result of a building height restriction of 12 ft by the municipality. Defiance of the 12 ft height restriction comes in the face of heavy penalties and/or bribes, or the risk of demolition by the authorities. This is a classic case of regulations unintendedly inhibiting people’s ability to improve their safety.

Finally, for this to be a sustained effort, it is critical to create local awareness and to enable and mobilize communities to take on protection measures that fall within their capacity. As mentioned above, poor drainage in one house has negative spillover effects on the surrounding houses; similarly, local drains blocked with plastics and garbage will not allow the main primary drains to work effectively, and so on. In other words, flood protection can only be effective if precautionary measures at the household level (such as high plinths and adequate waterproofing) are complemented with good drainage in and around the house and in the larger neighborhood/district. Decentralized and localized management of drainage and flooding issues must thus be recognized as a critical part of any comprehensive flood protection masterplan.
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