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Building **Inclusive** Urban Communities

CASE STUDY
OF HEALTH AND CLIMATE RISKS IN INFORMAL SETTLEMENTS IN MUMBAI: A CASE OF DEONAR

Mamta Patwardhan – 2017

Funded by the Erasmus+ Programme of the European Union

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Contact:
Design Cell
KRVIA - Kamla Raheja Vidyanidhi Institute
of Architecture and Environmental Studies,
Mumbai, India.
Email: admin@krvia.ac.in
Website: www.krvia.ac.in

Erasmus+

ABSTRACT

The vulnerability of urban areas and more so informal settlements is augmented by the rapid pace of urbanization coupled with the ever-increasing population burden. In Mumbai this vulnerability of the informal settlements is most acute and greatly compounded by the location of these communities that is often determined by their relative proximity to livelihood, on neglected, marginalized spaces in the city such as coastal zones, flood prone areas and geologically unsafe slopes, as well as proximity to dump yards, slaughter houses etc.

Moreover, such populations are subjected to a wide gamut of health risks arising due to an absence of planning and provisions of basic services by the respective institutions. And hence the marginalized areas coupled with a poor institutional and municipal framework, creates certain conditions which entrap the poorest citizen in a cycle of despair.

These conditions alone do not attribute to an upsurge in risk levels. Natural hazards driven by Climate Change impacts result in the marginalized communities exacerbated vulnerability towards health risks and life. Impoverished and migrant population are more vulnerable to the impacts of climate change such as extreme rainfall events, flooding and water logging, increase in summer temperatures or the urban heat island effect.

Thomas Hobbes, in his book, "The Leviathan," describes life in the natural state as being "short, nasty and brutish". These existential conditions, unfortunately, have become 'natural' and routine for the marginalized population in Mumbai - its swelling ranks lured by Mumbai's livelihood opportunities but cast aside in the concomitant planning and governance challenges.

This Case Study of the communities living in informal slums (Aadarsh Nagar, a neighbourhood in Deonar), occupying marginal low-lying land adjacent to the dump-yard, examines how these harsh existential conditions are being exacerbated through environmental forces (driven by climate change) like flooding, water logging and urban heat island effects, and specifically aims to establish an interlink between climate change and health. Further, it seeks to design some planning solutions that can play an important role in ameliorating the severe health outcomes suffered by Mumbai's marginalized, forgotten population.

" This Case Study examines how existential conditions are being exacerbated through environmental forces and specifically aims to establish an interlink between climate change and health."

CONTENTS

GLOSSARY OF TERM

The following terms have been explained within the context of the site.
(Adapted from 2009 UNISDR Terminology on Disaster Risk Reduction)

Acceptable risk
The risk of extensive damage to the dwelling in case of fire from the dump yard and extreme rainfall events, as well as loss of life and aggravation of health issues during these events that the inhabitants consider an inherent part of staying at the dump yard.

Affected
People who are affected directly or indirectly by extreme rainfall events that cause water logging and flooding in the BMC declared flood prone area of M-East ward. Also, people who have suffered permanent respiratory damage (consequences) due to proximity to the dump yard.

Adaptive capacity
The ability of the community to adapt and recover from adverse health conditions arising from water logging and flood situations.

Anthropogenic
Appalling and hazardous conditions resulting from choice of livelihood (dump yard) and unplanned and unchecked growth (proximity to livelihood) that are cause for further flood risks in the area.

Build back better
There is an absence of any formal or informal means of building back better. Socio- economic inequities handicap the ability to piece together their dwellings post disaster. The financial set back received amounts to around 5 years of savings.

Building code
A new risk-based land use plan drawn up setting the standards based on which the affected area will be re-planned and redesigned.

Climate Change
An evident increase in extreme rainfall events and storm surges in the city. Evidence supported by Adam Sobel's study, "Tropical Cyclone and Storm Surge Risk to Mumbai."

Coping capacity
There is inadequate response to cope with the repetitive occurrence of disasters. The community collectively works to assist disaster-affected people.

Critical infrastructure
The insufficient provision of clean drinking water, sanitation facilities, health infrastructure and evacuation plans.

Disaster
Hazardous events like extreme rainfall events, extreme heat as well as fires at the dump yard that cause serious loss of live, livelihood and aggravation of water borne, vector borne, air borne diseases (disruption of the functioning of the community).

Disaster risk
The potential loss of life, livelihood or damage to health, monetary loss and destruction or damage to physical assets during and after the period of disaster determined by the analytical framework that includes risk, vulnerability and exposure.
Climate change adaption is embedded within or is one aspect of disaster risk reduction. DRR addresses the issue at the core while CCA is one tool to assist with DRR.

Disaster risk assessment
Review of assessment of prevailing disaster risk in the area.

GLOSSARY OF TERM

Disaster risk governance
The system of institutions, mechanisms, policy and legal frameworks and other arrangements to guide coordinate and oversee disaster risk reduction and related areas of policy.

Disaster risk management
Disaster risk management is the application of disaster risk reduction policies and strategies to prevent new disaster risk, reduce existing disaster risk and manage residual risk, contributing to the strengthening of resilience and reduction of disaster losses.

Disaster risk reduction strategies and policies
Adaptive strategies that translate to policy interventions and an action plan that helps build social, health, infrastructural, economic and environmental resilience.

Geographic Information System (GIS)
Graphical maps used to analyse concentration of risks

Residual risk
The chronic respiratory ailments that the inhabitants are infected with and the aggravation of water borne diseases during extreme rainfall conditions

Resilience
The matter of fact way in which the inhabitants accept the risks they live with and attempt to best keep their lives safe.

Risk assessment
Graphical tool developed to ascertain the levels of possible impact of disaster in terms of the spatial distribution of the damage.

Risk based land use planning
Development of land use plans addressing zoning, layout, type of materials, size and design of dwellings. (World Bank 2012, *Building Urban Resilience: Managing the Risk of Disasters in East Asia and the Pacific)*

Urban upgrading
Prioritizes infrastructure for the most vulnerable populations living in slum settlements. (World Bank 2012, *Building Urban Resilience: Managing the Risk of Disasters in East Asia and the Pacific)*

ABBREVIATIONS

ACCCRN	Asian Cities Climate Change Research Network
BEST	Brihanmumbai Electric Supply and Transport
UN	United Nations
UNEP	United Nations Environment Programme
UNISDR	United Nations International Strategy for Disaster Reduction
UNFCCC	United Nations Framework Convention on Climate Change
IPCC	Intergovernmental Panel on Climate Change
MOEF	Ministry of Environment and Forests
NIH	National Institute of Health
UNDP	United Nations Development Programme
UN-HABITAT	United Nations Human Settlements Programme
CFC	Chlorofluorocarbons
GHG	Greenhouse Gases
LULUCF	Land use, land-use change, and forestry
MCGM	Municipal Corporation of Greater Mumbai
MESN	Mumbai Environmental Social Network
PM	Particulate Matter
CH4	Methane
CO	Carbon Monoxide
CO2	Carbon Dioxide
WB	World Bank

PART 1
INTRODUCTION

Research Objectives

The objective of the case study is to bring to light the close interactions between climate-related hazards and health impacts in informal settlements. The environment harbours toxic gases emitted out of the dump yard ascribing to the health hazards faced by these marginalised communities which would be further exacerbated by the impacts of Climate Change. The study hence advocates for the need of proactive planning action and help catalyse strategic thinking in that direction. To serve these objectives, the case study attempts to address the gap between urban planning, health of vulnerable communities and the challenges of urban adaptations to climate related hazards focussing on the physical aspects with health as a key element.

Action plan strategies include:

1. Explore Planning and infrastructure action for giving a chance to adapt and build resilience in these settlements like health infrastructure, municipal services, and economic opportunities.
2. Suggestions Institutional/Government Policies

Research questions

The research questions are:

1. In which ways do natural hazards (or: extreme rainfall events) contribute to further exacerbation of health risks/problems in informal settlements
2. Can slum upgrading and site-specific risk-based land use planning address the health inequities in informal settlements in the city? And how viable are they under the current conditions?
3. How do city growth and urban development impact the vulnerability of the informal community?

Methodology

The study positions itself to examine the dominant symptom of the vulnerability of the inhabitants of informal settlements and look at it from a health point of view and through this understand how planning is perpetuating this condition where degradation of life seems to be tightening the noose. It takes the case of the inhabitants of Adarsh Nagar, (a neighbourhood adjacent to the Deonar dump-yard), to understand the gap between root causes and the nature of these vulnerabilities and health risks.

A qualitative and quantitative approach was adopted to carry out the research and increase knowledge on the mutual influence between degrading health and natural hazard impacts (such as extreme rainfall events e.g. 26th July 2001) in informal areas. On this basis, the objective of the case study is to identify measures that consider the identified "hazard–health nexus", which are necessitated to reduce risk of the inhabitants of informal settlements.

Method

This case study is carried out using the following methods

1. A direct and empirical investigation of their living conditions was carried out through semi-structured interviews and visual surveys: first hand participant observations and on-site observations. Respondent based sampling was used to gain access to more respondents who participated willingly and actively. Interviews with the physician at the municipal health care centre provided the critical insights to establishing the reasons for their appalling health conditions. Interviews with stakeholders like members of various NGO's like the Ghar Bachao Andolan Samiti (Save our homes) and Apnalaya who have been working with the communities dealing with the legal and health issues, concerning these settlements, respectively. This revealed three risk indicators social(livelihood), environmental (sanitation and toxicity) and man- made hazard (fires)

2. Secondary data in the form of air quality tests, health and sanitation data from the Municipal authorities was looked at. The study of the current development plan (DP 2034 to be released in September 2018) with regards to the implications on the informal settlements was carried out. Published articles on the DP analyzing the current scenario for the slums were also perused. The legal issues concerning these settlements were also studied by means of literature review.

3. The exacerbation of risk due to flooding attributed to the urban geography of the settlement was assessed with the help of municipal data and data published by IIT and other world organizations dealing with mapping floods and storm surges due to climate change impacts. Risk due to the proximity of their livelihood means of waste picking from the dump yard was also analyzed by study of published data.

4. Suggestions about the need for and type of planning action that is necessary to address the living conditions in these settlements are made at the end of the report

The geographic location subjects it to increased vulnerability attributed to the to global temperature rise leading to heightened heat island effect in the intensively developed inner city and due to the combined impact of extreme events of rainfall on the increasingly constricted space for natural drainage. (BMC declared flood zone)

Outline of this report

This report is divided into 5 main sections. The research objective and questions have been identified in the present section (Section 1) that is followed by the methodology adopted to carry out the case study (Section 2). The background of the case study is discussed in the ensuing section (Section 3) that is followed by the results section (Section 4) that deals with the inferences from the study. Based on the results, the usefulness and development of a comprehensive risk index (as discussed earlier), which takes account of the complex hazard-health interlinkages is discussed (Section 5). ◆

PART 2
URBAN POOR, CLIMATE CHANGE AND HEALTH

Rapid urbanization and the creation of urban poor

Urbanization is a global phenomenon. The urban global tipping point was reached in 2007 when for the first time in history over half of the world's population 3.3 billion people were living in urban areas. It is estimated that a further 500 million people will be urbanized in the next five years and projections indicate that 60% of the world's population will be urbanized by 2030.
[1]

The term 'urban poor' is often attributed to be the economic predicament of the cities invisible denizen. It is imperative that the term be dealt with as it encompasses multiple ways in which it can be understood and the implications of which would help in a better comprehension of dealing with the concern. The World Bank explains Urban Poverty as follows:
Urban poverty is a multidimensional phenomenon. The urban poor live with many deprivations. Their daily challenges may include:

1. Limited access to employment opportunities and income,
2. Inadequate and insecure housing and services,
3. Violent and unhealthy environments,
4. Little or no social protection mechanisms, and
5. Limited access to adequate health and education opportunities."

In the cities of developing countries, the poor are largely relegated to informal slum areas. The development of these areas reflects both rapid urbanization and the inability of government institutions and the private sector to provide suitable shelter or effectively manage urban growth. The result is a marginal existence for a large segment of the population, who are often the core of the urban unskilled and semi-skilled work force.[2] The already marginalized community is subject to risks arising out of man-made as well as natural hazards. Out of these climate related hazards or hazards that are likely to increase as a result of climate change increasing (including rising sea levels and storm surges, heat stress, extreme precipitation, inland and coastal flooding, landslides, drought, increased aridity, water scarcity, and air pollution) are likely to be exacerbated causing wide spread disastrous impacts on people and their health, life, livelihood and assets.
Adaptation is defined by IPCC as adjustments in human and natural systems, in response to actual or expected climate stimuli or their effects, that moderate harm or exploit beneficial opportunities. Hence it is critical to talk about "adaptation" to current floods and heatwaves in the case study area in order to be prepared for future climate change events.

It might also help to explain that Adaptation is defined by the IPCC in relation to both existing and future climate (see the theory section of my thesis), which is why it is possible to talk about "adaptation" to current floods and heatwaves in the case area – even though we do not know whether they are a result of anthropogenic climate change.

