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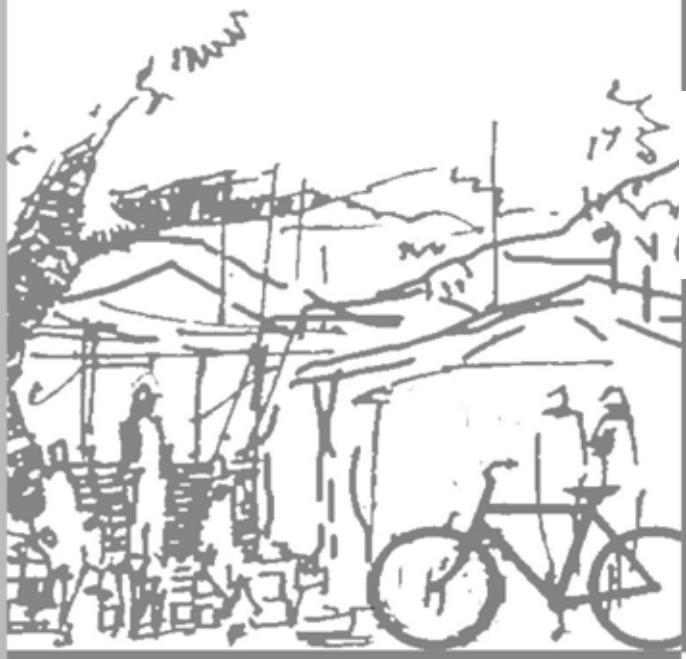

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CEPT University
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About Centre for Urban Equity (CUE)
CUE was established at CEPT University in 2009, evolving from the Urban Poverty Alleviation (UPA) Cell established in 2008. CUE advocates a human-centered and equitable urban development paradigm. CUE undertakes research and advocacy; conducts training and capacity-building; imparts education; and networks with stakeholders on various aspects of human settlements with a focus on urban equity.

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Abstract

Urban floods are one of the many risks and threats that climate change has brought in the last few years. Flooding and water-logging can put large areas of a city in entirely uninhabitable conditions, or damage infrastructure. In places where people lack adequate shelter and basic infrastructure, flooding could directly affect their health through injuries, transmission of infectious diseases, displacements or indirectly affect their living conditions through impact on properties, social infrastructure and livelihoods. Such negative impacts could exacerbate existing vulnerabilities, especially of the urban poor and the disadvantaged sections of the society who live in precarious housing conditions in low-lying areas or areas unsuitable for building habitation. This research thus looks if floods affect slum dwellers more than those living in formal housing in the two cities of the state of Gujarat – Ahmedabad and Surat. By comparing two different housing typologies - (i) formal settlements i.e. public housing schemes (in particular Basic Services to the Urban Poor (BSUP) and Pradhan Mantri Awas Yojana (PMAY)); and (ii) informal settlements i.e. slum settlements; the study looks at different impacts residents of these housing typologies bear, such as water-logging depths, loss in housing structures, loss in assets, etc. in case of floods and subsequent water-logging in the study areas.

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This working paper is from student dissertation research supported by the Centre for Urban Equity (CUE) under the CEPT University's Directed Research Programme. Numerous discussions at CUE have helped to develop methodology and arguments in this paper. Our gratitude to also the unknown but enthusiastic respondents to our probing queries in the public housing and informal settlements in Ahmedabad and Surat. Our gratitude to Dr. Minal Pathak for her extremely useful comments to the students, Prateek and Vipul, at various stages of their dissertation.

Contents

1. Introduction

1.1. Relevance of the study

It is widely accepted that climate change will increase the variability and incidence of extreme weather events such as heat waves and droughts in some locations, and heavy precipitation, storm surges, and potential sea level rise in others (Bicknell et al 2009; Hanson et al 2011; IPCC 2012). Climate variability affects cities in two ways essentially: (i) first is in form of extreme weather like heavy rains or floods; and (ii) second, in slower, subtler ways, like gradual increases in temperature or an increase in sea level (Rajshekhar 2017). The first can be considered as shock as it strangles and paralyzes the city in a short time-period whereas the second can be considered as stress as it impacts in a subtler way over a long time-period, which is difficult to observe in everyday lives. However, both the type of climate change effects may result to loss of assets, loss of livelihood, loss of lives and more.

The IPCC's Fifth Assessment Report states with very high confidence, based on strong evidence that urban climate change related risks such as rise in sea levels, urban flooding, heat waves, extreme precipitation, landslides, drought, water scarcity and air pollution are increasing with widespread negative impacts on people's health, livelihoods and economic assets and all these risks are increased multiple times for the vulnerable populations living in the informal settlements with lack of access to basic infrastructure and services (Revi et al 2014). With a large part of the population still residing in informal settlements, the damage from extreme events in future can be significant for these city residents, particularly, in densely populated cities. Also, the present network of infrastructural services, systems, built environment and ecosystem services are exposed to climate change risks (Revi et al 2014).

Urban floods are one of the many risks and threats that climate change has brought in the last few years. Around 38 per cent of the world's population, close to two billion, lives in 'highly' flood-prone area (Baker 2012). Low Elevation Coastal Zones (LECZ) that are often exposed to cyclones and storm surges cover two per cent of the world's land area, but contains 13 per cent of the world's total urban population (McGranahan et al 2007). Flooding and water-logging can put large areas of a city in an entirely uninhabitable conditions, or damage infrastructure such as transportation systems, storm water lines, energy plants, etc. In places where people lack adequate shelter, storm surges and floods could directly affect their health through injuries, transmission of infectious diseases and displacements (Bicknell et al 2009; IPCC 2012, 2014); or indirectly affect their living conditions through impact on properties, social infrastructure and livelihoods (Cannon and Muller-Mahn 2010; Wahlstrom 2003). Such negative impacts could exacerbate existing vulnerabilities, especially of the urban poor and the disadvantaged sections of the society who live in precarious housing conditions in low-lying areas or areas unsuitable for building habitation.

This research aims to assess whether climate change and its impacts affect different segments of the society in different ways, especially in case of low-income households. By comparing two different types of low-income settlements, (i) formal settlements - i.e. public housing schemes provided under the Basic Services to the Urban Poor (BSUP) component of the national programme Jawaharlal Nehru National Urban Renewal Mission (JNNURM) and the state government housing programme Mukhya Mantri Gruh Yojana (MMGY)[1] and (ii) informal settlements i.e. slum settlements across two case study cities in the state of Gujarat – Ahmedabad and Surat; this study identifies and assesses the short-term and medium-term impacts borne by the residents of both housing typologies (such as water-logging depths, loss in housing structures, loss in assets, etc.), and questions whether provision of affordable housing ameliorates these impacts.

1.2. Objectives

The research questions - What are the short-term[2] and medium-term[3] impacts of floods in the case study cities of Ahmedabad and Surat and does formal housing ameliorate the impacts in these cities? The objectives of the research are as follows:

1. To assess as to whether the case study cities have experienced change in with rainfall pattern.
2. To map the flood prone areas by the severity in case study cities.
3. To identify site locations of public housing programs and slums/ informal housing in both cities and select four sites (two formal and two informal) for detailed case study.
4. To assess the impact of last floods in all the sites with regards to damages,[4] livelihood,[5] health[6] and displacement[7] disaggregated by gender, income and occupation.
5. To compare the floods impacts between formal and informal housing sites.

1.3. Methodology

The methodology adopted in the study consists of:

- Phase 1: Perception study: This phase involves preliminary study of the case study cities – Ahmedabad and Surat. Understanding and identifying the flood-prone areas in the cities and relating those with literature on climate change and its impacts. It would also involve studying the change in rainfall pattern over the past years for Ahmedabad and Surat along with identifying and mapping public housing sites and slums in the city with respect to flood vulnerability.

[1] Since housing projects under Pradhan Mantri Awas Yojana (PMAY) are either under tendering phase/ under construction, PMAY has not been taken into consideration in this study.
[2] Refers to a time span of one to two years from the occurrence of flood.
[3] Refers to a time span of five years from the occurrence of flood.
[4] Regarding housing, durable assets, consumable assets, vehicles, documents, livestock and others.
[5] Regards to work days lost, livelihood days lost, income lost, etc.
[6] Regards to illness, healthcare expenditure due to illness, working days lost due to illness, and death (if any).
[7] Considered as relocation of the residents in times of flood.

- Phase 2: Documentation: This phase of the study is more focused on the documentation of the identified sites in the case study cities in terms of mapping the people affected, the state and their coping measures[8] at different levels. This involves understanding the severity of impacts that the different social groups experience at the time of heavy rainfall and floods.

- Phase 3: Data collection: This phase is focused on data collection via conducting surveys of selected public housing schemes and slum settlements.

- Phase 4: Analysis: This phase focus on analyzing the data of the flood impacts disaggregated by housing type, income and occupation.

- Phase 5: Recommendations: This final phase of the study would involve developing a framework and giving recommendations based on the findings and analysis in the analysis phase. Also, it involves on estimation of costs on city-level and recommendations based on the same with respect to the most feasible scenario.

Table 1: Methodology adopted

Objectives	Data Required	Source of Data
To understand as to whether Ahmedabad and Surat have experienced change in rainfall pattern.	Rainfall data	Indian Meteorological Department (IMD)
To map the flood prone areas by the severity in Surat and drainage network layout in Ahmedabad	Topography map, storm water drainage map, Municipal corporation boundary with ward boundaries	Bhuvan web portal (DEM data), Ahmedabad Municipal Corporation (AMC), Surat Municipal Corporation (SMC)
To identify site locations of public housing programmes and slums/ informal housing in the city and select four sites (two formal and two informal) for detailed case study.	Topography map, storm water drainage map, city municipal corporation boundary with ward boundaries, government programmes housing sites map, number of Dwelling Units (DU)	Bhuvan web portal (DEM data), AMC, SMC, Ahmedabad Urban Development Authority (AUDA), Surat Urban Development Authority (SUDA), Observations in primary site visits
To assess the impact of last floods in all sites with regards to damages, livelihood, health and displacement disaggregated by gender, income and occupation.	Structured questionnaire survey, qualitative survey	Housing residents (formal and informal settlements)
To compare the floods impacts between formal and informal housing sites.	Structured questionnaire survey, qualitative survey	Housing residents (formal and informal settlements)

Source: Prepared by the authors.

1.4. Scope and Limitations

The study is limited only to the selected public housing and informal settlement sites in the two case study cities – Ahmedabad and Surat. Many sites (of public housing

[8] With respect to services such as food and water access, toilet access, etc.