Adaptation to climate change impacts like floods and heat waves can come in the form of bridging the gap between planning and adaptation as well as planning and health. This can be explained through the literature reviews.

1 Potsiou et al, 2010. Rapid Urbanization and Mega Cities: The Need for Spatial Information Management
2 IHC 2011, Adapting to Climate Change: Cities and the Urban Poor

Climate change and health

The rapid rate of urbanization and the increasing number of environmental, economic, and social problems will have a negative impact on health and well-being in cities (Lawrence, 1999). Squatter and slum settlements have formed mainly because of the inability of city governments to plan and provide affordable housing for the low-income segments of the urban population. (Ooi and Phua, 2007). Hence that segment of society resort to squatter and slums housing for their housing needs). Slum dwellings have no ventilation or natural light and are vulnerable to fire. Slum dwellers suffer from dust, smoke, and noise pollution. Piles of garbage, potholes, stray animals, flies, and mosquitoes are common. Urbanization has increased disease-producing agent, for example, toxic chemicals and car exhaust fumes. Lead (Pb) emitted from car exhausts or industry causes reduced fine motor coordination, hyperactivity, lower IQs, and perceptual problems in slum children. Few slums have access to potable water and sanitation services (Mehta, 1992).

Climate change is a global phenomenon that is fast gaining the significance it requires. The evident transformations in climate have an urgent need to be dealt with as these changes have created adverse effects to the planet that are in turn affecting life on the planet. WHO published 10 facts on Climate change and health which states, "Climate and weather already exert strong influences on health: increased deaths in heat waves, and in natural disasters such as floods, as well as changing patterns of life-threatening vector-borne diseases such as malaria and other existing and emerging infectious diseases are observed.

Continuing climate change will affect, in profoundly adverse ways, some of the social and environmental determinants of health: food, air and water, according to WHO Director-General Dr Margaret Chan. Areas with weak health infrastructure – mostly in developing countries - will be the least able to cope without assistance to prepare and respond."

These inequalities in urban sanitation access have a great impact on the health, well-being and socio-economic status of women and girls. These inequalities continue to exist despite efforts to make the needs of poor urban women and girls an integral part of sanitation policies and project planning, implementation, monitoring and evaluation.[3]

The impacts of climate change could prove particularly severe for women. With Climate change, there would be increasing scarcity of water, reduction in yields of forest biomass and increased risks to human health with children, women and the elderly in the household becoming the most vulnerable. (NAPCC). A new UN report says that health risks related to climate change are on the rise worldwide. At the same time, coordinated international responses can help prevent some of the worst impacts of climate change on health.

Urban poor populations often experience increased rates of infectious disease after flood events. Increases in cholera, cryptosporidiosis and typhoid fever have been reported in low - and middle-income countries. Flood-related increases in diarrhoeal disease have been reported in India and Bangladesh. The greatest concern about the impacts of climate change on human health is regarding changes in freshwater resources, food supplies and increases in extreme weather events such as floods and droughts. The Indian National Assessment of Vulnerability and Adaptation has addressed the potential impact of climate change on malaria, and other reviews have described the impacts on health of heat waves and flood events.[4]

3 Chaplin 2017. Gender, urban sanitation Inequalities and everyday lives. CPR 2017.

4 Kovats et al: Climate, climate change and human health in Asian cities

Urban climate hazards in the context of India and Mumbai

Mumbai: an expeditiously growing mega-city

The Mumbai urban agglomeration is the one of the largest metropolises in the world, and it has seen a uniquely magnanimous increase in urban population over the past few years. Currently at 22 million, the population of Mumbai has more than doubled since 1991, when the census showed that there were 9.9 million people living in the Mumbai Metropolitan Region. The population explosion, a common occurrence with any metropolitan area, can be attributed to migration from other parts of the country with migrants seeking business and employment opportunities. The rapid expansion has led to serious health issues that have to be addressed by the government, and a large percentage of residents live in the city's slums. Sixty-two per cent of Mumbai is staying in slums-shanties and even brick and cement houses built in unplanned manner with limited access to civic amenities.[6]

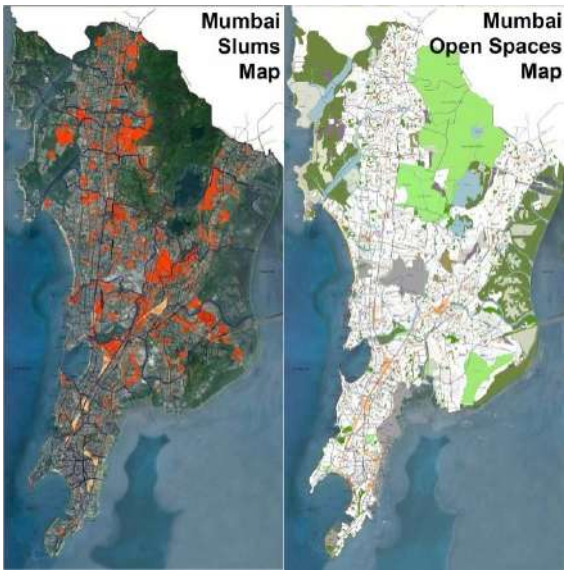
"Slums are a manifestation of the two main challenges facing human settlements development at the beginning of the new millennium: rapid urbanization and the urbanization of poverty." [7]

Mumbai has seen an alarming increase in migration numbers ensuing in the resultant numbers living in slums. As per the Census 2011, more than 60 per cent of Mumbai is staying in slums-shanties and even brick and cement houses built in unplanned manner with limited access to civic amenities. Pankaj Joshi, Executive Director, Urban Design Research Institute said the whole issue boils down to affordability. "Since the state cannot provide houses to this section, they have taken care of their own needs."

Slums proliferate in Mumbai because there is no construction or availability of affordable housing in the formal market, for both the poor and middle-class people. Slums are spread widely, and mostly are informally located (i.e., without government sanction or planning), thus adversely affecting the quality of life and environment of the entire city.[8]

Figure 1

Vision of Hope



Mumbai's Development Plan 2034 has earmarked the encroached areas as public offices leaving no clarity as to whether the slums will be under the wing of rehabilitation or will be relocated to rental housing which was initially the 1950's- 60's knee jerk reaction to the formation of slums, by the Government. The physical mapping of slums carried out by *Nivara Hakk* (an NGO), brought for the first time, to front, the extent of slums in the city. Upgradation of slums was the contemplation/ attempt of the 1970's-80's through acts, programs and World Bank aid that sought to provide basic services at these sites.

Projected climate change impacts in Mumbai

The National Institute of Health (NIH) states, "changes in precipitation are creating changes in the availability and quantity of water, as well as resulting

6 Census 2011

7 Anna KajumuloTibaijuka, Executive Director, United Nations Human Settlements Programme

8 (n.d.).Das, P. (2015, October 19). Claiming Participation in Urban Planning and Design as a Right. Mumbai, Maharashtra, India.

in extreme weather events such as intense hurricanes and flooding. Climate change can be a driver of disease migration, as well as exacerbate health effects resulting from the release of toxic air pollutants in vulnerable populations such as children, the elderly, and those with asthma or cardiovascular disease." [9]

Several studies have investigated the vulnerability of Mumbai in the present and future climatic scenarios. Over the coming decades, the pressures of urbanization may be aggravated by manmade climate change and increase in greenhouse gases. (Rana, 2014).

Heavy rainfall and flooding are also an important issue for environmental health in urban areas, (19) as surface water is quickly contaminated during heavy rainfall events. In July 2005, severe flooding occurred in Mumbai, India. The city received 944 millimetres of rainfall in a 24-hour period, compared to an average of 21.7 centimetres of rainfall per year. The consequent flooding affected many households, including those in the more affluent parts of the city. Most metropolitan cities in India, including Mumbai, have poor urban drainage systems, which are easily blocked and are more vulnerable today even to short spells of rain. The flooding in Mumbai was exacerbated by blocked canals and drains.

A report states, "Furthering the daunting picture painted by the changing atmospheric conditions, the latest report by risk consultancy firm Mapelcroft has Mumbai among its list of cities that are at extreme physical and economic risk due to changes in climactic conditions. According to it, Mumbai's proximity to the coast and the surrounding hilly terrain are the reasons why it is featured in Maplecroft's sixth annual Climate Change Vulnerability Index.

With respect to urban populations and human health in Asia, the key results of the IPCC report are:

- regional freshwater resources will be strongly affected by, and vulnerable to, climate change;
- increased rainfall intensity, particularly during the summer monsoon, in temperate and tropical Asia;
- increased risk of weather disasters, particularly flood events; and
- vulnerability of coastal cities due to climate change and sea level rise.[10]

(AKHTAR)

Floods

In 2013, Mumbai was listed by the journal Nature Climate Change as the fifth coastal city in the world to be most affected by flooding in the future, measured by economic losses. The first four are Guangzhou, Miami, New York-Newark and New Orleans.

Adam Sobel, a scientist (Columbia University), in his presentation at a workshop in Mumbai, raised the possibility of linking Mumbai being the landfall in the event of a severe storm in the future and low-lying areas being flooded with climate change.

A logical first stage of any adaptation assessment is to understand levels of current vulnerability to weather. Mumbai is prone to flooding and witnesses severe disruptions almost annually; for example, between 2004 and 2007, Mumbai experienced flooding each summer/ monsoon. But in July 2005, the city experienced the worst flooding in its recorded history, resulting in damages estimated at around $1.7 billion USD and around 500 fatalities (GoM 2005). Across Northwest India, the flooding crippled an area of over 35,500 km2, affecting 20 million people and causing economic damages of around $3–5 billion US (Swiss Re 2006; Munich Re 2006). Figure 1 shows a map of the flood extent across the City and Suburban districts of Mumbai (which collectively form the Greater Mumbai region) digitalised from Gupta (2007); around 20% of the area was affected, with flood waters to a depth of 0.5 to 1.5 m in low-lying areas.[11]

As per Rana, et al (2014), the change of various precipitation statistics due to climate change for the city of Mumbai have indicated an increased amount of precipitation from 20% to 40% in all future climatic pro-

9 Climate and Human Health, National Institute of Environmental Health Sciences Retrieved from https://www.niehs.nih.gov/research/programs/geh/climatechange/health_impacts/index.cfm

10 Kovats et al 2008: Climate, climate change and human health in Asian cities

11 Ranger et al 2010. An assessment of the potential impact of climate change on flood risk in Mumbai

jections. The same can be said about extreme events of rainfall as tested for the 50 and 100-year return periods using Lognormal and Gumbel distribution functions. The increase in the extreme events ranges from 0% to 40% with two projections indicating a slight decrease. Six out of nine projections show a positive trend of rainfall extremes in the period 2010–2099, including four showing a significant positive trend at the 0.05 level

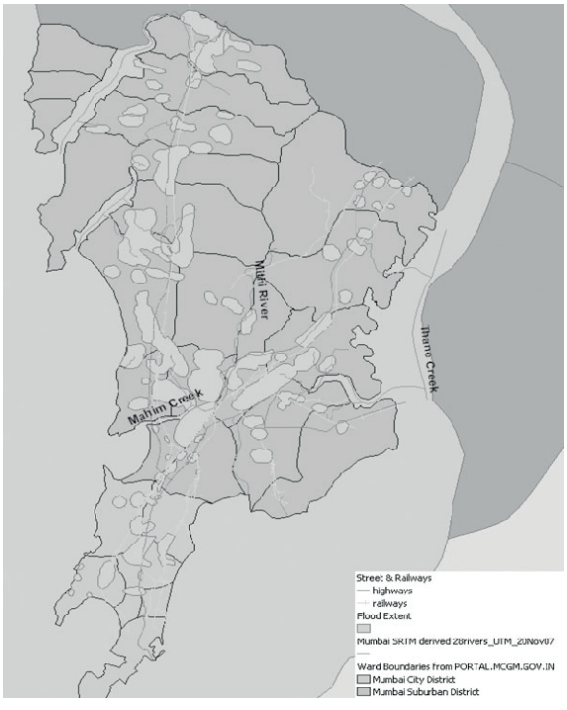
The root cause of Mumbai's susceptibility to flooding is its geography, both natural and manmade (Duryog Nivaran 2005). Firstly, the city's location leaves it exposed to heavy rainfall during the monsoon; typically, 50% of the rainfall during the two wettest months, July and August, falls in just two or three events (Jenamani 2006). Daily rainfall amounts of up to 250 mm are common during monsoon season (Rana et al., 2012). The scientific study conducted by Rana et al, "Impact of climate change on rainfall over Mumbai using Distribution-based Scaling of Global Climate Model projections," clearly states that the results show that the intensity of rainfall, which is already relatively high considering the design standard of 25 mm/h for Mumbai (Gupta, 2007), is projected to increase in the future. The average increase in maximum rainfall is about ~15–20% in each 30-year time slice and ~30–45% in the 90-year transient period.

There have been instances where the city received 944 millimetres of rainfall in a 24-hour period, compared to an average of 21.7 centimetres of rainfall per year. The consequent flooding affected many households, including those in the more affluent parts of the city. Poor urban drainage systems used as garbage dumps exacerbated the flooding in Mumbai.