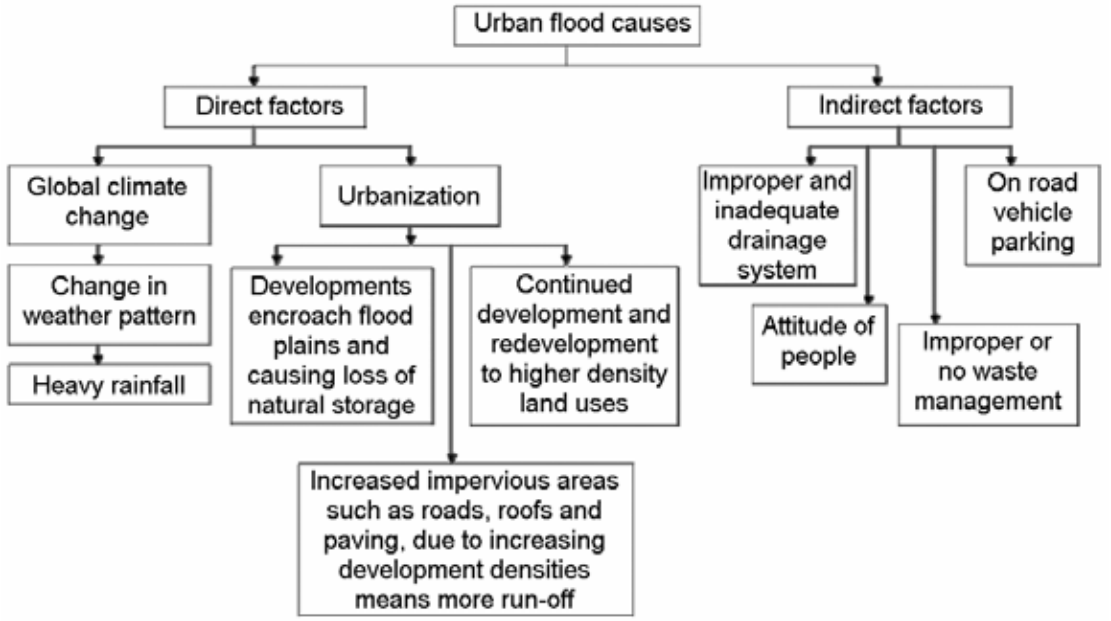
and slums) are located in different parts of the cities and experience different impacts. This happens due to their difference in their elevation and vulnerability from floods. It also varies in case the other sites have access to infrastructure such as storm water drainage, which would affect their vulnerability to water logging and further impacts. Therefore, sites located in the same area (the area most prone to floods) are selected, as they would have the same base conditions such as drainage network, vulnerability to floods from river Tapi (in case of Surat) and vulnerability due to their elevation. To minimize any further possible scope of variation in the sites and their responses, study has been conducted over one time period, through all the sites.

Due to forced re-settlement in BSUP sites, the perception of BSUP residents regarding the newer settlements is negative on account of distant location from their previous jobs and businesses. Thus, while interviewing the residents, it was kept in mind that this dissatisfaction with BSUP housing did not influence their response to issues due to floods and water-logging.

2. Housing as Flood Resilience: Literature Review

Adequate shelter is fundamental to ensuring the safety, well-being and protection of all people. It susceptible to climate change impacts, whether as a result of physical damage or destruction brought about by storm surges or floods, or by harbouring unsafe conditions, for example in the case of housing ill-equipped to cope with extreme heat or cold. Vulnerability to climate risk due to poor quality housing is further aggravated by absence of supporting infrastructure of water supply, drainage and transport. In many urban areas, the affordable housing that is built, often does not include risk reduction (Huq et al 2007).

Figure 1: Causes of Urban Floods in India



Source: Gupta et al 2010.

Many studies have focused on urban floods in India and their causes. There are two types of factors involved (i) direct factors are globally known as causes of urban floods or in other words they are the factors which contribute to climate change in a manner which has direct consequences in the shape of urban floods; and (ii) indirect factors involved in causing urban floods contribute negatively in terms of increasing the damages or factors which effect the urban resilience of the city negatively (see Figure 1). The former are that of global climate change and urbanization, where climate change includes change in weather pattern which means, change in global temperatures, change in rainfall pattern, change in rainfall periods, heavy torrential rainfall in shorter duration of time, etc. As a result of such factors involved, there would be sudden occurrences of events which would lead to urban floods and situations for which our cities or urban areas are not fully prepared for.

Urbanization as a direct cause of urban floods is evident from examples of many Indian cities where cities have expanded in terms of its urban area and more people flow-in for search of economic opportunities. In case local governments are not pro-active to accommodate the needs of this population influx, then this results in rampant unauthorised construction and encroachments on ecologically sensitive areas such as flood plains, wet lands, etc., resulting in loss of natural storage of water bodies which is useful in case of heavy precipitation. Urbanization also leads to more built-up space which mainly comprises of materials such as concrete, cement, etc., employed in structures essential for any urban area such as roads, paving, roofs, etc. A common property of these materials and structures is that all of these are impervious to water thereby adding to the surface run-off water. This in turn leads to more amount of water to be handled by the city storm drainage infrastructure and also increases damages owing to the fact that larger amount of run-off water flows at higher velocities through urban areas. Another aspect of urbanization is that it leads to densification of urban areas and often urban poor, the people with highest vulnerability are located in the areas with highest risk, which further puts life and property in immense danger. Basic characteristic of urban areas is that there are a large number of people living in high densities. This fact itself puts a large number of urban population in danger at times of any such disaster.

The indirect factors that negatively affect are many. The first defence that a city has against heavy rainfall is its drainage system, which in case of most of Indian cities is inadequate to even handle the regular drainage flow, i.e., sewerage. Also, coverage of storm water drainage network in Indian urban areas is very less, inadequate and often under designed in terms of carrying capacity. During heavy torrential rainfall, both these factors add up to further worsen the conditions. Lack of adequate waste management system adds up to the impacts of urban floods even months after its occurrence. Health impact is one of the major impacts. Due to lack of waste management facilities in the cities, vulnerable residents face health related issues in form of diseases such as malaria, dengue, cholera, typhoid, etc. These are generally vector-borne diseases affecting people with low immunities. The urban poor are the

ones who get affected the most and amongst them, women, children and the elderly are the most vulnerable owing to factors such as lack of nutrition, social inequity, ageing, etc. Such health impacts push these people further into poverty owing to lack of financial resources or means which would help them to bounce back. Thus, the least resilient sections of urban areas are the ones to get most affected by disasters such as urban floods.

Flooding in cities can affect the urban poor with more intensity (in comparison to the other sections of the society), resulting in multiple impacts. Lack of drainage systems in such the areas they reside may lead to extended water logging in these areas, thus aggravating and worsening flooding. This extended water logging can result in deaths due to collapse of weak structures, deaths by drowning, health issues (such as malaria, dengue, cholera, diarrhoea) caused by water-borne vectors, temporary or permanent displacement/ relocation of the residents to near-by places (such as temples and schools) and loss in livelihoods (due to work days lost). High density of slums leads to over-crowdedness which aggravates health issues due to exposure to water-borne diseases throughout the settlement. Low permeability of infrastructure in informal settlements (due to absence of storm water drains or blockage of the same), result in extended water-logging, thereby creating favourable conditions for mosquitoes to breed. To add to this, owing to the location of these settlements and lack of sewerage lines, hazardous chemicals and faecal matter can contaminate water, resulting in chronic health issues and epidemics (even after the flood water decreases). Citing case studies of four cities Dar es Salaam, Jakarta, Sao Paulo and Mexico; Baker (2012) shows with empirical evidence of hazards impacting the urban poor. From which, it is evident that urban flooding is one of the major hazards urban poor faces in common across these cities (see Table 2).

Table 2: Study showing evidence of the hazard impacting the urban poor through studies in four cities

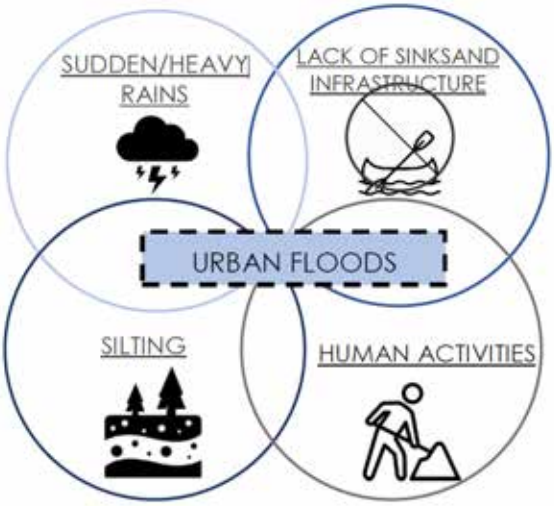
Hazard	Dar es Salaam	Jakarta	Sao Paulo	Mexico City
Earthquake	○	◉	○	●
Wind storm	○	○	○	●
River flow	○	◉	◉	○
Floods, inundations, and waterlogs	●	●	●	●
Drought	●	○	○	●
Volcano	○	○	○	○
Landslide	◉	○	●	◉
Storm surge	○	●	◉	○
Extreme temperature	◉	◉	NA	●

Notes: ● High Risk; ◉ Medium Risk; ○ Low Risk.
Source: Baker 2012.

The National Institute of Disaster Management (NIDM) classifies the causes of urban floods into four broad categories: (i) heavy torrential rainfall or flash floods; (ii) lack of sinks; (iii) silting; (iv) human activities. Heavy rainfall is seen as a potential cause for urban floods as drainage networks are often not adequate to accommodate the

sudden inflow of water leading to overflow of such systems in place. The water from such overflows follows the course of natural drainage in the urban areas and gets collected in the low-lying areas flooding them heavily. These low-lying areas are often areas where there is lack of infrastructure which further worsens the conditions. Silting is a natural phenomenon responsible for decrease in depth of a water body over time resulting in reduction in carrying capacity of such water bodies. Therefore, over time carrying capacity of water bodies reduce which earlier was adequate to carry water inflow added by heavy rainfall might now fail. Human activities such as urbanization, population growth, inadequate and ineffective planning, etc., can be seen as activities which are direct or indirect cause of phenomenon such as urban floods. These also include dumping of city waste into water bodies further reducing their carrying capacity. During flooding, areas in the vicinity, which are often encroached upon, are at very high risk of flooding and sometimes water-logging. This addition in the waste serves as breeding grounds for various diseases which are often seen as the after effect of floods.

Figure 2: Causes of Urban Floods



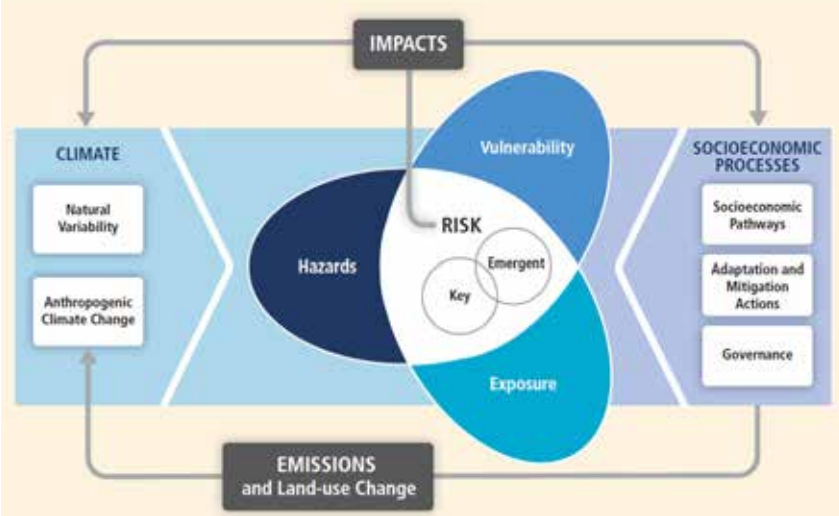
Source: NIDM nd.