This situation is aggravated by the manmade alterations to the geography of the city; large areas of the land are reclaimed and are situated only just above sea level and below the high-tide level. This inhibits natural runoff of surface water and the complicated network of drains, rivers, creeks and ponds drain directly in the sea, meaning that during high tides, sea water can enter the system preventing drainage and in extreme cases, leading to salt water deluge. The drainage systems of the city are now inadequate to cope with heavy rainfall and are impeded by urban encroachment and channel blockages. Continued rapid urbanisation, particularly in the absence of effective spatial planning and improved drainage systems, is likely to lead to an increase in flood risk in Mumbai. This occurred during the July 2005 event; a massive inundation of the drainage systems caused as almost 1000 mm of rainfall fell on the city in 24 h was combined with a failure of the system as sea water entered during high tide. he average annual rainfall of Mumbai is 2142 mm with monsoon rainfall accounting for 96% of the total annual rainfall (Rana et al., 2012). During the monsoon, it usually rains uniformly over the city and severe flooding occurs in many parts. The duration of a rainfall event usually ranges from 30 min to 120 min, however in some cases they can be as long as 3–4 h (Rana et al., 2013).

Figure 2

Digitized flood extent map for the 2005 event (based on Gupta 2007), showing the city wards and the location of the Mumbai City and Suburban Districts



Heat

Over the coming decades, the pressures of urbanisation may be aggravated by manmade climate change. Like many other areas, the Northwest of India has observed a statistically significant warming of annual mean surface air temperatures over the past century (IPCC 2007, Figure 3.9). While no statistically significant trend in annual rainfall has been observed in the past three decades (IPCC 2007, e.g. Figure 3.13), there are signs of an increased contribution to annual rainfall from very wet days.[12]

The "urban heat island (UHI) effect" is the phenomena where cities become warmer than surrounding rural areas as temperatures are raised by heat-absorbing concrete and asphalt, high population densities, and pollution. Kovats et al, says in tropical cities, the mean monthly urban heat island intensities can reach 10°C by the end of the night, especially during the dry season. Particularly in informal settlements the materials used for the dwelling like tin sheets add to increase in temperatures within the houses.
"Pollution generated locally is usually swept away by wind blowing in from the sea. In Mumbai's case, however, it is surrounded by hilly terrains and numerous mountain ranges that lock this air within the area. Also, the extreme humidity tends to hold on to particulate matter for a longer time. Increase in temperatures especially during fires adds to the increase in the particulate matter in the environment.

We think it's factors that put it at risk of extreme weather events and climate change," explained Gufran Beig, scientist at the Indian Institute of Tropical Meteorology. ◆

12 Alexander et al. 2006

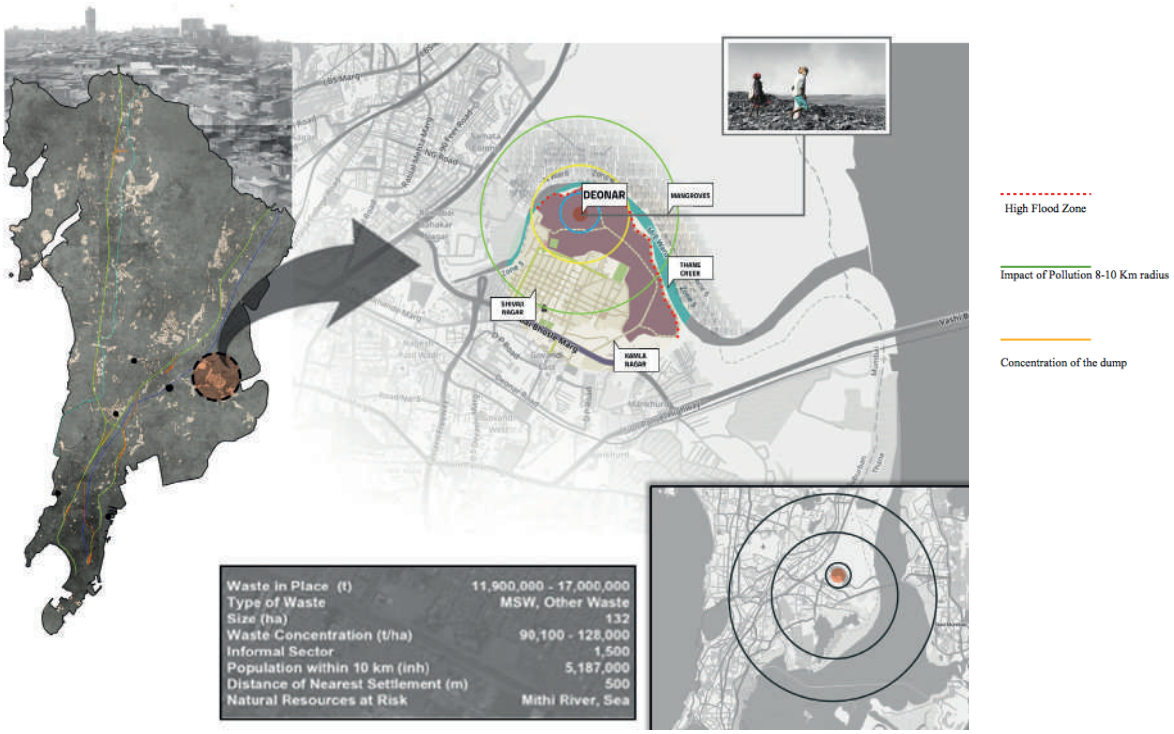
PART 3
CASE STUDY

Case Study: Deonar (Aadarsh Nagar)

The Adarsh Nagar, the research area, is a settlement near the Deonar dump yard site and is situated in the eastern suburbs of the city, adjacent to Thane Creek, in an area of about 132 ha of land. The dump yard is surrounded by the creek on one side and a slum on the other.

Figure3

Deonar Dump yard and surroundings



In 1972-73, poorer residents from inner city areas were relocated to Shivaji Nagar, Baiganwadi, and Lotus Colony. More people, largely Dalits[13] (formerly known as untouchables) and Muslims relocated around the dumping ground, following acute droughts in rural Maharashtra and other parts of the country. In 1976, people were internally displaced within the ward, when residents of Janata colony within and around the Bhabha Atomic Research Centre were shifted to Cheetah Camp. The Prime Minister's special grant for urban renewal from 1986 to 1993 resulted in massive eviction of poor people from inner city areas to Deonar. This trend of relocating a large number of slum households from all over the city for "development" continued from 2003 to 2006, with World Bank-funded infrastructure projects.[14]

Source: MapsofIndia

13 Retrieved from https://www.dalitsolidarity.org/dalits-and-untouchability.html

14 Parasuraman 2016, on the margins in a city of dreams

The Shivajinagar - 1 and 2 area was made available by the BMC and was laid out in the traditional grid iron pattern land, water lines, and toilets, but homes were to be built by each family itself, as one NGO puts it, "as per their means": either pucca – out of concrete and brick – or *katcha* (temporary)– out of tin and bamboo poles and whatever materials were readily available. Each grid housed 16 families with individual toilets and four shared taps. The lower caste Maharashtrians (a prominent caste in Mumbai) of downtown Churchgate (workers at Mantralaya- the government headquarters) were amongst the first to be relocated followed by families who came from areas that were demolished in a wave of urban development and infrastructure projects.

Bainganwadi (eggplant field), the second phase of Shivajinagar was made available after displacing the vegetables and was settled through a process of demolition, resettlement and migration. The relocation of the Bandra west (western suburb in Mumbai) slaughterhouse into the M-East Ward (as zoned in the 1967 Development Plan), confirmed the large migration of butchers who were allotted the "Bandra plot" on the eastern side of Bainganwadi. Similarly the municipal employees employed at the depot were housed near the BEST plot adjacent to the bus depot on the southeast corner of Bainganwadi. (Lisa Björkman: Becoming a Slum: *From Municipal Colony to Illegal Settlement in Liberalization-Era Mumbai*).

The exponential growth of Adarsh Nagar, Deonar, settlements were a resultant of the livelihood means offered by the dump yard. In M-East ward, over half a million-people living in the most difficult conditions contribute immensely to keep the city moving. They maintain our antiquated colonial sewage disposal system, clean the streets, take away and sort garbage, work as security staff, as maids in well-off households, as constables, and provide other basic services.

Man Made Hazard

Garbage dumped here is often mixed waste – with paper, plastic containers, bottles, cans and at times electronic goods. Moreover, when it accumulates with decomposable wastes from food, dead animals, construction debris and even industrial waste then it is definitely a serious health concern.

- Burning even small amounts of plastic and rubber releases chemicals that are unsafe.
- Open burning is an inefficient combustion process that releases significant amounts of air pollutants and ash, and dense white or black smoke, the scientist explained.
- The air contaminants released depend on the material being burned and the conditions of the fire.
- The greatest health risk from the open burning of garbage at a waste disposal ground is for those closest to the fire who may inhale the smoke.
- The pollutants are all toxic to humans depending on their concentration and may cause irritation, skin and respiratory problems. Some are carcinogenic. Those individuals with respiratory problems such as asthma or with allergies may be even more sensitive to the smoke.

Impact of urban development on settlements at Deonar

During this period, popular neighbourhoods and affordable housing were built and provided with civic amenities in Bombay through a variety of processes and arrangements that index a lively politics of housing possibility and infrastructural provisioning during these years. In the M-East Ward, for instance, the self-built neighbourhood of Kamla Raman Nagar had by the early 1980s been officially "declared" a slum under the provisions of the Slum Act.

Figure 4

Dp sheet 1991 showing the "Utopian" Land-Use Zones created.

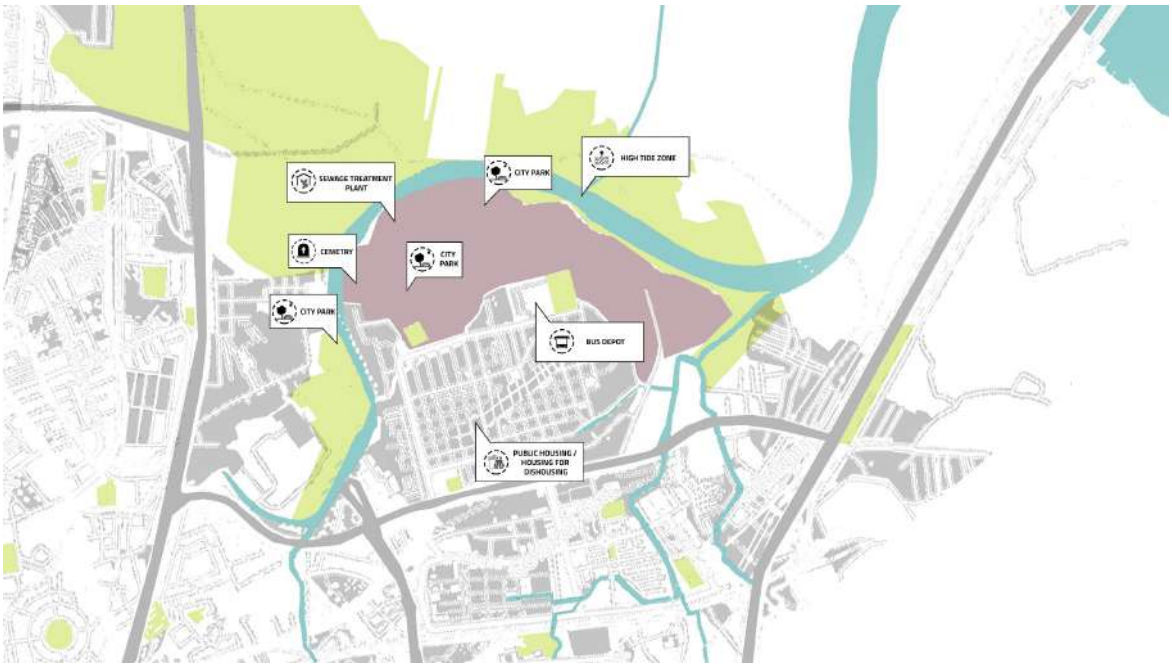


Figure 5

Growth of the Dump yard and slums as taken from Google maps

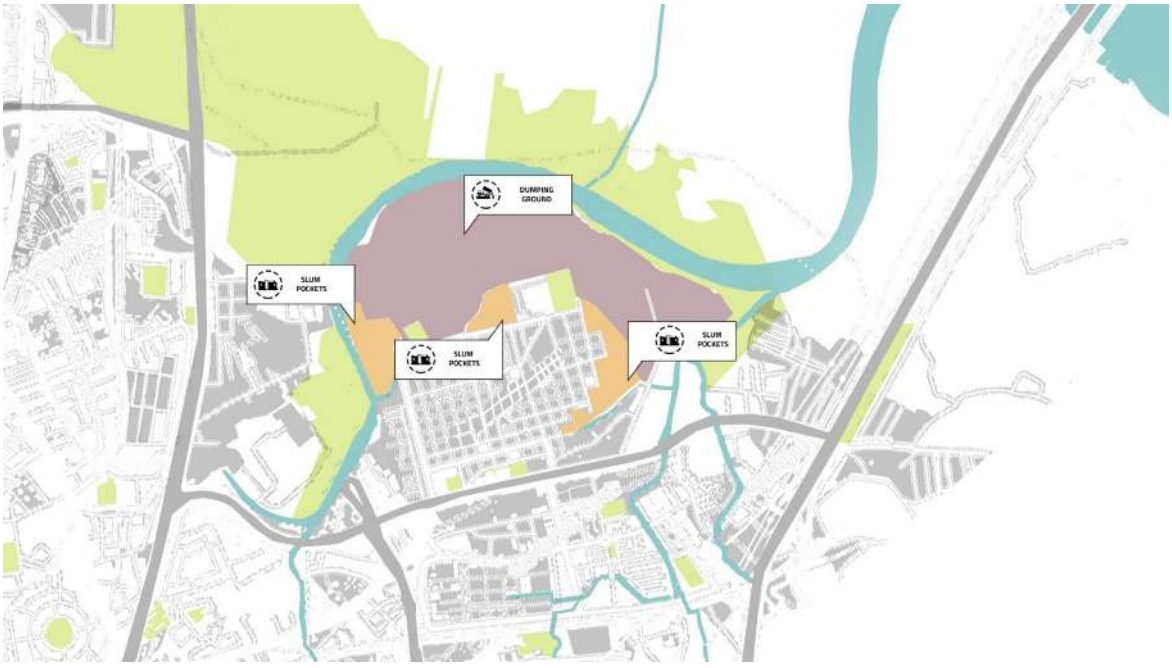


Figure 6

DP Sheet 2034. Marking the dump as "Municipal Services" and the slums as "Education"

Neighbourhoods like Kamla Raman Nagar were "declared" slums in the 1970s and '80s, which facilitated the laying of water mains and other infrastructures. Unfortunately, the shift in slum and housing policy since the early 1990s has since then side-lined policies based on the official definition of slum as an underserved neighbourhood eligible for infrastructural-upgrading programs. Jane Jacobs an advocate of configuring cities around desire lines said, "There is no logic that can be superimposed on the city; people make it, and it is to them, not buildings, that we must fit our plans."

Apart from the enlargement of the size of the dump, this ward is the poorest and most deficient in civic services. Most of the houses do not have sanitation and water facilities as they are on encroached land. Toilets are provided with septic tanks and no formal drainage network exists.

A little later, a large section of migrants and displaced families had begun to inhabit in the huge marshy terrain beyond the gridded area mentioned above. The inhabitants, including children, have been sorting garbage and engaged in rag picking for years together. The makeshift shelter built of marshy land and garbage heap is characterized by tarpaulin sheet, tin shades, crowded and filthy lanes, overflowing drains and the overpowering stench from the dumping ground. The ethnographies of the locality and resident provide vivid description of precarity and insecurity of work and habitat, informality and illegality associated with access to basic services and experiences of humiliation and indignity while interacting with the 'other'. Accustomed to the reality that their shelter would be bulldozed and demolished by BMC at least three times in year, the ethnography captures people's struggle, patience, perseverance, negotiations and assertion. The constant fear of eviction and experiences of unprofitability of livelihood by rag picking haunt the lives of men, women and children as they sift through the garbage. Excluded even in the urban periphery of M-East ward, an area that is infamous for its underdevelopment and lowest HDI in Mumbai, Nagar symbolized poverty and marginality of migrant population in the city.

Site Conditions

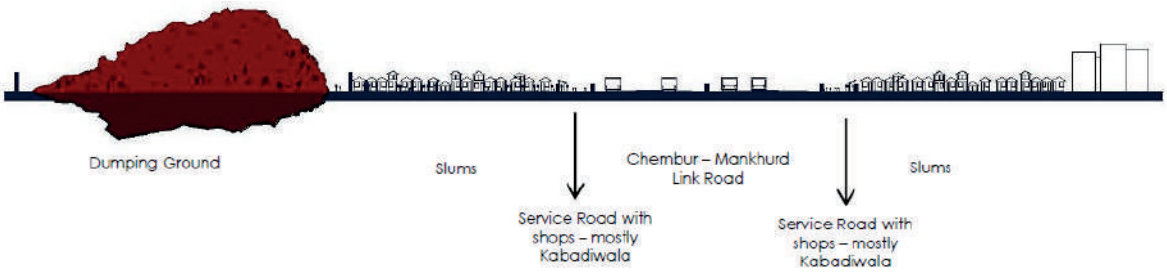
Visual surveys constructed on site reveal appalling conditions that the inhabitants (mostly migrants), live in. The Government has been permitting the people to fill in the marshy land as reclamation which they build their shelters on. They live on the edge or virtually on the garbage dump. The ani-encroachment drive that takes place twice or thrice a year instils insecurity in the inhabitants who also suffer from losses of assets. The nallahs (open drains) are perpetually filled with garbage and seepage from the septic tanks at times.

Living by the side of a dumping ground is the last thing on the earth one would imagine, however, they seemed to have reconciled to their situation as the place has become a hub of a number of entrepreneurial activities and businesses based on waste collection from the dumping ground.

Images 1-4

Figure 7

Typical section of the Deonar Dump and neighboring Slums



Source: Author

Layout and density of dwellings

The dwellings though laid out in a grid iron fashion are extremely closely knit. The units at Kamla Raman Nagar are constructed in brick and are one storeyed, characterised by narrow alleys that separate two rows of dwellings also serving as the storm water drain. Windows of the units open out into this small alley. The storage drums for water are placed in these alleys and most of the washing and cleaning activity also takes place in this alley. Most of the drains are in a damaged condition. (Image 3) and often strewn with garbage. This leads to the clogging of the drains and collection of contaminated water leading to unhygienic conditions as it forms a breeding place for mosquitoes that in turn result in vector borne diseases.

The dwellings at Aadarsh Nagar are made of more temporary materials like tin sheets crudely boarded up and roofed with the same material. The units in this area are just about a metre apart. Single rooms of around 10 x 12 ft made of thin tin sheets - the walls and the roof - with light wood logs supporting the structure. There is no scope for windows or any ventilation, the shelters have very hot interiors. Their belongings usually consist of a few ragged beds, a large mat, a kerosene oil stove, some aluminum utensils, two large jerry cans for water storage, a bucket, an air bag and a suit case and a few clothes - were casually strewn in the shelter.

Images 5-7

Narrow alleys between settlements



Lack of Basic Services and their relation with health issues:

Drinking water and Toilets

On December 15, 2014, in a long-awaited ruling on a Public Interest Litigation (PIL) filed by the Mumbai-based organization Pani Haq Samiti, the Bombay High Court ruled that "the state cannot deny the water supply to a citizen on the ground that he is residing in a structure which has been illegally erected," directing the Municipal Corporation to formulate a new policy. The delinking will once again allow municipal staff to turn their full attentions back to water supply planning, hydraulic engineering, and to the much-needed work of infrastructure upgrading, maintenance, and repair. [15]

A typical day at these settlements starts at around 4 am when the municipal water becomes available. All the members are involved in filling water in the containers they possess. Drinking water that is provided is of poor quality as mentioned by the residents and is further contaminated by inappropriate storage methods arising out of lack of space.

Source: Author

15 Björkman 2015. *Of Pipes and Slums: Understanding Mumbai's Proposed New Water Rules for Residents of "IllegalStructures"*

They remarked that the water is visibly turbid at times. The containers are often left open and most often children take a comforting dip to beat the heat. The other alternative is to buy drinking water which is a stress on their finances.

Kamla Raman Nagar has one public toilet for women and men in the entire locality. There is no provision of water and hence the users carry one bucket per person for the daily rituals. The water is highly inadequate for keeping the toilets clean and despite the fact that the municipality carries out cleansing of the toilets twice a day, the condition is deplorable. (Image 4)

The ratio of the toilets per person works out to 1 in 290 as per the study carried out by MESN for MCGM and is the main reason for inhabitants to resort to open defecation. This gives rise to two issues. One that is obviously related with hygiene issues related with menstrual hygiene, where women are concerned. The unhygienic conditions as well as the lack of water lead to skin allergies and genital ailments. Inadequate quantity of water would mean inability to clean the private parts thoroughly thereby causing the skin allergies that eventually lead to the genital ailments.

Images 8-11

Sanitation and Drinking Water

Source: Author

Emphasizing upon insanitary and dangerous living condition, Menon (2013) says "it can be surmised that given the quantum of faecal matter that is disposed of in the open, in and around the living spaces of the poor, means that the poor are literally living in the conditions of their own demise".

Shriya Malhotra in her paper "Population Health through Inclusive Urban Planning: Healthier Communities and Sustainable Urban Development in Indian Cities", establishes that due to the exponential increase in city population, it is imperative that we explore the "*urban*" dimension of health and sustainable living.

Environment Quality

The doctor also blames the pollution oozing from the dumpsites for the spiralling incidence of respiratory infections in the area. This is supported by a recent study of air pollution in the Mumbai area, which found Deonar to be one of the areas most susceptible health impact due to the high concentration of the air pollutants PM10, NO2 and SO2 (Kumar et al. 2016).In fact, inhabitants at Deonar, have the maximum exposure to Pm10 which is the primary cause of chronic obstructive pulmonary disease (COPD) and allergic rhinitis among them. Similarly, they have the maximum exposure to NO2 and SO2 that makes them susceptible to cold and allergic rhinitis

and result in lower respiratory diseases like cardiac ailments and other chest illnesses respectively (Kumar et al. 2016).

Dr. Dilip Sarda, former President of Indian Medical Association (IMA), Maharashtra states, "The pollutants are all toxic to humans depending on their concentration and may cause irritation, skin and respiratory problems. Some are carcinogenic. Those individuals with respiratory problems such as asthma or with allergies may be even more sensitive to the smoke, he explained. Stunted growth, birth with disabilities are prominent in these areas and poor access to heath infrastructure is the primary factor for inhabitants to reduce their vulnerability." The air quality is largely affected and pollutants like particulate matter PM 10 and PM 2.5 remain suspended in the air. Inhaling particulate matter 2.5 (very fine particles) are even more dangerous than PM 10 as they directly enter the lungs, NEERI scientists explained (Hindustan Times, March 23, 2016, Air quality poorest in Maravali, Deonar and Andheri). Tests conducted show an increase particulate matter during summers but a distinct reduction during monsoons but a definite rise in contamination of drinking and ground water.

Image 12

Overflow of garbage

Image 13

NASA picture of fumes from the dump yard

Kumar et al. (2016) also reveal that the maximum concentration of pollutants is found in winter and a minimum concentration in the monsoon. I would like to bring to your notice that this particularly indicates an increase in pollution levels as the air in thinner in winter and in the monsoon the pollutants are diluted or dissolved, and hence an aggravation of respiratory diseases during the winter. According to the physician interviewed at Deonar, though the cases of respiratory ailments may drop during the monsoon, contrarily the cases of inhabitants suffering from water borne ailments is on the increase. Though the nature of the disease may thus vary at different times in the year, people in this area are perpetually exposed to health risks.

Health Care Centre

There is only one public health centre located near Kamla Raman Nagar. This centre is visited by around 200 patients daily, mostly women), with complaints of throat and eye irritations, respiratory ailments, skin allergies and genital and menstrual problems. (Interaction with the physician at the public health post). Most women tend to be at home looking

Source: Author

after the needs of the children and the home. That exposes them for a longer period to the toxic gases in the environment. Also, their biological structure makes them more vulnerable to genital allergies and diseases as compared to men.

A "Right to Information" in obtaining the logs for diseases in women shows almost a three to four time increase in water borne diseases during the monsoon. The vector borne diseases were not indicated and it was only from the physician that it was established that there was increase of cases during the monsoon. The respiratory diseases are not well indicated either, but the inhabitants suffer from chronic respiratory ailments. Extensive interaction with them on site at various times of the year helped in observing the throat irritation they suffered from at all times. I personally experienced burning sensation in the eyes as well throat irritation accompanied by skin irritation.