2.1. Housing vulnerability and resilience

The most vulnerable section that of urban poor is the one to suffer maximum losses in terms of damages, health, livelihood and education. Here it is important to understand the term *vulnerability* so as to further understand the context of resilience. The term vulnerability with respect to climate change is very context and hazard specific. For example, the people who are living near a water source, say along river banks are more vulnerable to events such as floods as compared to those living inland far from the water source. Similarly, people living far from the water source are the ones more vulnerable to events such as droughts than those living near the water source. Therefore, the term is context specific. Vulnerability is a product of the hazard and the exposure level an individual or a community is exposed to. Therefore, the first step is to assess the hazards that the region is anticipated to face and then map out the exposure levels of different communities. The term with respect to this study means

people who are living in the flood-prone areas of the city, be it near the river or in low-lying areas without proper infrastructure and don't have the financial means to bounce back in case of any urban floods.

Figure 3: Risk Formulation



Source: IPCC 2014.

Risk is another term which is often used in climate change studies and is required to be understood in order to understand urban resilience concept. It is depicted very well in Figure 3 which says that risk is an overlap of vulnerability, hazard and exposure. For example, if a group of people are vulnerable to floods because they are living close to the river and also living in spaces such that they will have the longest duration of exposure to any hazard such as flood, if it occurs are the ones at the highest risk. Then there are various factors such as climatic factors where a group has natural vulnerability which when combined with man made changes increase the vulnerability and exposure. Similarly, the socio-economic processes including governance, adaptation and mitigation actions have an impact on risk. Risks don't occur – they unfold. There is a difference between slow developing risks and sudden disastrous events such as famine. Following a sudden hazard or disaster there are often long ranging impacts after the initial short-term impacts such as impacts on quality of lives and livelihoods, but the condition build-up of these disasters may have been forming over a long period of time.

It is also important to understand the term *resilience* in the context of urban resilience studies. The etymological roots of resilience stem from the Latin word *resilio* which means 'to bounce back' (Klien et al 2003). The terms such as 'climate resilient', 'resilient city' and 'climate-proofing' has been used often with relation to the idea that cities and urban systems need to be able to recover or bounce back from climatological stresses and hazards. Another term used frequently is 'urban resilience' which generally refers to the ability of a city or urban system to withstand a wide array of stresses and shocks. Although to define urban resilience clearly it is essential

to first specify the meaning of the term 'urban', the definition of which can vary depending upon the discipline or theoretical construct through which it is viewed (Arup 2015).

Ecologist C.S. Holling's seminal paper (1973) on the resilience of ecological systems is recognised as the origin of modern resilience theory (Folke 2006; Klein et al 2003; Meerow and Newell 2015). He introduced resilience as the capacity to persist within such a domain in the face of change and proposed that "resilience determines the persistence of relationships within a system and is a measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist" (Holling 1973: 17). Various scholars have defined city as an urban system structure containing many complex systems which are dependent on various networks which are interlinked and intertwined. On similar lines, Seeliger and Turok (2013) explain resilience as ability of the urban system to maintain the vital functions while at the same time adapting and developing in the light of changes while maintaining the pace of development and growth. Also, they put across resilience as the social, economic and environmental response to change in cities be it sudden or gradual (Seeliger and Turok 2013). Sudden changes are the one which occur in a short duration of time such as natural calamities or disasters and gradual changes are the ones which happen over a long duration of time for example the increase in global surface temperature is a gradual climatic change.

In the modern world countries are facing multiple challenges, one of which is climate change which has been compared with terrorism in threat matrix by Robin Leichenko (2011). Also, the author here has explained the various approaches which have evolved from the more traditional approaches towards urban resilience. The urban areas or cities are more of composed of complex social ecological systems composed of interlinked and interdependent networks. The term resilience can also be seen as social, environmental and economic response to sudden or gradual change in urban area. One of the definitions of urban resilience is: "Urban resilience refers to the ability of an urban system-and all its constituent socio-ecological and socio-technical networks across temporal and spatial scales-to maintain or rapidly return to desired functions in the face of a disturbance, to adapt to change, and to quickly transform systems that limit current or future adaptive capacity" (Meerow et al 2016).

According to this definition urban resilience is a dynamic phenomenon which offers multiple pathways leading to resilience which are persistence, transition and transformation. This definition is based on the assumption that urban system is a complex and adaptive network of socio-ecological and socio-technical networks which extends across many spatial scales. Urban resilience is viewed as a positive and desirable concept. Leichenko (2011) argues "the idea that resilience is a positive trait that contributes significantly to sustainability is widely accepted." At the same time definition given by Brown et al (2012) is most explicitly positive, "urban resilience as the ability not only to maintain basic functions but also to improve and prosper."

Bahadur et al 2010 have rightly said "we are experiencing a resilience renaissance." Due to the recent disasters, frequency of which have increased multiple times over the last few decades have led to a growing emphasis on improving the resilience of urban areas in the face of unprecedented urbanization and climate change. There are multiple stakeholders involved in any urban area and implementation of policies related to it and more so for policies which talk about improving urban resilience. Other factors involved are the motivations, urban power dynamics and trade-offs across temporal and spatial scales across the city. Hence there are many questions to consider while planning for urban resilience which are whom, why, what, when and where as shown in Table 3. These 5 W's have been recognised by scholars who stress upon the point of resilience for whom and of what to what? (Carpenter et al 2001).

Table 3: Fundamental questions related to urban resilience

Questions to Consider		
Who?		Who determines what is desirable for an urban system? Whose resilience is prioritized? Who is included (and excluded) from the urban system?
What?	T R A D E O F F S	What perturbations should the urban system be resilient to? What networks and sectors are included in the urban system? Is the focus on generic or specific resilience?
When?		Is the focus on rapid-onset disturbances or slow-onset changes? Is the focus on short-term resilience or long-term resilience? Is the focus on the resilience of present or future generations?
Where?		Where are the spatial boundaries of the urban system? Is the resilience of some areas prioritized over others? Does building resilience in some areas affect resilience elsewhere?
Why		What is the goal of building urban resilience? What are the underlying motivations for building urban resilience? Is the focus on process or outcome?

Source: Carpenter et al 2001.

Urban resilience is dependent upon: who defines the agenda, whose resilience is being prioritized and who benefits or loses as a result of such policies and their implementation. These preferences will differ from city to city and at various levels of government unless there is a central guiding principle and force to the policies intended to improve urban resilience with a clear priority and agenda from the government authorities.

The term urban resilience, therefore, is a complex term dependent on multiple variables as discussed above. City governments' need to act upon formulating policies regarding adaptation and mitigation of climate change impacts while considering all the stakeholders involved. This is a challenging process but is essential owing to the fact that there have been immense damages due to disasters related to climate change and human activities are a major cause for climate change which if unchecked may worsen the condition with catastrophic impacts.

3. Case Study City Profiles: Ahmedabad and Surat

3.1. Location

Located in the state of Gujarat, the two case study cities – Ahmedabad and Surat, are situated along the banks of Sabarmati and Tapi rivers, respectively (see Map 1). Ahmedabad, the seventh-largest metropolis in India and the largest city of the state, has undergone various transformations over time, in terms of its economy, labour markets, and urban planning paradigm (Mahadevia et al *forthcoming*). While, Surat, the second largest city in the state, is an important commercial and business centre owing to its strategic geographic location.

Map 1: Location of Case Study Cities

Source: Prepared by Centre for Urban Equity (CUE)

3.2. Demography and Administration

According to Census 2011, Ahmedabad had a population of 5.8 million in the municipal area and 6.3 million in the urban agglomeration area. The municipal area comes under the jurisdiction of the Ahmedabad Municipal Corporation (AMC), the administrative boundaries of which were last extended in 2010 to cover an area of 466 sq. km. The Ahmedabad Urban Agglomeration (AUA)[9] includes 4 towns and 103 villages, apart from the area under AMC, and covers a total area of 1,866 sq. km. The second entity in the city's governance structure is the Ahmedabad Urban

[9] The AUA area, which is larger than the AMC area, is not an administrative unit and is defined by the Office of the Registrar General & Census Commissioner, India.

Development Authority (AUDA), a planning authority that largely covers the AUA area and more.

Surat had a population of 4.5 million in its municipal area in 2011 which comes under the jurisdiction of the Surat Municipal Corporation (SMC), the boundaries of which were last extended in 2006 to cover an area of 326.5 sq. km (SMC 2018). The Surat Urban Development Authority (SUDA), the second planning authority in the city's governance structure, largely covers an area of 715 sq. km. (including area under SMC and 95 surrounding villages) which has been increased to 1351 sq. km. with addition of another 100 surrounding villages in 2015 (SUDA 2017). During past four decades, the city has been experiencing rapid growth in population, one of the highest in the country (SMC 2008), higher than the urban growth rate in the state (Table 4).