Image 14

Patients at the Health Care Centre

Image 15

Poorly ventilated homes

Source: Author

Table 1

Health and Climate Change Nexus

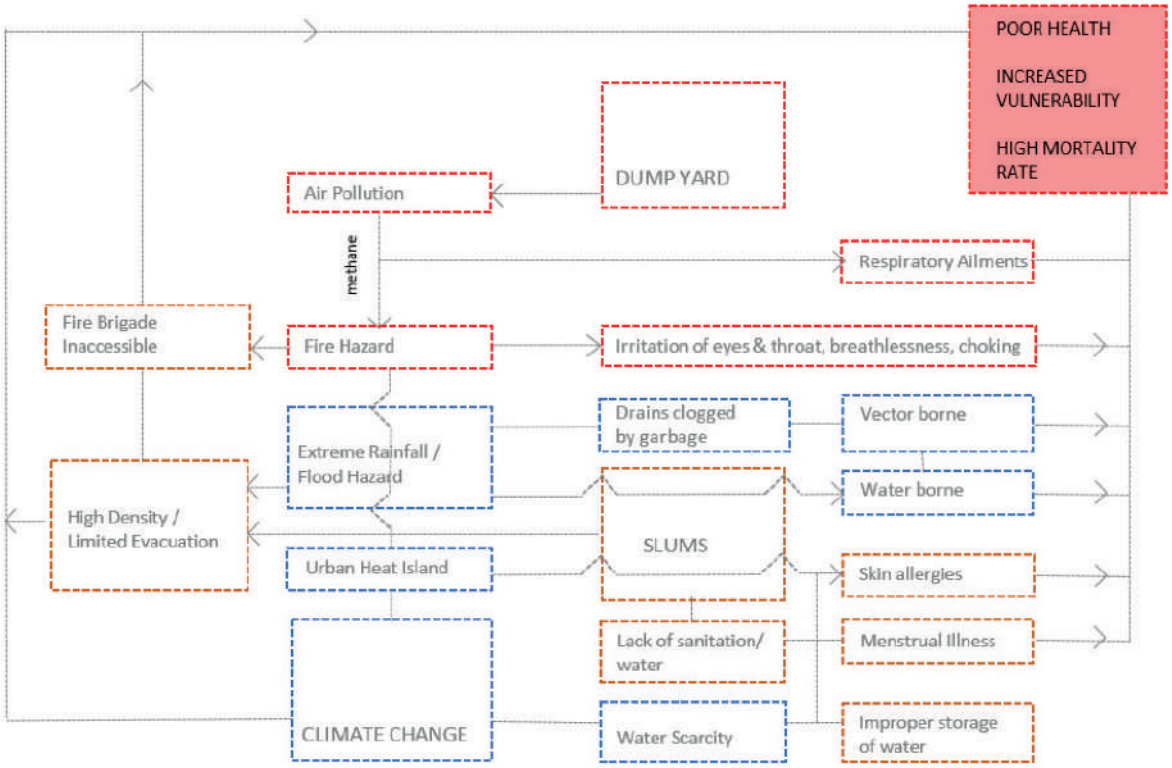


Table 2

Analytical framework for the research question

How do natural hazards (or: extreme rainfall events) contribute to further exacerbation of health risks/ problems in informal settlements. ◆

Risk Component	Hazard	Vulnerability	Response Preparedness	Recovery Preparedness
RQ1: What are the existing risk? And what are the adaptation and reduction methods used?	**Flooding** – During rains mainly and due to drain blockage. **Fire Breakouts** – Due to short circuits and cigarette butts or during cooking on chulhas. **Epidemics** – like diahorrea and jaundice due to bad water quality and sanitation facilities like lack of toilets. **Local fights** due to druggists	1. To avoid flooding people lay big stones on paths to demarcate paths even if water fills in order to be able to know the existing holes on paths. 2. Lay plastic sheets on roofs to avoid leakage and water entering from top. 3. Keep big tyres handy in order to float. 4. Cover the alleys between two houses to avoid rain water to come directly on lanes and home. For fire breakouts, small fires are extinguished by soil. Basic health centres for curing diseases in area.	1. Mostly people have the mobile furniture. 2. They keep their valuables and documents on the higher level. 3. In case of emergency they can leave their houses immediately as they do not have any valuables or electric devices. 4. They go to basic government hospitals like Rajawadi hospital in Ghatkopar for their health issues. 5. Basic defence like rods and bamboos are kept handy by women in order to drive away druggists. 6. In case of minor fires drain water and soil is used.	1. Firstly, they do not have pukka houses and more to it they do not have any valuables, so resettling at new places is easy. 2. During rains, floods, they have now started having higher plinth homes in order to avoid water entering the houses. 3. They do not have all their money at home, but all of them have bank accounts and so their money is safe during emergencies, hence rehabilitation becomes easy.
RQ2: What is the Link between risk reduction/adaptation practices and health	• During rains they drink boiled water to avoid diseases. • Nowadays even though they defecate in open they cover feaces with soil, thus reducing risk of diseases to some extent.	Vulnerable to many lung and skin diseases due to dumping yard, as a result lifespan is decreasing.	Health centers in the area serve the basic purpose. Things like childbirth are often carried out at home with the help of experienced ladies.	At times, time is wasted while travelling the narrow alleys as no vehicular access is possible. Nothing beyond local health centres help. In case of local fights, people themselves resist without involving police.
RQ3: What are poor health → disaster risks	Diseases of lungs, eyes and skin are mainly associated with area. Also lack of hygiene causes many women problems and infant mortality is on high.	Things like consistent smoke by burning dump and continuous bad stench causes lot of lung diseases. Also, at times there are cuts on hands and legs while fetching waste.	Lack of awareness and money leads to no exposure or visit doctors for health check-ups.	Due to lack of knowledge, awareness and bad financial condition, they refer suffering to death or else the whole family income gets disturbed.
RQ4: Disaster risk → poor health	• People have started drinking boiled water. • They cover their open faeces with soil, than leaving them open to spread diseases. • Childbirths are carried out with the help of the local doctors. • Children are given vaccinations on time from the time of birth.			
RQ5: Role of lack of basic services	• Basic services like lack of widened roads, limits the access of emergency vehicles like fire brigades and ambulances in case of emergencies. • No proper water supply in toilets leads to bad sanitation. • No electricity leads to increased eve teasing and encourages druggists and drunkards during the dark. • Locals do not allow police to enter areas as a result, there are increase in crimes. • Lack of health centres and monthly health camps lead to increase in diseases.			

PART 4
RESULTS

This section presents the inferences and concluding observations in relation to the 3 research questions.
The interaction with the inhabitants, undercovers the fact that the inherent nature and characteristics of the slum dwellings places the inhabitants at a concentrated disadvantage especially where health is concerned.
By drawing on secondary data and by analyzing the responses, the research questions have been answered with the help of participatory mapping.

1. Exacerbation of health risks due to extreme climate change events
2. Slum upgradation and risk-based land use planning to address health inequities
3. Impact of city growth and development on the vulnerability of the marginalized communities

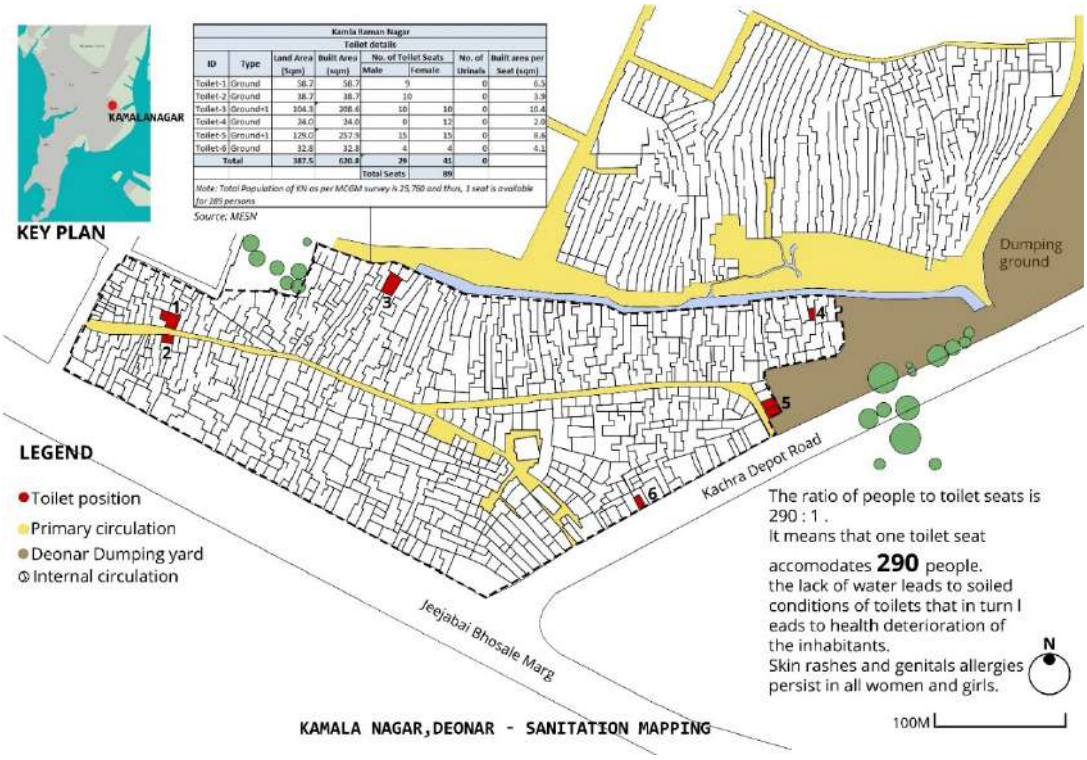
Impact of extreme rainfall on health issues arising out of lack of basic services, aggravation of water borne and vector borne diseases
The choice of geographically hazardous locations arises out of the insecurity of tenure of the migrant homes. The proximity to their place of livelihood determines the location of their residence and adverse impacts arising out of seem to be ignored by the inhabitants. The consequences however are monstrous.
Many slums are not notified (registered in official books) in official records and remain outside the purview of civic and health services. Lack of access to primary health care services due to their inadequate numbers and poor quality of health care arising out of their economic status. Hence during extreme climate events when the health issues aggravate, the inhabitants are more vulnerable to formal drinking water supplies are available only at Kamla Raman Nagar settlements that were originally provided. The illegal status of the slums does not merit them water connections by the Municipal authorities. Only one municipal drinking water line is provided at every lane. Unauthorized connections are available at a steep price of Rs. 16,000 each and near to impossible to obtain for those who with meagre incomes. It is important to fathom the priority of wants by the settlers taking into consideration the pitiful incomes that are generated.
It is thus evident that due to lack of basic services, extreme rainfall events make them more susceptible to water-borne and vector borne diseases.

Structured interviews were conducted by respondent driven sampling and the results have been documented in the form of participatory risk maps (see Figures).
The supply of drinking water is restricted to a couple of hours in a day and is usually contaminated at source which is subject to further contamination due to improper measures of storage that warrants attention as health issues aggravate due to non-sanitized conditions. Storage water drums are kept uncovered and often used to take dips by the children to counter the scorching heat. Thus, the scarcity of water leads to improper storage and use of the water. The long hours spent in collection of drinking water results in children abstaining from school, as more hands to help are a welcome relief.

"People are suffering. Children and senior citizens are the worst-hit," said Dr Rahil Qumar Siddiqui, who works at Rajiv Gandhi Medical Centre, which is located on the edge of the dumping ground. The outpatient numbers have gone up by 20 per cent ever since the fire started this year. "People are complaining of irritation in the throat and eyes, and also of breathlessness," he said, adding that the visibility at night drops to 8 to 10 metres at times.

Figure 7

Mapping of Sanitation Services



Source: Author

The appalling ratio of the number of people to the toilet seats available (Figure 1) coupled with the absence of water supply leads to unhygienic conditions. It is virtually impossible to maintain cleanliness in the toilets due to lack of water. The areas that have come up post 2001 are completely devoid of toilets. The women and children resort to open defecation that leads to aggravation of skin diseases as well. Open defecation is resorted to as the number of toilets is grossly insufficient that only worsens the unhygienic situation. The interviews with the inhabitants as well as the public health office establish the high occurrence of chronic skin allergies among the women that arose from unhygienic conditions viz. absence of adequate toilets at Kamla Raman Nagar and the fact that women have to resort to open defecation at Bainganwadi. A large percentage of women suffer from menstrual problems and genital infections. (Table 1).

The absence of a sewage system is major factor in aggravation of unhygienic conditions leading to further spread of diseases. The spillages of raw sewage are observed which collects on the streets or flows into the open nallahs (drains). There have been instances where the toilet floor has collapsed and users have fallen into the septic tank below. The exposing of the septic tank, lack of water and reluctance to use the public toilet due to large distances all lead to the disease problem.

In which ways do natural hazards (or: extreme rainfall events/ extreme heat) contribute to further exacerbation of health risks/problems?

In case of extreme rainfall events the narrow lanes experience water logging and flooding. The drains present in the lanes are of deplorable condition and

are often filled with garbage. Stagnant and unclean water are breeding places for mosquitoes and the result is an aggravation of vector borne diseases especially malaria (interview results).
Interview results show that the poor quality of drinking water is affected in these times and the health office at the public health centre states that it causes an aggravation in the water borne diseases.

It is very evident that there is an exasperation of water borne diseases during the monsoon and flooding situations and the lack of available public health infrastructure and timely treatment aggravates the situation further. A number of NGO's provide free medication during the times of disasters but that serves only as a temporary relief.
The area has been examined and after thorough visual inspection and researchers' observations along with the help of the resident's interviews, a hazard map of Deonar (Aadarsh Nagar) has been drawn.

Primary Data of the health issues in women after extreme weather conditions (Interviews)
Out of the 72 houses interviewed, around 56 women suffered from respiratory diseases which escalated to 65 during times of extreme weather. 20 women suffering from water bone diseases escalated to 65 and 28 women suffering from vector borne diseases escalated to 47 during extreme weather events.

Table 3

Secondary Data of the health issues in women after extreme weather conditions.