Table 4: Population and growth rate of areas under the AMC and SMC

Year	AMC		SMC		Gujarat urban CAGR over past decades****
	Population (in millions)	CAGR over past decades	Population (in millions)	CAGR over past decades***	
1981	2.16*	3.1	0.77**	5.1	3.5
1991	2.88*	2.9	1.49**	6.8	2.9
2001	3.52*	2.0	2.81**	6.6	2.9
2011	5.57***	4.7	4.47***	4.8	3.1

CAGR = Compound Annual Growth Rate

Source:

* AMC 2005 (for 1981–2001 population figures)

** SMC 2008 (for 1981–2001 population figures)

*** Census 2011[10]

**** (Mahadevia 2012, 3)

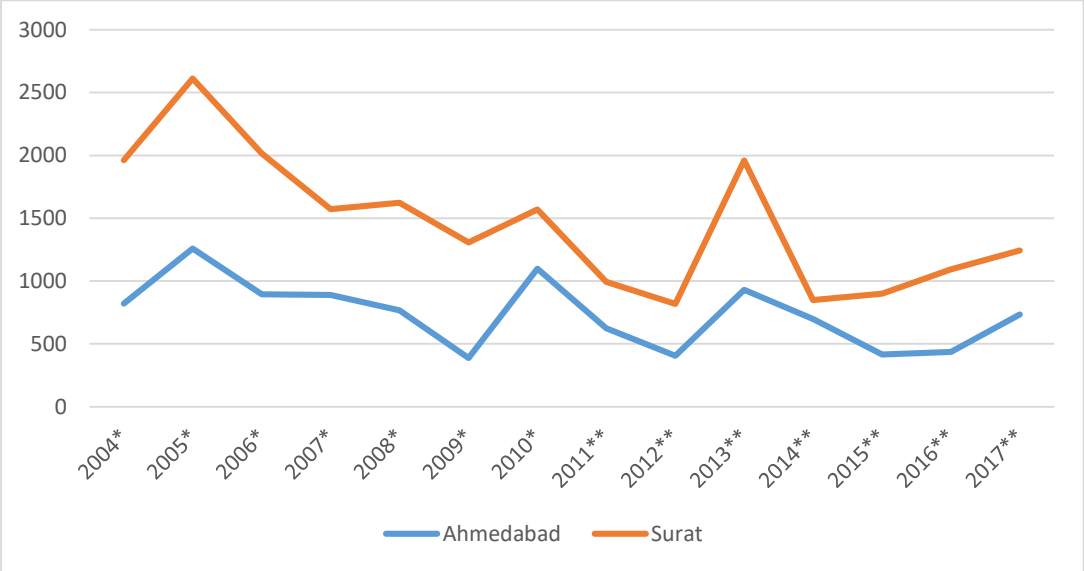
3.3. Topography and Climatic Conditions

Strategically located in the centre of Gujarat, Ahmedabad is spread on both banks of Sabarmati River which cuts through the city. The city is divided into two broad segments, the east, which is to the east of river Sabarmati that runs north to south, and the west. The eastern Ahmedabad consists of the walled city that is 600 years old, around it on the north, east and south are the industrial areas, all the way upto the eastern boundary of the city. The eastern industrial areas are therefore also the residential areas of the low-income households (Mahadevia 2002), who prefer to live near their place of work. The western parts are occupied by higher income groups and has experienced new high-end gated community developments (Mahadevia 2013). The city experiences hot semi-arid climate. Ahmedabad faces multiple climate change related risks such as increase in observed ambient temperature and frequency of heat waves (see Parikh et al 2011), infrequent heavy torrential rains causing flooding and water logging, etc.

[10] Accessed May 10, 2018. http://censusindia.gov.in/pca/pcadata/Houselisting-housing-Gujarat.html.

Located at the mouth of Gulf of Khambhat, Surat is an important historical trade centre and serves as a trade link between India and the Gulf countries. It is a port city; the nearest port now is Hazira, located at the mouth of the Tapi. The river dictates the topology of the city as the landscape slopes gradually from Northeast to Southwest (TARU 2017). The city experiences tropical monsoon climate. It faces the climate risks of both sea level rise and flooding. During the last two decades, Surat and the surrounding metropolitan region has witnessed major floods. For example, the entire city was flooded in 2006 which affected nearly two-third of the city population.

Figure 4: Annual Rainfall Pattern in Ahmedabad and Surat



Source:
* Accessed from http://www.indiawaterportal.org/articles/district-wise-monthly-rainfall-data-list-raingauge-stations-india-meteorological-department
** IMD 2018[11]

Over past two decades, it is observed that the quantum of rainfall has declined overall. However, in 2017, Gujarat witnessed one of its worst floods in which the districts of Ahmedabad and Gandhinagar along with few others received heavy torrential rainfall in a time span of few days. According to the Indian Meteorological Department (IMD) data, from July 1 to July 28, 2017, the state received 559.4 mm of rainfall, as against the average of 339.6 mm for the said period, representing an excess of 65 per cent (IMD, 2017). On observing the annual rainfall pattern in both cities, it is clearly evident that Surat has witnessed larger quantum of rainfall annually over past years as compared to Ahmedabad (see Figure 4).

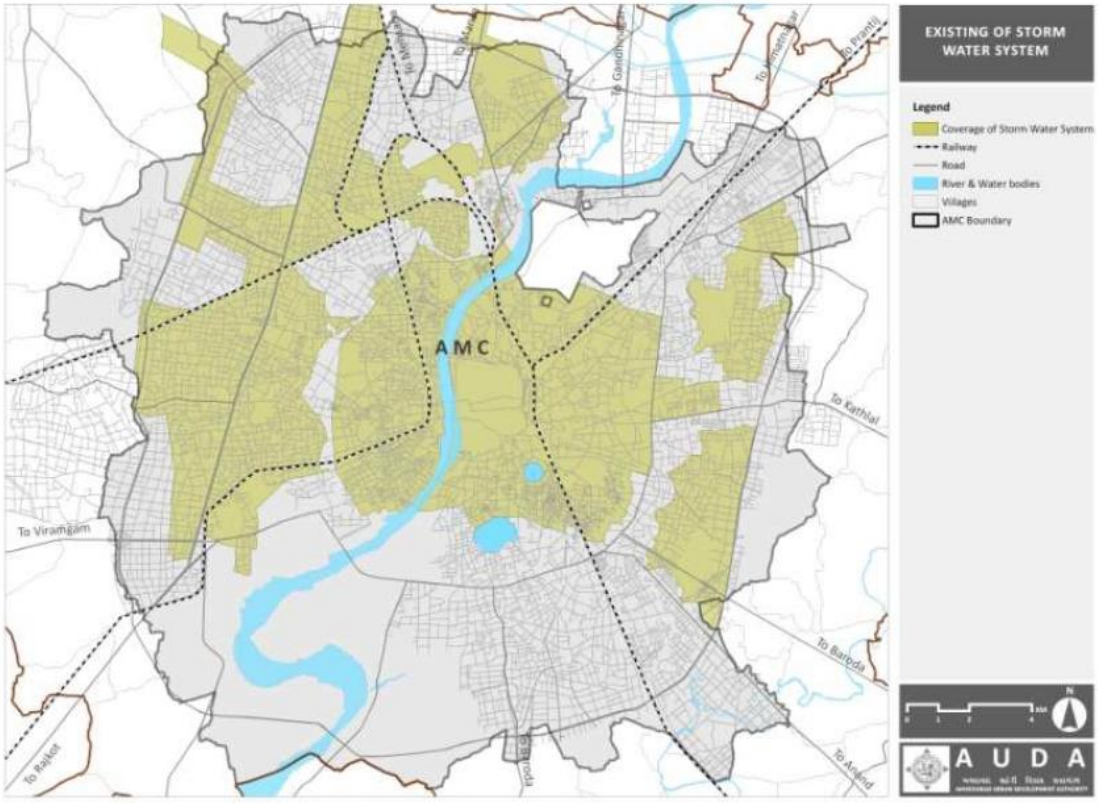
Drainage Infrastructure

In terms of drainage infrastructure, currently around 249 sq. km. of area within AMC (53.4 per cent of AMC area) is presently covered by the storm water network (AUDA,

[11] Accessed from http://hydro.imd.gov.in/hydrometweb/(S(fxqmdb3gelm0st45llq0ye45))/DistrictRaifall.aspx

2015).[12] The Map 2 shows the extent of storm water drainage within AMC. Other than these lines, storm water system also includes lakes. Excess water is expected to automatically flow towards other lakes. These lakes are interlinked and the interlinking of lakes is expected to benefit from the overflow and catchments of each lake that would feed into the next, ultimately leading to the draining of excess water into the river. Also, the surplus water during the monsoons can be used to recharge the ground water.

Map 2: Extent of storm water drainage network in Ahmedabad



Source: AUDA 2015.

Whereas in Surat, around 144 sq.km. of SMC area have complete coverage of storm water system while the remaining areas will be covered on need basis (SUDA 2017).

3.4. Current Housing Programmes

At present, various affordable housing programmes, including national programmes such as BSUP, RAY, PMAY, etc., as well as state-level programme such as the Mukhymantri Gurh Awas Yojana (MMGY), etc., have been implemented in the state. The table 5 below provides the details of various national- and state-level programmes implemented in both cities in last decade. Under the MMGY programme, the state government aims to make Gujarat slum free by providing housing at reasonable price

[12] The walled city of Ahmedabad (having area of 4.46 sq. km.) has its natural slope which serves as the natural drain for storm water. Due to this very reason, provision of storm water lines is not required in the walled city (AUDA 2015).

to poor, lower- and middle-income group urban families. Under this programme, following policies have been carved out: (i) Gujarat Rehabilitation & Redevelopment of the Slum – 2010; (ii) Gujarat Slum Rehabilitation Policy (PPP)-2013; and (iii) Gujarat Affordable Housing Policy (PPP) – 2014.

At present, amongst the various affordable housing programmes listed in Table 5, housing sites proposed under RAY, MMGY, PMAY and Gujarat Slum Rehabilitation Policy (PPP) – 2013 are either in proposal stage or under construction or are yet to be inhabited by beneficiaries. Hence, for the purpose of this study, only housing sites under BSUP and MMGY have been considered as the research study locales. Another major factor in deciding upon the research study locales was the areas without coverage of storm water drainage as these areas are unprepared for and prone to water logging situations. Also, there are various income groups residing in these areas of the city. As discussed earlier the urban poor are the least resilient to any such events and if they reside in such low-lying areas without storm water drainage coverage, then they are most prone to damages in case of urban floods.

Table 5: Affordable Housing Programmes in Ahmedabad and Surat in 2005-18

Programme/ Scheme	**Ahmedabad**			**Surat**		
	Project Cost (INR crores)	**Central Assistance + (INR crores)**	**DUs sanctioned**	**Project Cost (INR crores)**	**Central Assistance + (INR crores)**	**DUs sanctioned**
National Level						
BSUP*	567.40	276.07	33,808	696.73	331.26	46,664
RAY**	110.86	52.89	2,528	-	-	-
AHP***	613.93	68.00	9,066	57.19	6.36	848
PMAY (proposed)	1,121.78	234.10	19,083	999.30	196.22	13,081
- ISSR@	625.80	104.30	10,430	-	-	-
- AHP$	495.98	129.80	8,653	999.30	196.22	13,081
State Level****						
MMGY	-	-	10,011	788.83	-	11,017
EWS Housing	-	-		43.51	-	7,424
Safai Kamdar Yojana #	-	-	2,496	-	-	-
SRS 2010	-	-	3,333	-	-	-
Gujarat Slum Rehabilitation Policy (PPP) – 2013	-	-	3,876	-	-	-
Total	**2,413.97**	**631.06**	**84,201**	**2,585.56**	**533.84**	**79,034**

Notes:
+ Requested share from the central government
BSUP construction is completed and RAY is ongoing
PMAY includes In-Situ Slum Rehabilitation Projects (ISSR) and Affordable Housing in Partnership (AHP)
Sources:
@ From 32nd CSMC Meeting presentation held on March 26, 2018, Source: http://mohua.gov.in/upload/uploadfiles/files/Gujarat_CSMC.pdf, (accessed on August 20, 2018).
$ From 36th CSMC Meeting presentation held on July 27, 2018, Source: http://mohua.gov.in/upload/uploadfiles/files/Gujarat.pdf, (accessed on August 20, 2018).

* As of August 6, 2018; Source: http://mohua.gov.in/upload/uploadfiles/files/BSUP_CITY_WISE(7).pdf, (accessed on August 20, 2018)
** As of August 6, 2018; Source: http://mohua.gov.in/upload/uploadfiles/files/Ray_City_wise_project(6).pdf, (accessed on August 20, 2018)
*** As of August 6, 2018; Source: http://mohua.gov.in/upload/uploadfiles/files/AHP_Project_Details(6).pdf, (accessed on August 20, 2018)
**** For Ahmedabad, source: http://ahmedabadcity.gov.in/portal/jsp/Static_pages/slum_ntwk_project.jsp (accessed on August 20, 2018) and for Surat, source: https://www.suratmunicipal.gov.in/Departments/SlumUpgradationHome, (accessed on August 20, 2018)
# 1,984 units are constructed under Phase 1 and 512 units are under construction in Phase 2.

Keeping these factors in mind, public housing sites in such areas were selected in both the cities. For example, in Ahmedabad, Odhav, Nikol and Vastral were such areas wherein all above factors were present – (i) these areas are low lying areas with respect to the city; (ii) they were not covered by the storm water drainage network; and (iii) public housing sites for Economic Weaker Section (EWS) categories built under various government schemes such as BSUP and MMGY were present.

In Surat, the strategy adopted for selection of public housing sites for this research was tweaked a little in comparison to Ahmedabad. Public housing sites under the BSUP and MMGY programme were spatially mapped over the flood prone and topography maps of the city to identify the 'most flood prone' regions in the city. Two regions were identified out of the 'most flood prone' from flood prone area map: (i) Adajan falling in west zone; and (ii) Katargam falling in north zone. However, on procuring the list of public housing sites from the Slum Upgradation Department of SMC, it was identified that addresses of public housing sites located in Adajan ward were easily available in comparison to the latter. Hence, sites falling under the Town Planning Scheme (TPS) 31 and 10 in Adajan ward were selected as the research locales in Surat.

Map 3: TPS 31 and TPS 10 located in the 'most flood prone' area of Surat.

Source: Prepared by the authors.

Since the main objective of this research was to compare the housing conditions of formal and informal settlements, therefore informal settlements located within the same areas as of the public housing sites were chosen as control groups with other factors such as topography, infrastructural services and location remaining constant making it possible to compare housing conditions of chosen sites with regard to flood resilience.

This was followed with a reconnaissance survey to observe and interact with the residents of the identified public housing and informal settlement sites in both cities about the living conditions, changes after shifting from informal housing to formal housing and issues/ improvements during flooding in comparison to their earlier residence, etc. These interactions enabled the authors to formulate questionnaire for the survey to be conducted in these selected sites. See Table 6 for the list of selected research locales in both cities. Out of the total number of households, sample size of around 5 per cent, based on random stratified sampling method, was chosen for detailed questionnaire survey.

Table 6: List of research study locales selected in Ahmedabad and Surat

Typology	Ahmedabad			Surat		
	Name of Site	No. of DUs	Sample Size	Name of Site	No. of DUs	Sample Size
Public Housing	Odhav BSUP EWS 3	256	25	Adajan BSUP TPS 32	192	30
	Nikol MMGY EWS	1,020	50	Adajan BSUP TPS 32	349	34
	Vastral MMGY EWS	656	32	Adajan BSUP TPS 31	640	64
Informal settlement	Bhagvati nagar (Odhav)	1,911	85	Revanagar TPS 10 (Adajan)	250	30
	Rajiv nagar (Odhav)	223	22	Mahadev nagar TPS 10 (Adajan)	500	50
Total		**4,066**	**214**		**1,931**	**208**

Source: Primary Survey.

4. Findings on flood experience and impacts

Overall, areas without storm water drainage connection in cities are prone to inland floods; and the ones falling in low-lying areas of the cities are even at a higher risk of flooding. The study showed that in spite of absence storm water drainage network coverage across of the selected sites and being situated in low-lying areas of the cities, MMGY public housing sites, particularly in case of Ahmedabad, ameliorated the monsoon resilience of the residents most followed by BSUP public housing and slums, respectively. One of the major factors attributing to the resilience of the residents could be the quality of construction of the MMGY public housing sites.

4.1. Sample Distribution

The analysis of surveyed households was based on the selected housing typologies in both case study cities. In Ahmedabad, of the total 214 sample households surveyed, 50 per cent of households were located in public housing sites (with 38.3 per cent in MMGY housing sites and remaining 11.7 per cent in BSUP) and slum settlements each. In Surat, the distribution of the total 208 sample households was 61.5 per cent from public housing sites (basically BSUP housing) and remaining 38.5 per cent from slum settlements.

In both case study cities, it was observed that even though female-headed households were not present in significant numbers, higher proportion of female-headed households were observed in slum settlements in comparison to the public housing sites. In Ahmedabad, out of the 214 sample households surveyed, only 1.63 per cent of households were female-headed, remaining 98.37 per cent were male-headed. Out of which, higher proportion of female-headed households were observed in the slum settlements (3.70 per cent) as compared to the BSUP (0 per cent) and MMGY (1.20 per cent) public housing sites. In Surat, only 3.8 per cent of the total 208 surveyed households were female-headed, remaining 96.2 per cent households were male-headed. Higher proportion of female-headed households were observed in the slum settlements (5 per cent) as compared to the public housing sites (3.1 per cent).

4.2. Ownership Pattern

In terms of ownership pattern, in case of Ahmedabad, self-owned housing was more prevalent in public housing sites – 96 per cent in BSUP sites and 90.20 per cent in MMGY sites in comparison to the slum settlements (83.30 per cent). These settlements had larger presence of rental housing (16.70 per cent) in comparison to the BSUP (4 per cent) and MMGY (9.80 per cent) housing sites. In case of Surat, housing in slum settlements was predominantly self-owned, whereas in case of BSUP housing around 4 per cent of households were tenants and remaining 96.10 per cent were self-owned.

Table 7: Ownership Pattern as per housing typology

Ownership pattern/ Typology	Ahmedabad (%)			Surat (%)	
	Public Housing MMGY	Public Housing BSUP	Informal Settlement	Public Housing BSUP	Informal Settlement
Self-owned	90.20	96.00	83.30	96.10	100.00
Rental	9.80	4.00	16.70	3.90	0.00
Total	**38.32**	**11.68**	**50.00**	**61.54**	**38.46**

Source: Primary Survey.

4.3. Occupation and Income Distribution

In terms of occupation distribution, in Ahmedabad, around 27.33 per cent of sample households are working in factories owing to the fact that the selected sites in the city are situated in Odhav ward, whose land use is predominantly industrial. This proportion is as high as 52.8 per cent in case of slum settlement households. Since jobs are readily available in the nearby factories and minimal transport costs to workplace are involved, most of the slum residents either use cycle or walk to their workplace. This is also attributed to the fact that their saving capacities are low/ negligible due to the expenses involved in living in slums. While considerable per cent of residents living in public housing sites are employed as factory workers; however there is more or less an even distribution of residents working as auto/ cab drivers, involved in other business or are self-employed in both public housing typologies. In MMGY public housing sites, residents are also employed in private and government sectors.

In Surat, large proportion of sample households in both BUSP public housing (56.3 per cent) and slum settlements (45.0 per cent) typologies are employed in private jobs such as technicians, gym trainer, diamond worker, housekeeping, etc. Around 18.8 per cent of sample households are working as auto/ cab drivers in both housing typologies.

In both cities, looking at the occupational patterns, it is evidently visible from Table 8 that in comparison to the slum settlement, residents in public housing have attained a higher level of stability. Less proportion of residents in public housing sites are employed in informal sector such as factory workers, informal vendors, contract labourers, etc.

Table 8: Occupation distribution as per housing typology

Occupation type/ Typology	Ahmedabad (%)			Surat (%)	
	Public Housing MMGY	Public Housing BSUP	Informal Settlement	Public Housing BSUP	Informal Settlement
Factory worker	25.6	24.0	52.8	2.3	5.0
Retailer	2.4	4.0	10.2	7.8	7.5
Informal vendor	1.2	0.0	9.3	7.0	10.0
Auto/ cab driver	20.7	36.0	9.3	18.8	18.8
Labourer	2.4	8.0	8.3	2.3	7.5
Private job	23.2	4.0	3.7	56.3	45.0
Other business/ self-employed	12.2	24.0	5.6	3.9	5.0
Government job	12.2	0.0	0.9	0.0	0.0
Housewife	-	-	-	0.0	1.3
Unemployed/ retired	-	-	-	1.6	0.0
Total	**38.32**	**11.68**	**50.00**	**61.54**	**38.46**

Source: Primary Survey.

With regards to monthly income distribution as per housing typology, in Ahmedabad, it is observed that sample households living in MMGY public housing sites are earning in higher income brackets followed by BSUP housing residents and slum settlements. Around 63 per cent of sample households living in slum settlements fall in the monthly income range of INR 5,000-10,000. This observation can also be correlated with the occupational patterns of residents as per their housing typologies – i.e. larger proportion of sample households living in slum settlements are working in informal jobs such as factory workers, informal vendors, etc., which are least paying jobs. This resulted in residents of MMGY housing sites have more disposable income followed by BSUP housing residents and lastly slum settlements. Hence, due to least disposable incomes, in case of any climate-induced event slum dwellers are the most vulnerable of all, followed by BSUP housing residents and MMGY housing residents.

Table 9: Monthly income distribution as per housing typology

Total HH monthly income/ Typology	Ahmedabad (%)			Surat (%)	
	Public Housing MMGY	Public Housing BSUP	Informal Settlement	Public Housing BSUP	Informal Settlement
0-5,000	0.0	0.0	0.0	3.1	11.3
5,000-10,000	29.3	28.0	63.0	54.7	56.3
10,000-15,000	50.0	72.0	34.3	37.5	31.3
15,000-20,000	18.3	0.0	2.8	3.9	1.3
> 20,000	2.4	0.0	0.0	0.8	0.0
Total	**38.32**	**11.68**	**50.00**	**61.54**	**38.46**

Source: Primary Survey.

Similar trends are observed in Surat also, wherein BSUP housing residents fall in higher income brackets as compared to the slum settlement residents; although not as distinctively as in case of Ahmedabad. Overall in both case study cities, this shift to public housing from slum settlements/ up-gradation of residents to public housing can be linked to lesser vulnerability to climate-related events, thus more savings and slowly moving out of the vicious cycle of poverty.

4.4. Impact of Water-logging on Housing Typologies

During the survey in Ahmedabad, all residents in BSUP public housing and slum settlements reported facing issues due to water logging in past five years. Whereas in past one year, 78 per cent of the MMGY public housing residents reported facing issues due to water logging, which was slightly higher than those affected by water logging in past five years (76.08 per cent). On comparing the three housing typologies in the city, it is observed that the residents of MMGY housing sites were less affected by water logging in comparison to the BSUP public housing and slum settlements, also in terms of depth and days of water logging. The point to be noted here is that the MMGY public housing residents reported water logging in the vicinity of their housing schemes, and not inside the scheme, which caused problems of vehicle damages and perishable asset losses when left unattended. Higher damages of assets were reported in BSUP public housing and slum settlements. During the survey, Hiren bhai from Bhagvati nagar, Odhav mentioned, "*We have to vacate our house in monsoon as we are located right beside the pond where the water level is highest*."