No.	Respiratory Diseases	Skin Allergies	Water borne	Vector borne
Normal	35%	100%	25%	35%
Extreme weather	55%	100%	50%	55%

In both cases, it evidently shows an aggravation of health issues during extreme weather conditions. A notable increase in water and vector borne diseases is observed after extreme rainfall events. Similarly, an aggravation of respiratory ailments during and after a fire can be established looking at the results.
Skin allergies are persistent at all times with women that is attributed to lack of sanitation facilities. The sanitation requirements of women and girls differ from that of men in the sense that they have to be concerned about personal safety, dignity and menstrual hygiene. They are burdened by spending long hours standing in queue and often compelled to use the early hours of the morning to ensure their safety as well as ensuring timely reporting to their place of work or labour. This further results in begetting down their level of physical safety and there have known to be a number of instances when women and girls have been subject to molestation in case they have had to resort to open defecation. Notwithstanding to say that women with disabilities, pregnant women and early mothers are exposed to health problems arising out of reduced immunity levels.

An interviewee says, "My wife is suffering from high fever and vomiting perpetually. This stems from the quality of drinking water available to them."
He did not seem very concerned about the entire family suffering from dengue, malaria or diarrhoea, not understanding the intensity of the seriousness of the disease.
He stated that during rains the situation becomes worse as waste from the open dumping ground floods into their locality and their houses giving away foul odour.

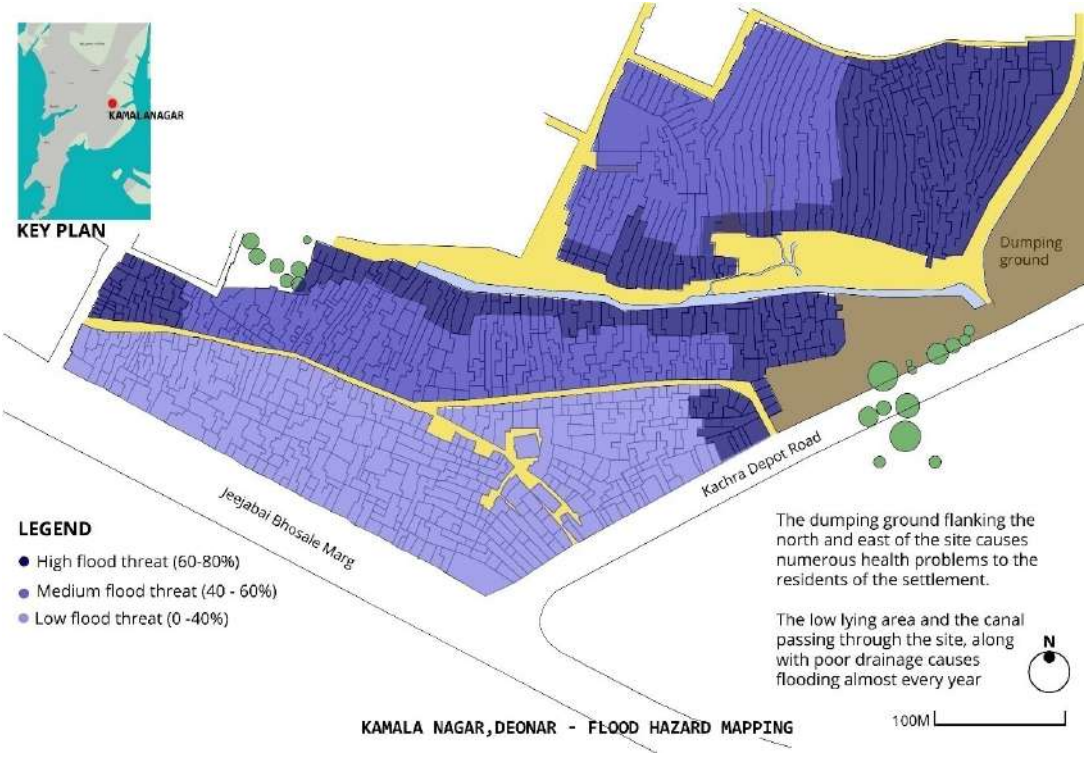
Najma Basir who stays at Adarsh Nagar says, "There are no toilets in this area and we have to resort to open defecation which is unhygienic as well as dangerous. Our homes are made of temporary materials and in case of demolition, it takes almost ten years to recover from the debt." She is a rag picker at the dump yard who earns around 300-400 Rs/day.
Rabia Sheikh says, "I need to carry out sonography tests almost every month due to menstrual problems. I can hardly afford it and have learnt to live with it. All our belongings were burnt during the fire. We even used drain water to try to dowse it but

it didn't help. Since the girls were at home all of them were affected with acute respiratory issues months after the fire was put out. This clearly shows how the women suffer prominently from menstrual and respiratory issues.

These quotes show how fire hazards are not only linked with health (respiratory) problems in the slums but can also get aggravated during summers when the temperatures are really high.

Figure 8

Flood Mapping



The slum under study come under a flood prone area and lies adjacent to the nallah (drain) and the waterlogging and flooding takes place where the lanes have an extremely narrow width. Under the event of extreme rainfall, the nullah faces water logging which leads to an aggravation in water borne diseases. The BMC mentioned in the Age Correspondent of June 19, 2016 that Deonar has a maximum of polluted nullahs (drains) and is hence prone to flooding due to garbage in the nullahs that was supported by a study by the Indian Institute of Technology-Bombay (IIT-B), Monash Academy and IIT-B's Interdisciplinary Program in Climate Studies that found areas of Deonar, to be at a maximum risk of loss to life and property.[16]

The respondents are observed to be clearing their throats and coughing perpetually and the surveyors also experience itching, throat irritation and irritation in the eyes during the site visits. As per the MCGM report the environment quality is very poor and contamination of ground and drinking water exists leading to susceptibility of water borne diseases in that area.

16 http://www.iitb.ac.in/climate/en/breaking-news/5-mumbai-wards-risk-floods-landslides-study

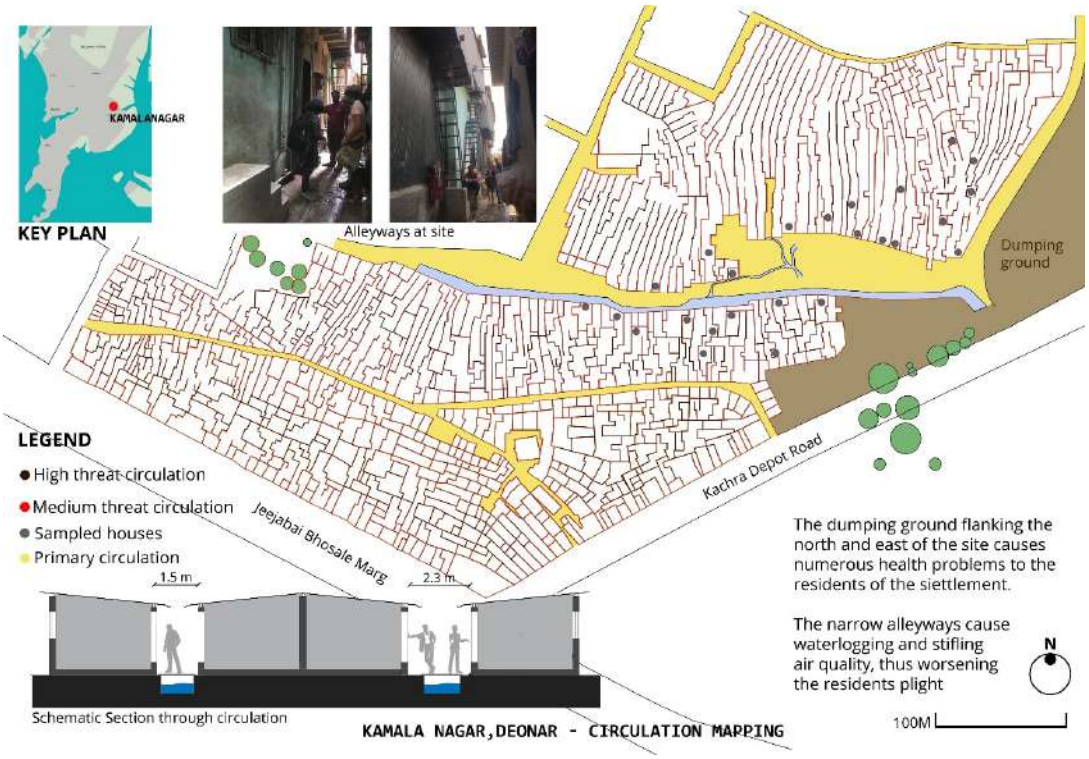
The medical officer at the public health office explains the depleted conditions of living at the Adarsh Nagar, Deonar slums. The high density of household population is the primary driver to very poor living conditions. He reiterates that skin infections are on the rise, the increasing temperature during summers that cause an increase in sweating also aggravate the situation. He treats around 200 women a day for skin complaints. Timely medical attention is not provided due to both absence of adequate number of health centres as well as the economic conditions that do not permit them to be treated at private clinics.

His observation and practice reveal that the though there is an increase in respiratory issues at the time of fires, not all infected visit the medical centres and tend to leave it untreated. He does impose the fact that those already suffering from diseases like asthma and TB face an aggravation in health problems during the summer and during fire. It is evident that existing health problems make people more vulnerable to climate related impacts.

A study of circulation in and around the sampled houses revealed the level of threat in case of water logging as well as occurrence of fire. A detailed inspection taken with regards to the widths of the lanes as well as their condition exposes the fact that the only escape routes available do not offer any assistance during the time of a fire. There is also the insecurity of losing the house and belongings which that prevents them from leaving the place until a dire situation arises or they are forced to leave. This leads to life threatening situations at the

Figure 9

Physical Circulation Mapping (of people)



Source: Author

Images 16-18

Narrow lanes of 1m width

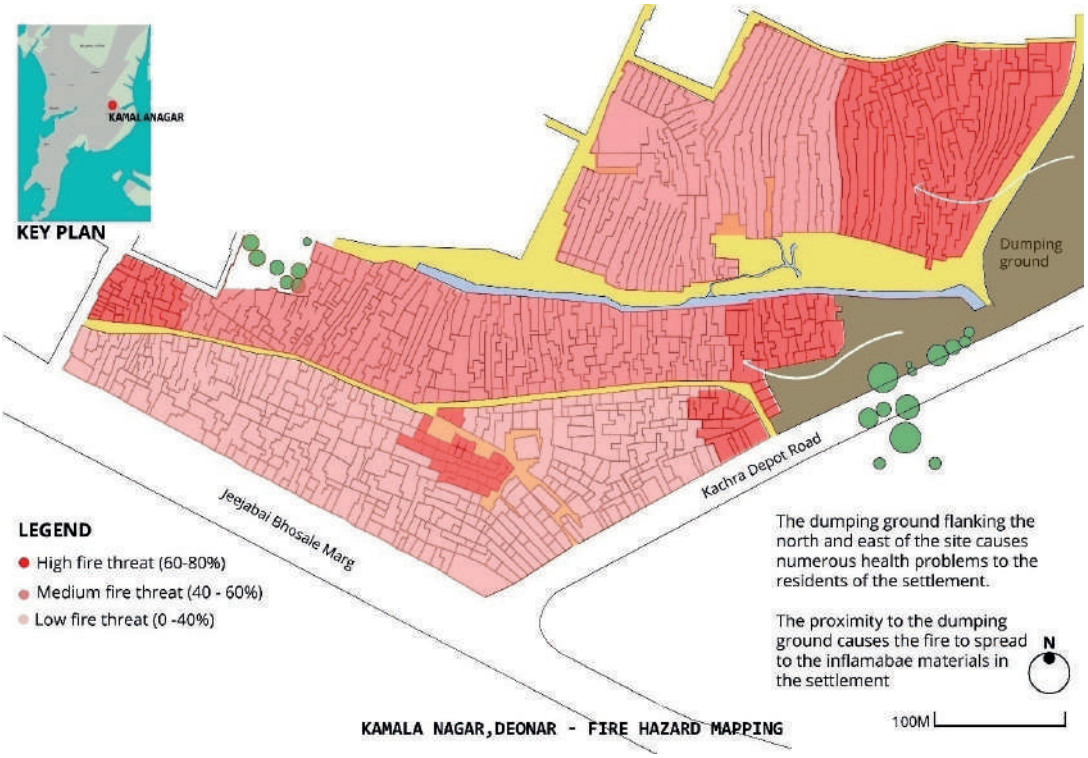
time of fires.

Narrow lanes showing broken drain covers that hinder escape in times of floods and fire. It has been observed that large part of the population at home are the women and children and they are the ones who are affected during these times.

This is the major cause of concern during floods and fires as this confined space does not facilitate easy escape during the time of fires and extreme rainfall events. The materials obtained arise mostly from what the financial status allows the inhabitant. They comprise of bamboo or casuarina framework, tin and plastic. used for the dwellings.

Figure 10

Fire Hazard Mapping



Source: Author

This hazard has been mapped with the help of visual inspection of the lane width and proximity to the dump yard.