On comparing the current and previous housing scenarios, depth of water logging in MMGY housing sites reduced by 0.22 m (reduced by around 31 per cent); however this change was negligible in case of BSUP housing sites – reduced by 0.06 m (around 8.57 per cent). Similar trends in terms of reduction in water logging days were observed – with minimum of two days of water logging in MMGY housing followed by four days in BSUP housing which increased to six days for slum settlements. These figures indicate that living conditions for residents of MMGY housing sites have definitely improved after shifting from their previous housing; however negligible improvements are visible for residents in BSUP housing sites who were forced to resettle from their previous slum settlements situated at the banks of Sabarmati River. On the contrary, in spite of currently living in *pucca* housing under BSUP schemes, all residents have reported to be affected by floods in past one year which was comparatively lesser in their previous slum settlements (88 per cent).

Table 10: Impact of water logging across housing typologies over years

Impacts/ Typology	Ahmedabad			Surat	
	Public Housing MMGY	Public Housing BSUP	Informal Settlement	Public Housing BSUP	Informal Settlement
Current Housing					
% affected in past 5 years	76.8	100	100	43.00	85.00
Depth of water (in mts.) (Mean)	0.53	0.79	0.91	0.5	0.7
Water logging days (Mean)	2	4	4	2	2
% affected in past 1 year	78.00	100.00	100.00	15.60	75.00
Depth of water (in mts.) (Mean)	0.49	0.64	1.00	0.3	0.4
Water logging days (Mean)	2	4	6	1	1
Previous Housing					

% affected in previous housing	91.50	88.00	0	80.50	0
Depth of water (in mts.) (Mean)	0.71	0.70	-	0.8	-
Water logging days (Mean)	5	7	-	2	-

Source: Primary Survey.

In Surat, as evident from Table 10, residents in slum settlements were affected around 2 times and 4.5 times than residents of public housing by water logging in the past five years and one year, respectively. It is observed that not only more people living in slum settlements were affected, but also the average depth of water in slum settlements was higher than in public housing in past five years as well as last year. However, no difference in the number of water logging days in both housing typologies was observed. Rammohan, a resident of BSUP housing, stated that "*Here we are better off if only the flooding scene is looked at, as we have better pucca houses (now)*." When residents were asked about past five year impacts, they were reminded of the previous floods experienced in 2006 and 2013. As per Ganga of Mahadev Nagar slum settlement, "*In floods of 2006, whole settlement was under water till ceilings, and it was devastating*."

Also, around 80.5per cent of residents in BSUP housing reported to have been affected by water logging in their previous housing location, i.e., slum settlements, with highest average water logging depth of 0.8 m. Tushar, a resident of BSUP housing who is an auto driver, stated that "*Water used to get filled in Bhagwati Nagar (previous housing location), but not in my (current) place*."

4.5. Losses incurred across Housing Typologies

In Ahmedabad, it was observed that across housing typologies, MMGY housing residents did not suffer any loss to housing structure due to water logging or rainfall. However, due to absence of storm water drainage network in the area, issues of water logging in the vicinity of sites led to vehicle damage which incurred cost of INR 946. This was not the case with other respondents, in BSUP public housing, 36 per cent respondents suffered loss to housing structure which was as high as 73.10 per cent in slum settlements. In terms of working days lost, residents of MMGY housing lost the least number of days followed by BSUP housing and slum settlements, respectively. The residents from slum settlements lost 2.5 times more working days than MMGY housing residents, resulting in loss of income for these days. A similar pattern was observed in case of education days lost with least days lost for MMGY housing residents and most by slum settlement residents (twice as many days as compared to MMGY residents). In terms of repair costs, working days lost and education days lost, not much difference was observed between BSUP housing and slum settlements. On comparing the current and previous housing scenarios, there has been a stark improvement in terms of per cent of respondents reporting loss to housing structure. But, in terms of repair costs, there has been much more improvement for MMGY

housing residents whose expenditure decreased by INR 2,663 (average), an improvement by 73.79 per cent than BSUP housing residents whose expenditure decreased by INR 344 (average) only, an improvement of 7.95 per cent from expenditures in respective previous housing.

Table 11: Losses to housing structures and costs incurred towards repairs across housing typologies

Impacts/ Typology	Ahmedabad			Surat	
	Public Housing MMGY	Public Housing BSUP	Informal Settlement	Public Housing BSUP	Informal Settlement
Current Housing					
Loss to housing structure (%)	0	36.00	73.10	10.20	17.50
Cost incurred (in INR) (Mean)	0	3,982.00	5,420.00	1,857.10	5,730.8
Work days lost (Mean)	2	3	5	2	2
Education days lost (Mean)	3	4	6	2	3
Previous Housing					
Loss to housing structure (%)	39.50	92.00	-	46.90	-
Cost incurred (in INR) (Mean)	3,609.00	4,326.00	-	5,208.40	-
Work days lost (Mean)	3	4	-	2	-
Education days lost (Mean)	3	5	-	3	-

Source: Primary Survey.

In Surat, as seen in Table 11, housing structures affected by water logging were significantly lower in both the housing typologies – around 10.2 per cent in BSUP public housing and 17.5 per cent in case of slum settlements. However, in terms of cost towards repairing these damaged housing structures, there is a significant variation in both housing typologies. The average cost towards repairs in slum settlements is thrice the costs incurred in BSUP housing. All residents reported loss in education days, where children were unable to attend school/ college for an average of two days in BSUP housing and three days in slum settlements. Higher costs towards repair of housing structures and number of education days lost in case of slum settlements indicated the intensity and severity of monsoons the residents faced in these settlements. An average of two working days lost was reported in both housing typologies. On comparing the current conditions of public housing with their previous settlement, a decrease is seen in per cent of housing structure affected by water logging and cost incurred per year towards repairs when BSUP public housing moved from their previous settlements. Around 46.9 per cent BSUP housing residents were affected in their previous housing locations (i.e. slum settlements), a difference of 4.5 times. Similarly in terms of costs incurred towards repairs in their previous housing around three times than that incurred in their current public housing.

4.6. Impact of Water-logging on Health

As it is evident from Table 12, highest per cent of residents faced health issues within three months of rainfall in slum settlements (83.30 per cent) in Ahmedabad followed by BSUP housing (80 per cent) and MMGY housing (61 per cent), respectively. There was higher occurrence of potentially fatal diseases in BSUP housing and slum settlements than in MMGY housing. This is a direct indicator of the dismal living and housing conditions of residents in slum settlements and BSUP housing who suffered from vector-borne diseases due to higher water logging levels and dilapidated housing conditions. Alka ben from Nikol MMGY public housing reported, "*We don't fall sick as often as we used to in our previous housing* (slum settlement) *in Odhav*."

Also, being located in industrial areas, residents of slum settlements and BSUP housing are highly exposed to pollution from these industries. Also, during the surveys, it was reported that in case of water logging due to heavy rainfall, factories directly discharged their toxic waste into clogged water, thereby increasing the risk of being susceptible to diseases in these sites. Lack of sewerage network in slum settlements, clogged sewerage network in BSUP housing sites resulted in overflowing of sewage in these low-lying settlements, and hence these areas turn into breeding grounds for vector-borne diseases. Hence, residents of slum settlement and BSUP housing spend considerable amounts per year on health treatments. However, in spite of lesser per cent of MMGY housing residents being affected by post-rain health impacts in comparison to BSUP housing residents; statistics from survey indicate higher level of spending by the former (INR 1,250) in comparison to the latter (INR 1,070). This is largely due to the higher income levels of the MMGY housing residents, higher affordability for better treatments to health impacts in comparison to the residents of BSUP housing. Women, children and elderly had the least immunity against these pathogens, hence were the most vulnerable group to be affected amongst all. Although dispensaries have been built in all BSUP housing sites, however, during the survey it was observed that these were not operational and remained in dilapidated state.

Table 12: Health impacts across housing typologies

Health Impacts (3 months post flood)/ Typology	Ahmedabad (%)			Surat (%)	
	Public Housing MMGY	Public Housing BSUP	Informal Settlement	Public Housing BSUP	Informal Settlement
Post flood health issues (yes)	61.00	80.00	83.30	35.20	46.3
Diseases					
Fever*	66.00	45.00	44.40	53.3	50.0
Skin disease	4.00	5.00	3.30	-	-
Malaria	16.00	15.00	20.00	35.6	36.1
Cholera	0.00	10.00	6.70	-	-
Chikungunya	0.00	10.00	5.60	0.0	0.0
Dengue	8.00	5.00	8.90	6.7	13.9
Typhoid	6.00	10.00	11.10	-	-
Common cold	-	-	-	4.4	0.0
Costs incurred (INR)	1250.00	1070.00	1626.67	188.00	346.50

(Mean)					

Notes: * Fever indicates either viral fever which lasts a few days or any other undetected disease.
Source: Primary Survey.

In comparison to Ahmedabad, less number of households were affected by health impacts post three months of monsoon in Surat across both housing typologies – 46.3 per cent in slum settlements and 35.2 per cent in public housing. Major diseases by which households were impacted included fever, malaria, dengue, etc. Rameshbhai from Mahadev Nagar reported*, "Every Tuesday workers from SMC come to spray medicine, but still mosquitoes are there. Whole family gets fever after rains."* Also in terms of treatment costs incurred, costs incurred by residents of slum settlements was around 1.8 times the costs incurred by residents of BSUP housing.

4.7. Impact of Water-logging on Household Asset Damage

In Ahmedabad, it is evident from the household asset damages across housing typologies that damages were severe in informal settlements for various assets, followed by BSUP public housing and MMGY public housing.

Table 13: Household assets damage across housing typologies in Ahmedabad

Household Assets Damage/ Typology	Ahmedabad		
	Public Housing MMGY	Public Housing BSUP	Informal Settlement
Current Housing (No. of HH)			
Cycle	0	0	0
2-wheeler	9	4	16
3-wheeler	0	0	0
4-wheeler	1	0	0
Others	0	0	0
T.V	32	17	9
Food	2	4	26
Fridge	0	0	6
Table fan	0	0	0
Machinery	0	0	1
Multiple Items	0	0	6

Source: Primary Survey.

Table 14: Household assets damage across housing typologies in Surat

Household Assets Damage/ Typology	Surat	
	Public Housing BSUP	Informal Settlement
Current Housing (No. of HH)		
House furniture	1	3
Food items	1	1
Electronic items	0	3
Documents	0	0
Everything	0	1
4-wheeler/ 2-wheeler/ Auto	2	3
Cycle	1	2
Value of assets damaged (in INR) (Mean)	780.00	1315.00
Previous Housing (No. of HH)		
House furniture	3	-

Food items	3	-
Electronic items	7	-
Documents	1	-
Everything	1	-
4-wheeler/ 2-wheeler/ Auto	3	-
Cycle	2	-
Value of assets damaged (in INR) (Mean)	1444.00	-

Source: Primary Survey.

Similarly, it is also evident in Surat that the household mean asset damage was twice across current housing in slum settlements and previous housing in comparison to the BSUP public housing. Mukesh Bhai who lives in Mahadev Nagar slums stated that, *"My bike was kept on bridge in floods of 2013, but still electronic items were destroyed."* Major problem encountered by residents in saving their assets is their inability to move heavy items during rains and water-logging. Prahlad from Revanagar slum stated that, *"We can't carry so much stuff from home to temples, thus heavy stuff like fridge, bed, etc., gets washed away in case of flood."*

On comparing the estimated average household losses to the average monthly household income across housing typologies, the magnitude of losses suffered/ incurred by residents of slum settlements (both in absolute values as well as per cent of their monthly income) is higher as compared to the residents of public housing in both cities. In Ahmedabad, it is clearly evident from Table 15 that residents of MMGY housing have the highest income and lowest expenditure; hence are able to incur such expenses against losses. While the residents of BSUP housing and slum settlements have lower income and negligible amount of monthly savings. Thus, whenever in need, they end up borrowing money from informal sources such as workplace/ social circle/ kin. Loss of income due to loss of working days also aggravates this issue. Overall, such losses are least for residents of MMGY housing (24.35 per cent) followed by BSUP housing (66.64 per cent) and then slum settlements (102.58 per cent) respectively. It is apparent that a poorly done public housing (BSUP) only partially ameliorates the resilience towards monsoon or inland flooding. Similarly in Surat, average losses incurred by residents of slum settlements is 22.20 per cent of their average monthly income (higher than losses incurred by public housing residents – around 9.4 per cent).

Table 15: Comparison of household losses to their monthly incomes across housing typologies

Household Assets Damage*/ Typology	Ahmedabad			Surat	
	Public Housing MMGY	Public Housing BSUP	Informal Settlement	Public Housing BSUP	Informal Settlement
Total household loss (in INR) (Mean)	2,969.44	7,396.67	9,735.08	921.00	1,916.00
Total household income (in INR) (Mean)	12,915.12	11,100.00	9,490.74	9,726.60	8,625.00
% of total household income	24.35	66.64	102.58	9.40	22.20

Note: * Reported asset damages include vehicle damages due to water-logging, electronic asset damages (TV sets, fridge, table fan, machinery, etc.) and perishable assets (food items, spices etc.).
Source: Primary Survey.

4.8. Impact of Water-logging on Infrastructure

In Ahmedabad, both MMGY and BSUP public housing were connected to sewerage network. Parts of slum settlements had been connected to sewer lines only last year (2017) by the AMC. However, due blockage of all sewer lines, there is backflow of sewage onto the water logged streets. In terms of mobility, residents of BSUP housing and slum settlements were the most affected as no mode of transport was available to most of the respondents during rainfall. Most of the BSUP sites were located in interiors of the industrial areas of Odhav ward. The nearest point of access to public transport (basically BRTS system) was about 1.5 to 2 km away, which used to be water logged during rainfall. Ramnik bhai from Odhav BSUP housing mentioned, "*We have been given house but the site is not accessible by main road. We have to take the longer route*." Very few residents from BSUP housing and slum settlements owned private vehicles, however, these vehicles were either damaged or residents were not able to move them out due to water logging during rainfall. On the other hand, residents of MMGY housing were least affected in terms of mobility owing to lesser water logging depth, higher income and more private vehicle ownership. Residents of BSUP housing and slum settlements faced same but longer hours of power cut (six hours) in comparison to the MMGY housing sites. Resident the BSUP housing sites were also discontented with the fact of being forced to resettle far away from their previous housing which was located in the city centre. This forced resettlement have resulted in increased transportation costs and caused a disruption in their social lives.

Table 16: Impacts on infrastructure across housing typologies

Impact on Infrastructure/ Typology	Ahmedabad (%)			Surat (%)	
	Public Housing MMGY	Public Housing BSUP	Informal Settlement	Public Housing BSUP	Informal Settlement
Sewer line availability	100.00	100.00	8.30		
Drainage network blockage	100.00	100.00	100.00	10.90	32.50
Resident Mobility					
Nothing available	26.80	100.00	94.40	0.00	0.00
No issues faced	20.70	0.00	0.00	79.70	83.80
Frequency affected	26.80	0.00	5.60	20.30	16.20
Nothing available during heavy rainfall	25.60	0.00	0.00	0.00	0.00
Power cut duration (hours)	4.00	6.00	6.00	2.00	3.00

Source: Primary Survey.

Whereas in Surat, noticeable impact on infrastructure was observed, especially in terms of drainage lines. Around 32.5 per cent of residents from slum settlements reported blocked drainage lines (before and during monsoons) which caused water

logging outside their houses. While in case of BSUP housing, only 10.9 per cent residents report this issue which proved that drainage infrastructure facilities in these sites were more reliable and maintained. Ashwin who lives in Revanagar slums stated that, *"Government doesn't help us. Our drainage lines are blocked as government doesn't come to clear them and we had to send one of our friend inside to clear it. He died!"* Also, impact on mobility of residents was not an important issue, as most of them reported that their mobility was not affected during or after water-logging (79.7 per cent in case of BSUP housing and 83.8 per cent in case of slum settlements). Remaining responses were towards hindrance in private mobility and not on public which means that these residents might have faced issues in reaching to the main roads of the city or public transport due to water logging in the site or vicinity of the site. Also, mobility of the residents in slum settlements is also hampered due to poor condition of roads within and surrounding the settlement. These either remain unconstructed (i.e. are *katcha*) or are built using low quality materials which get easily damaged due to water logging and hence travelling becomes an everyday struggle. Prakash from Revanagar slum responded that, *"There is no problem in general rainfall and monsoon, as there are no floods anymore; however, my bikes slips in the rainy season due to muddy roads."*

4.9. Coping Strategies across Housing Typologies

In terms of coping strategies, in Ahmedabad, most of the respondents in all sample sites do not do anything. However, people living on ground floors of BSUP housing use sand bags to make embankments in order to keep water out of their houses when water logging reach such levels. Similarly, residents of slum settlements keep their perishable assets on top of furniture to save them and like BSUP residents, they also use sandbag embankments to keep water out. Part of Rajiv nagar settlement is located beside a pond which is the lowest level in the settlement; hence houses near them get flooded to such an extent that they have to temporarily shift to some other location till the water level recedes. In terms of help from the government during water-logging/ flooding, most of the residents reported that there was no help from AMC and rarely did AMC sprang into action during severe rainfall. Only MMGY public housing residents reported that AMC helped by clearing blocked sewage line and logged water with help of suction pumps. It was also reported that prior to the elections, political party workers distributed food parcels in these settlements with the motive to gather vote bank from these settlements, but after the elections no help came from the ruling political party.

Table 17: Coping strategies and external help across housing typologies

Impact on Infrastructure/ Typology	Ahmedabad (%)			Surat (%)	
	Public Housing MMGY	Public Housing BSUP	Informal Settlement	Public Housing BSUP	Informal Settlement
Role of local government					
No help	72.00	92.00	93.50	28.40	32.90
Open manhole covers and clear clogged drains	26.80	8.00	3.70	31.80	26.30

through pumps					
Health services like medicine inspection and spray	1.20	0.00	2.80	39.8	40.80
Assistance from NGOs/ Civil groups (yes)	2.40	8.00	9.30	0.00	3.80

Source: Primary Survey.

In Surat, there were many similarities and differences observed in the strategies adopted by the residents across both housing typologies during water-logging/ flooding. While opening manhole covers (87.5 per cent in public housing, 52.9 per cent in slum settlements) and moving to terraces (12.50 per cent in public housing and 11.8 per cent in slum settlements) were common strategies adopted. However, residents of slum settlements also moved their belonging to higher levels/ heights as well as moved temporarily to nearby safer places like temples and schools during water-logging/ flooding. These additional strategies were not observed in public housing as the settlement layouts had safe margins where water would not enter the house in case of water-logging.

Local government (SMC) plays a vital role in helping residents to cope with water-logging. According to the respondents of public housing and slum settlements, SMC helped them open manhole covers, clear blocked drainage lines, provide them with health services, like health check-ups, medicines, mosquitoes spray, etc. Gopal, a resident of BSUP public housing stated that, *"SMC keeps the campus clean by cleaning it daily. Thus, (there are) no health problem."*

4.10. Summary of Findings

4.10.1. Ahmedabad

From the above analysis of sample surveyed, it is evident that residents of the MMGY public housing sites were least affected by water-logging in terms of depth and duration of water-logging due to location of these housing sites in the residential area which had less negative externalities in comparison to others. This in addition to better locational advantages leads to less number of health issues faced by the residents as well as minimizes asset losses and housing structure damages, thereby increasing their savings and enabling better living conditions. On comparing the current and previous housing conditions, there is a considerable improvement in water logging depths for MMGY public housing (by 30.99 per cent) and negligible for BSUP public housing (by 8.57 per cent). Similarly, in terms of repair costs incurred, residents of MMGY public housing have benefited the most as their expenditures declined enormously by 73.79 per cent in comparison to the BSUP housing residents whose expenditure declined meagrely by 7.95 per cent from expenditures in their respective previous housing. Although both public housing schemes were connected to sewerage network but during rainfall, these sewerage lines got blocked and clogged resulting in an overflow/ back flow of sewage onto the water-logged streets. All the sample sites received rare/ no help from the AMC during monsoons. It was only

during severe situations did AMC intervened. Amongst the three housing typologies, health issues faced within three months of rainfall were found highest in slum settlements followed by BSUP public housing (nearly same as in slum settlements) and MMGY public housing respectively. On aggregating all the impacts in economic terms, residents of BSUP public housing spend 2.50 times as much as MMGY public housing residents whereas residents of slum settlements spend nearly 3.28 times as much as MMGY housing residents annually to recover from problems during monsoons. As a result, moving into MMGY public housing has improved monsoon resilience of the residents considerably as compared to their previous housing

In case of BSUP public housing, it is apparent being surrounded by factories acts as a negative externality. During rains, not only the streets are water logged, but these factories discharge chemical wastes onto the streets exacerbating the risk of diseases. Also, in spite of having a bore well for water supply at the site, water from the bore well is not potable, increasing risks for residents. The depth and duration of water logging are higher in comparison to the MMGY public housing scheme due to which residents face asset and housing structure damages. These water-logged streets also act as breeding grounds for mosquitos aggravating exposure to vector-borne disease. This means that residents of BSUP public housing have to spend more on health and repairs during such times. The lower income levels (in comparison to residents of MMGY public housing) further reduced due to loss of working days due to impacts on health and mobility results in negligible savings. On comparing these conditions with their previous housing (i.e. slums along Sabarmati riverfront), their monsoon resilience remains more or less the same.