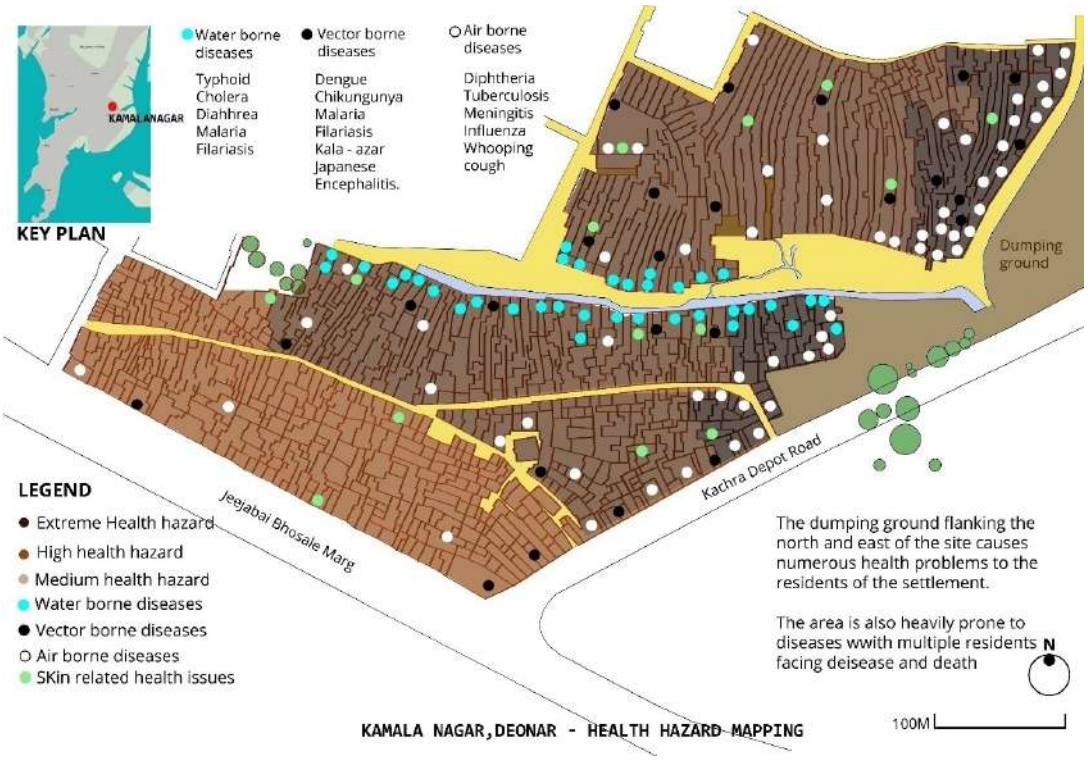
Presence of the highly combustible methane generated by the decomposition of garbage is the main cause of fires and coupled with the high temperature during summers increases the frequency of the fires due to this combustibility. The urban heat island effect is responsible for aggravating the release of methane and other toxic gases in the atmosphere that results in increase in the number of respiratory ailments (include proper reference).

The inhabitants are assiduously exposed to the multiple risks. Firstly, the hazardous levels take on alarming proportions in case of breakout of major fires. Immediate escape is virtually impossible and the implications on health, magnanimous. Raging fires lead to difficulty in breathing and an aggravation in respiratory ailments like bronchitis, asthma and tuberculosis, Secondly, situated in the flood prone area (declared by the municipal corporation) subjects the inhabitants to frequent water logging and flood conditions. Inhabitants allude a sharp escalation in water borne diseases at such settlement area creating unbearable foul odour in the area as well as an upsurge in unhygienic conditions sterning from sanitation issues.

The prevailing health issues have been mapped from the results of the structured interviews. It can be observed that the water borne diseases are prevalent near the nallah (drain) while the residents with respiratory diseases are closest to

Figure 11

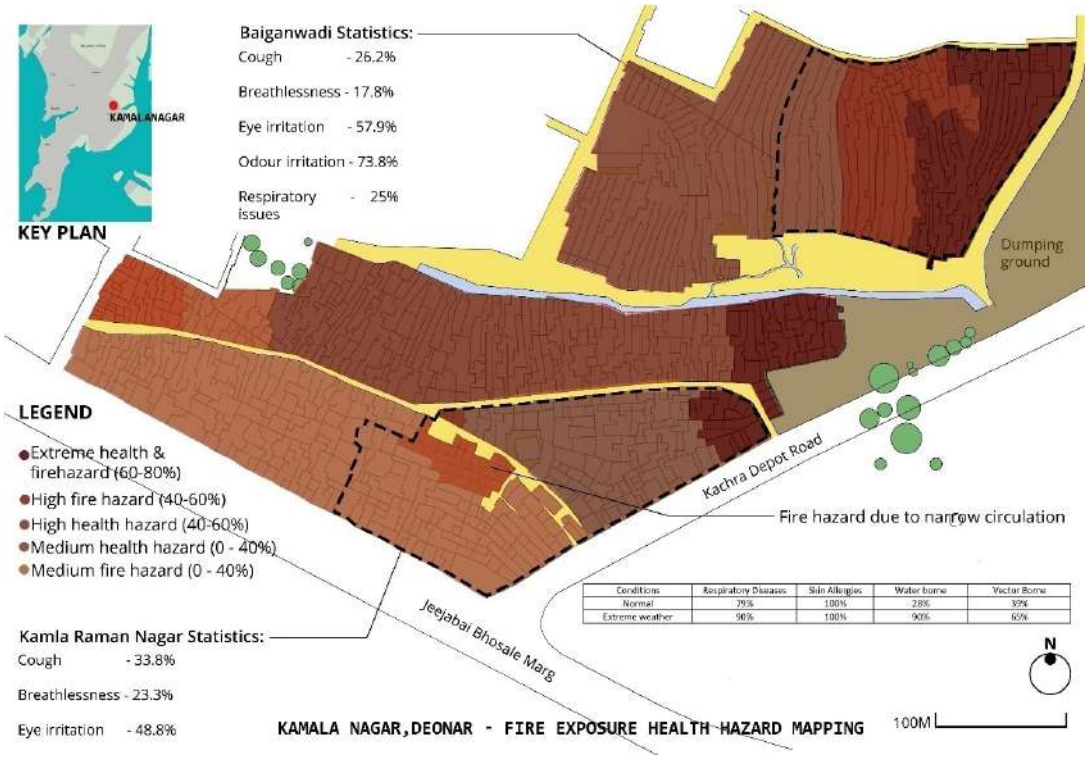
Health issues



Source: Author

Figure 12

Multiple risks



Conditions	Respiratory Diseases	Skin Allergies	Water borne	Vector Borne
Normal	79%	100%	28%	39%
Extreme weather	90%	100%	90%	69%

the dump yard.

This map shows the interplay between the fire hazard and resultant respiratory ailments arising from the fire. At times of a fire breakout, the area is filled toxic smoke from the dump yard. Smoke engulfs the densely packed houses almost immediately not allowing for quick escape. This results in the inhabitants being affected by the toxic fumes and hence the aggravation in respiratory ailments.

This is supported by a study carried out by MCGM, "Systematic Up gradation of Slum Infrastructure: Case: Kamala Raman Nagar, Govandi, Mumbai (Documentation, Micro Mapping & Analysis) concludes that there is one seat per 290 persons. These numbers are insufficient and upkeep does not exist. The lack of water leads to soiled conditions of toilets that in turn leads to health deterioration of the inhabitants. The consequences of poor sanitation are devastating on human health and the environment in Adarsh Nagar, Deonar. Conventional sewerage infrastructure investments are technically challenging and financially infeasible and the sanitation needs are acute which, if left unmet, carry major consequences for the inhabitants.

As a result, skin rashes and genital allergies persist in all women and girls. Visiting the government health care centre for immediate medication is the coping strategy adopted by them while the core issue is of hygiene is not dealt with at all.

The concentration of suspended pollutants, which can be inhaled in to the body, was nearly eight times the permissible limits during the mornings in residential areas close to the Deonar dumping ground. Hourly data from the Chembur air monitoring

Source: Author

station set up by the System of Air Quality Weather Forecasting and Research (SAFAR) revealed that of levels of PM10 – air-borne particulate matter measuring less than 10 microns – were as high as 788ug/m3 as against a safety limit of 100ug/m3 between 8am and 9am; and 718 ug/m3 between 7am and 8am on January 29, two days after thick smog was released from the fire at the dumping ground.

Similarly, PM2.5 – pollutants measuring 2.5 microns or less – between 8am and 9am were 583ug/m3 as against permissible standards of 60ug/m3; and 538ug/m3 between 7am and 8am on January 29. PM, which consists of soot, organic matter and chemicals, can stick to the sides of the windpipe or travel deeper into the lungs.[17]

In Adarsh Nagar, Deonar, the inhabitants face multiple health issues related to the lack of basic services as well as poor environment conditions. It is now evident that tackling the health issues is hurdle due to their economic status.
In the Adarsh Nagar, Deonar settlements

a. **Only 2% follow safe sanitation and hygienic practices.**
b. **Only 5% drink safe water.**
c. **Over 80% are living below poverty line.**

To address the extreme rainfall issue that causes water logging and flooding and eventually leads to an advent of water borne and vector borne diseases, no attempt has been made towards risk reduction. The priority of the inhabitants begins at protecting belongings and home first and it is only when the circumstances are unbearable that they run for their lives. The drinking water is now in covered containers although as mentioned earlier may be used as a cool water dip by the children in hot summers. Also, out of the 72 families that were interviewed only one family raised the plinth of their house to keep the flood waters away. This arises out of the need to protect the belongings more than addressing the health issue.

One of the respondents say, "When the last major fire broke in 2001, it burnt all our belongings. We tried to stop the water by every means we could. We even threw drain water to stop the fire but it didn't. So, we all ran with their children and let our belongings burn. It caused massive coughing due to the smoke emitted. The smoke remained there for a week and the smell reached distant places."

There are daily visits made to the public health officer for free medication that can be termed as an adaptive practice on a short-term basis. No attempt is made to address the issue at the root of the problem which is the hazardous location of the slum. It is therefore imperative that appropriate adaptive strategies be developed with the assistance of urban planning measures. The physician states that there are around 200 women and girls who come to see him daily with complaints of skin allergies and genital issues.

Hence, we can say that due to the lack of awareness as well as poor economic status of the inhabitants, no formal risk reduction or adaptive practices are being followed. The residents suffer from chronic respiratory and skin diseases and further the lives of the inhabitants are characterized by factors like the insecure tenure that endanger their means of livelihood and residences. Insecure tenure harbours the fear of eviction in the inhabitants that prevents them from investing in more permanent and safer building materials for the construction of their units, thus bringing on the exposure to fire risks. There is a lack of awareness of preparing for future disasters and these factors are the primary cause for unpreparedness in relation with developing risk reduction and adaptive practices. The dump yard has persistent small fires within caused by the high temperatures and methane. Respondents mention that they first prod at the garbage in the dump with sticks to explore if a fire exists and only then proceed to picking garbage and segregating it. The step taken

17 http://www.hindustantimes.com/mumbai/pollutant-particles-near-deonar-were-8-times-more-than-permissible-limit/story-VOWHREbj7pIpHzRxmiqzEO.html

to risk reduction is where fires are concerned are taken by the government and construction waste is dumped in the yard to contain the fires..

A third set of gaps in the effective development of a risk knowledge base derives from the lack of a "safety culture" among land use planners, as well as among institutions and citizens. Although it has been recognized that increasing economic losses and persistent high victim's tolls are mainly due to growing exposure and vulnerability determined by poor building techniques, lack of enforcement of building codes, and insufficient or absent land use and urban planning[18]. Slums or informal communities must be recognized as a valid and unique form of urban growth and development. It is desired that formal planning and design services develop these urban areas over time into places of higher quality living. [19]

1. **Can slum upgrading and site-specific risk-based land use planning address the health inequities in informal settlements in the city? And How viable are they under the current conditions?**
2. **How do city growth and urban development impact the vulnerability of the community?**

A central role of urban planning is to deliver housing land to meet needs that result from urban population growth and the replacement of sub-standard dwellings. The combined effects of sea-level rise, floods and storms have damaged the homes and livelihoods of millions of urban dwellers. Despite debate among the scientific community about the frequency and predictability of natural disasters and extreme weather events, there is consensus that the concentration of urban populations and economic activity in hazardous locations is increasing. The impacts of hurricanes, tornados or earthquakes can reduce economic outputs, reverse development gains and threaten the livelihoods of the urban poor (UNISDR, 2013, p68). Urban planning has a key role in managing areas at risk, both in helping protect existing populations and in reducing risk for new urban development. (Brown 2015: *Planning for Sustainable and Inclusive Cities in the Global South*)

From the study of the development plans and tracing the trajectory of the growth of the city specific to the M east ward and the dumping ground we can see that what was ear marked as a green park converted to a dumping ground and the formal housing allotted for the relocation of project affected people grew uncontrollably as slums. What began as a plan of settlement during the emergency, additionally led to relocation of the project affected families caused by rapid urban development and infrastructure projects. The colossal growth of the dump yard has been directly proportional to the development of the city. "We continue to dump because we have no option," said Amita Bhide, chairman of the Center for Urban Policy and Governance at the Tata Institute of Social Sciences in Mumbai. "We are exhausting our landfills. This issue is reaching crisis proportions and will blow up in the face."

The inhabitants get branded as encroachers and illegal and face constant threat of eviction that leads them to live lives laden with insecurity. The governmental as well as societal approach towards these homeless migrants clearly shows the subjugation by state agencies.

The condition and situation of the slum dwellers are not addressed in political conversations. It is unfortunate that in the rush to cover the development deficit of the nation, the neoliberal state has turned a blind eye to the already excluded population and is indifferent to the migrant and vulnerable populace.[20]

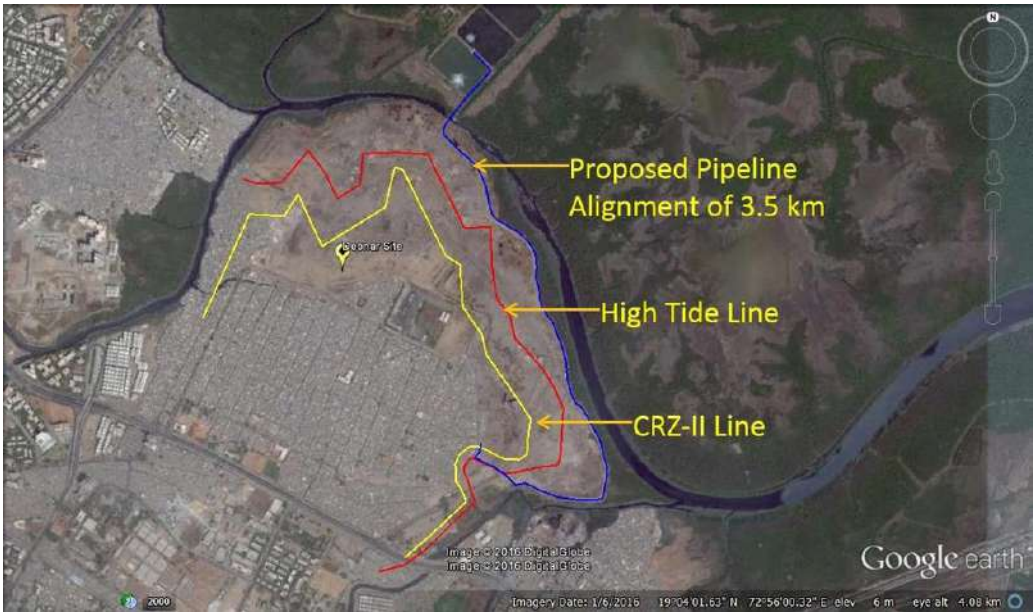
18 UN, 2011;Kousky, 2012; White et al., 2001

19 Cantada, 2015; Why public space planning is vital to improve slums, *World Economic Forum*

20 Jha et al Cities, Rural Migrants and the Urban Poor – II Migration and the Urban Question in Mumbai

Figure 13

Tata Consulting Engineers Limited 2016 *Development Of Waste-To-Energy (Wte) Project At Deonar, Mumbai*



Hence this vulnerable condition of the inhabitants is the consequence of the exponential growth in migration in this area coupled with the increase in waste generation resulting out of the process of urban development in the city. It is a cyclic process of increase of migrants with increased dependency on the dump yard for means of livelihood that generates a well enough income for migrants looking for a means of sustenance in the city. Their legal status enables them to be ignored and these forces acting on the marginalized are worsening their condition.

Hence the existing condition of the community is a direct function of the development of the city surrounding Deonar Dump as has been seen in section.

The dump yard is home to a number of toxic gases like carbon monoxide, methane, particulate matter, etc. It has been established that this toxicity in the atmosphere is responsible for the chronic respiratory ailments thriving in the area. COPD, allergic rhinitis, throat and eye irritations, bronchitis, TB, chest illnesses and cardiac ailments. [20]

Stunted growth is observed in the children (visual observation while the interviews were being conducted), has also been attributed to the toxic levels at the site.

Can slum upgrading and site-specific risk-based land use planning address the health inequities in informal settlements in the city? And How viable are they under the current conditions?

Inclusion of slum pockets, their upgradation or vulnerability issues, within the planning of the city has been dealt with in terms of incentive development to builders in terms of Slum Rehabilitating. This looks at provision of incentive FSI for rehabilitating the inhabitants in tower structures and creating a sale component to the developers as reason for provision of free housing for the slum dwellers.
Site specific context to exposure to natural and man-made hazards are not considered in the planning purview. The challenge is to create a safe livable environment for the inhabitants that can build their

20 Kumar et al (2016.) Air quality mapping using GIS and economic evaluation of health impact for Mumbai City, India

resilience towards natural and man-made hazards. Building resilience by means of disaster reduction should form part of urban design and creation of adaptive strategies to achieve sustainable development, mentions the UNISDR handbook for "Making Cities Resilient". Building regulations and Land-Use planning is one of the ten essentials identified for making cities disaster resilient.
InHabitat published "Resilient Building Design: Is Resilience the New Sustainability?" that points out the deficiency in green buildings not being resilient to climate change impacts. Citing the example of the destruction caused by Hurricane Sandy, InHabitat points out that resilient design come into play at such times. In terms of increased awareness, the Rockefeller Foundation has been involved in creation of "100 Resilient Cities" and has invested along with partners more than $230 million in pro bono solutions and services to their member cities. In India, The Rockefeller Foundation launched ACCCRN that focused on strengthening the capacities in cities to plan, finance and implement urban climate change resilience (UCCR) strategies and actions in 10 cities across India, Indonesia, Thailand and Vietnam.

Considering the multiple hazards that they face and their dependency on the dump for their livelihood the following factors play an important role:

1. **Building material**
2. **Layout of houses**
3. **Water and Sanitation requirements**
4. **Evacuation means**
5. **Protection from toxic environment**

Gap between planning and health (a review of literature)

Jason Corburn in "Confronting the Challenges in Reconnecting Urban Planning and Public Health", discusses the gap between planning and public health. He mentions that while urban planning underwent a paradigm shift in its focus towards environmental health by adopting the environmental impact assessment (EIA) process, this method came under criticism as evaluating population health laid more emphasis on cancer compared to other chronic diseases. Area specific health exposures and risks could not be ignored and had to play the primary role and help position of experts in the planning process. The adoption of quantitative analysis was only serving to increase the disconnect between planning and environmental health. The cumulative effect of hazards as seen in this case study is hardly ever considered and planning practices must prioritize risks that get incorporated in the decision-making process. He expresses that health disparities arise from differences in socio-economic inequities and cities must involve themselves in creation of a clear enunciated strategy to improve the health of urban populations. Communities must participate in the decision-making process that will ensure incorporation of important contextual information. Expert models developed must have scope for improvement and will spell success for bridging the gap. He suggests a conceptual framework especially including eco-social epidemiology, that provides an interdisciplinary, multilevel perspective for understanding the health status of, and health disparities in, populations.

Paul Davidoff in his paper, "Advocacy and Pluralism in Planning," throws light on advocacy planning that dealt with structured planning that was context specific. Planning under the reigns of governmental organizations may not serve to procuring the ideal solution and meeting the needs of the poor and underprivileged. The possibility of laissez faire attitude to city planning has to be overridden with a more humanist and grassroot approach to achieve urban renewal. Training of planners is essential in areas of contemporary philosophy, social work, law, the social sciences, and civic design in order that they are charged with making urban life more beautiful, exciting, and creative, and more just.

Building resilience by means of disaster reduction should form part of urban design and creation of adaptive strategies to achieve sustainable development, mentions the UNISDR handbook for "Making Cities Resilient". Building regulations and Land-Use planning is one of the ten essentials identified for making cities disaster resilient.

Shriya Malhotra also states that India needs to deal with additional challenges as far as the vulnerable are concerned and it is only through integrated urban planning that a balance between human and environmental priorities can be accomplished. In India, no distinct divide exists between urban planning and public health for slums or informal urban poor settlements and hence inclusion and participation, especially in the Indian context, are crucial.

Table 4

Planning framework suggested for Aadarsh Nagar

Christine Wamsler says the gap between planning housing and risk reduction must be overcome to achieve integration. The planning framework suggested attempts to bridge this gap and provide a holistic approach to risk base planning in the

affected area of study.

Discussion and Concluding Remarks

This paper examined the interlinkages between climate-related hazards and health issues of the vulnerable population at the Aadarsh Nagar, (Deonar) settlements. The important features of their vulnerability can be attributed to the lack of basic services, institutional support as well as social and health inequities that aggravate level of vulnerability. The cascading effect of the risks arising from the effects of rapid urbanization, climate change impacts as well as social exclusion.

The results of the interviews suggested that female population are at a higher risk compared to the male population. The inputs provided by the doctor at the public health centre reinforces the fact that women are most susceptible to health issues arising out of the prevailing living conditions. The lack of adequate toilets, water supply, access to safe drinking water are the primary cause of health issues in women that aggravate during extreme climate events.

There is little or no attempt made by the residents to develop risk reduction and adaptation strategies. There is an attitude of destiny prevails and few houses have been rebuilt with raised plinths to keep the rain water from the entering the house. Financial resources play an important role in making decisions regarding physical changes in their dwellings. This does not deal with the flooding or water logging issue. The primary aim of the inhabitants during disasters in the protection of lives and belongings. The consideration of health impacts post disaster is not dealt with at all. During extreme rainfall events, safeguarding the dwelling is prioritized as the economic background faces a five-year setback in case of rebuilding.

Hence it is evident that though climate change is a known phenomenon and Mumbai has been placed as a highly climate sensitive city, it impacts on the city with special attention to health aggravation in informal settlements need to be explored and studied further. Another relevant gap between needed and provided knowledge derives from the fact that scientific analyses address one hazard at a time. It is often neglected that hazards "can be single, sequential or combined in their origin and effects" (Birkman, 2006), as in the case of floods, toxic environment quality as well as extreme heat in the summers.

Clearly it is of critical position that forced government policies and advocacy planning may be the key to tackle adaptation in relation to climate change. "Adaptation in the context of climate change comprises measures taken to minimize the adverse impacts of climate change, e.g. relocating the communities living close to the sea shore, for instance, to cope with the rising sea levels."[21] What the policies should not ignore is the fact that relocation of units lead to disruption/ loss of livelihood, schooling, and additional economic burden to travel to the workplace as well as impediments in adjusting to surroundings like probable worse locations.

Many of the problems associated with the informal sector are not attributes inherent to the informal sector but manifestations of unresponsive urban planning itself. Accommodating – maybe even welcoming - the informal sectors in urban spaces will not only reduce the conflict between urban authorities and the informal sector, but also reduce the environmental problems associated, and eventually accelerate urban transformation and increase the quality of life in many developing urban areas. (Rukmana 2007, Planitizen Urban Planning and the Informal Sector in Developing Countries)

The study has provided crucial and critical acumen on the diverse risks that exist during different weather conditions and examined how extreme weather events have resulted in near epidemic circumstances. Heavy rainfall results in the entire households infected with water-borne or vector borne diseases. Entire populations at the slums have been affected by chronic respiratory ailments, evidently reducing life spans and eventually taking mortality rates higher.

Hence it is imperative that the role of planners be explored to help accommodate this important component (informality) of urban economies. The study aims at developing curricula at the higher education level and outline the role of urban designers and planners in designing resilient communities. ◆

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Author Bio

Mamta Patwardhan *holds a B.Arch degree (First class with honours) from Sir J. J. College of Architecture, 1993, M.Arch in Project Management (1st Ranker) from Mumbai University, 2016 and has completed a certificate course on Climate Change and Urban Environment from CEPT, Ahmedabad in 2012. She has been involved in a design-charette with the renowned Plater- Zyberk for the design of Koramangala at Bangalore while working with Thadani-Hetzel Architects. She has shared her professional expertise with many architectural firms like Ratna Dharia, Ved Segan Associates, Frischmann Prabhu, Hirani Engineering, NY (handled India back office) and others and her experience involves working on landscape projects, conservation documentation, preparation of international financial and technical bids and is currently managing residential redevelopment projects under Manoj Parmar Architects.*

Climate change impacts, environmental risk assessment and disaster reduction constitute the areas of her recent academic focus. She is conducting research as part of the EU funded BinUCom project that deals with assessing climate change impacts on the health of the slum inhabitants. She has recently presented her paper, "Debating Sustainable Resilience: A Case of Gazdar Bandh", co – authoured with Shantanu Khandkar (Visiting faculty, KRVIA), at 12th Conference of The International Forum on Urbanism (IFoU): Beyond Resilience held at Tarumanagara University, Jakarta, Indonesia this year. She also made a poster presentation at the WCRP of Columbia University, NY in 2017 on the vulnerabilty of communities.

She has been a faculty member at KRVIA since 2009, teaching modules on Graphics, Building Construction, Working Drawings and Professional Practice. She has also conducted an elective on environmental risk assessment in the master's programme.
This year she is conducting an elective "Resilience by Design" with the Bachelors Programme that deals with the question, "Can Design and Planning Inform Adaptive Strategies to Climate Change Impacts in Vulnerable Communities."