Amongst these three housing typologies, residents of the slum settlements were the severely affected ones. This is due to the fact that water logging depth and duration in these settlements is the highest, the settlements are located in industrial area, the residents have lowest income levels which is further reduced by loss in working days, suffer highest health impacts and asset damages. Overall, residents of slum settlements have the highest vulnerability. During the survey, it was clearly evident that most people currently residing in the MMGY and BSUP public housing sites were former slum residents from various parts of the city.

On comparing the impact of moving into public housing on their monsoon resilience, MMGY public housing has been done well in terms of location, service provisions and all the aspects discussed above, hence an increase in the monsoon resilience levels despite of the fact that there is absence of storm water drainage network in the area. Whereas, in terms of BSUP public housing scheme, which has been poorly constructed and implemented, there is negligible or no increase in flooding resilience levels for residents and their living conditions; with their housing condition and monsoon resilience levels being similar to those of slum settlements. This raises concerns over the government authorities responsible for making these public housing schemes as both MMGY and BSUP public housing were provided by the government.

The only difference between the two being that MMGY public housing is sold on a lottery basis at subsidised rates to economically weaker sections of the society (i.e. households' having annual income less than INR 0.3 million as per government norms) whereas the beneficiaries of BSUP housing paid INR 66,000 as their contribution towards the housing. This implies that if any public housing scheme is constructed and implemented properly, then it is beneficial for the people moving into such schemes from slum settlements as it results in an increase in monsoon resilience. But, at the same time, if public housing schemes are done poorly then it results only in relocating the slum settlements from an unplanned sprawl to a planned vertical slum in shape of three/ four-storied buildings which is evident from the current conditions of BSUP public housing. Also, if any area in the city turns into breeding ground for mosquitos and there is an outbreak of any vector-borne disease, it is a signal for danger for all residents of the city as mosquitos do not discriminate between poor or rich people or people of different housing schemes. Hence, city governments should pay more attention to such areas. A mere provision of public housing for urban poor residing currently in informal housing is not enough, but it is imperative to ensure that public housing is well planned, only then it will have a positive impact on the monsoon resilience of the residents. The BSUP housing sites in Ahmedabad have been implemented poorly which has led to the costs being passed onto the resettled households than to the local government and has partially ameliorated the monsoon resilience of its residents. The residents of MMGY public housing are expected to have higher incomes due to the mode of provision - these housing units were sold at a subsidised rate to the economically weaker sections of the society (i.e. households' having annual income less than INR 0.3 million as per government norms).

4.10.2. Surat

In case of Surat, it is evident how better housing (in this case, public housing) lowers the vulnerability and exposure of residents living in it, as compared to those residing in slum settlements in poor living conditions (such as lack of infrastructure, unhealthy surroundings, etc.). The residents of slum settlements as compared to the residents of public housing, face adverse challenges during floods/ heavy rainfall such as water-logging problems, loss of household assets, damages in housing structure, impacts on health, etc., due to the vulnerable locations of their settlements, such as in low-lying areas and near to river banks. Also, one of the major causes of water-logging due to flooding or rains is the absence of infrastructure or blockage in the existing infrastructure. Due to such amplified impacts on slum settlements, the residents also happen to spend more as a recovery cost which may be less in absolute terms as compared to that incurred by the residents of public housing; however, the proportion of these costs to the monthly income levels of the slum settlements residents is much more in the case of slum settlements. This creates a vicious loop for the people living in informal housing of the city who are affected by the impacts of climate change, an in-escapable one. Although, help from the local government (SMC) was reported in to both housing typologies, however, they are not adequate enough to help the residents tackle these threats in a better way and increase their resilience.

5. Discussion

Through this study, it is evident in both case study cities – Ahmedabad and Surat, how formal housing (i.e., public housing) ameliorates the vulnerability and exposure of residents, as compared to those living in informal settlements in precarious conditions with lack of basic infrastructure, unhealthy surroundings, etc. Hence, the impacts borne by residents of informal housing such as water-logging issues, loss in household assets, damage in housing structure, impacts on health, etc., are exacerbated in comparison to those experienced by residents of public housing. Multiple reasons attribute to their vulnerability including vulnerable locations on which the sites/ settlements are located (such as in low-lying areas or proximity to river banks as in case of Surat), absence of storm water drainage infrastructure which leads to water logging conditions or blockage in the existing infrastructure. Due to such amplified impacts on their living conditions, informal housing residents also tend to spend more as a recovery cost. These recovery costs per household spent by residents of slum settlements, to recover or as a loss in any way, may be less in absolute terms in comparison to the public housing residents; however, per cent of these costs to their monthly incomes is higher in case of slum settlements. This creates a vicious loop for the urban poor affected by the impacts of climate change. Albeit, help from the local government were report to some extent in the case study cities, however these efforts were not adequate enough either to help residents tackle these threats in a better way nor build their resilience.

Based on the analysis and findings discussed in the previous section, it was important to extrapolate the costs associated with direct impacts in both cities. This would enable us to come up with policy recommendations at city-level. These extrapolations have been attempted based on certain individual assumptions in both cities.

5.1. Estimation of Economic Losses

5.1.1. Ahmedabad

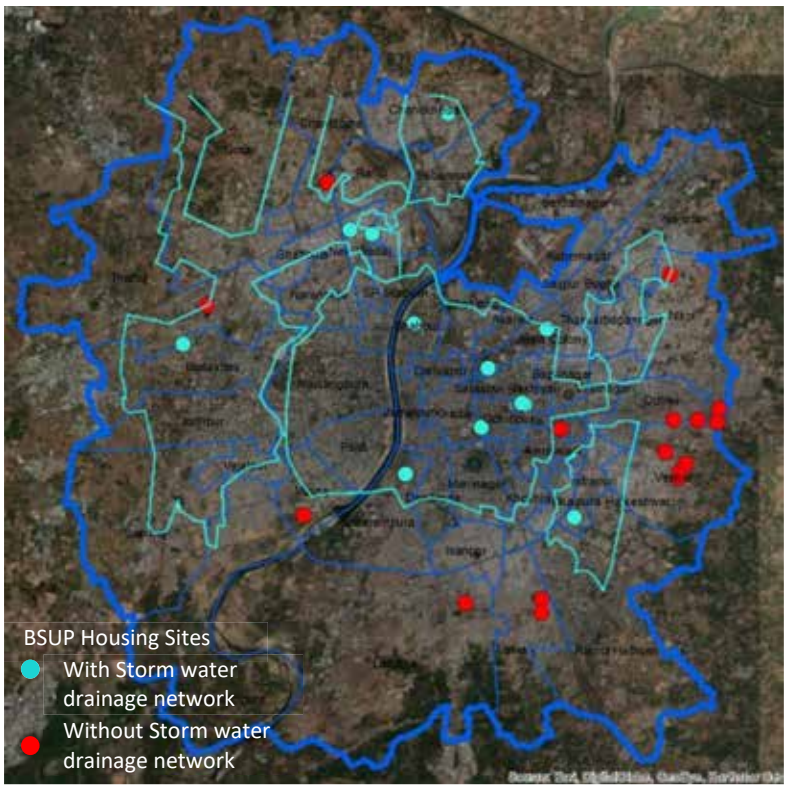
Based on the assumptions: (i) public housing sites (BUSP as well as MMGY) without access to storm water drainage network coverage will have similar conditions to cope with and hence the losses/ damages estimated in such sites would be 100 per cent; whereas in case of public housing sites (BSUP as well as MMGY) having access to storm water drainage network, losses/ damages are estimated to be 50 per cent (see Map 4 and Map 5); and (ii) all slums in the city will have similar conditions to cope with and expenses to incur in event of flooding/ water-logging in these settlements. With 691 slums in the city (MHUPA 2014), around 13 per cent of the total city population consists of slum population, which is a significant number.

Table 18: Estimation of economic losses in slum settlements and public housing in Ahmedabad

Type of damages	% HH reporting loss	Avg. cost per HH (in INR)	Estimated no. of HH to be affected*	Estimated damages (in INR Crores)
Informal Settlements				
Asset	51.90	1,156.00	84,467	9.76
Housing structure	73.10	5,420.00	1,18,970	64.48
Health treatment	83.30	1,626.67	1,35,570	22.05
Income loss	100.00	1,532.41	1,62,749	24.94
			Sub-total (A)	**121.23**
Public Housing - BSUP				
Asset	84.00	1,048.00	13,951	1.46
Housing structure	36.00	3,982.00	5,979	2.38
Health treatment	80.00	1,070.00	13,287	1.42
Income loss	100.00	1,296.67	16,608	2.15
			Sub-total (B)	**7.42**
Public Housing - MMGY				
Asset	46.30	946.00	1,779.00	0.17
Housing structure	0.00	0.00	0.00	0.0
Health treatment	61.00	1,250.00	2,344.00	0.29
Income loss	78.00	773.44	2,998.00	0.23
			Sub-total (C)	**0.69**
			Total (A+B+C)	**129.34**

Notes: * These figures are rounded off to approximate figures (of higher values).
Source: Estimated from Primary survey.

Map 4: BSUP public housing sites in Ahmedabad

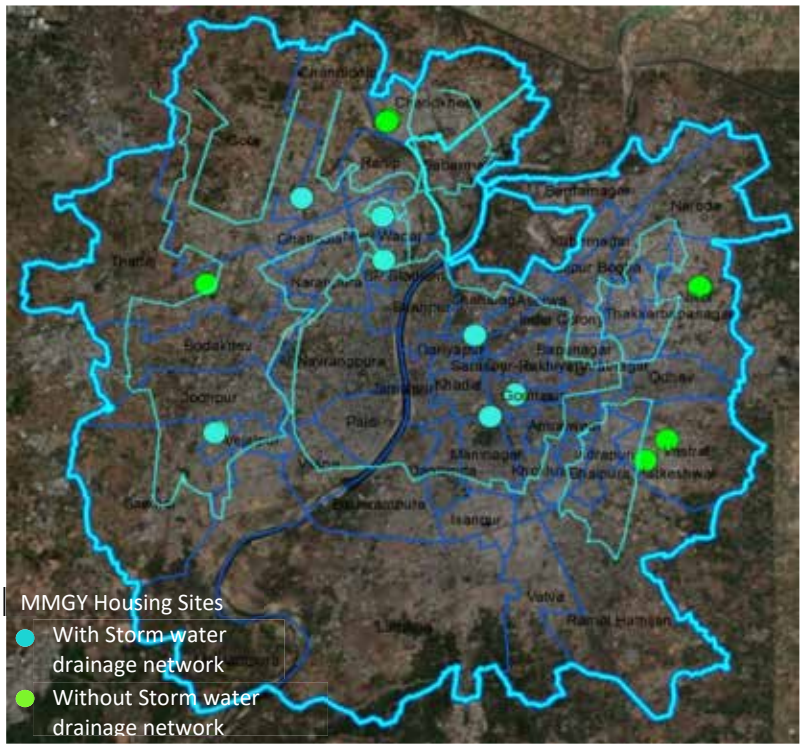


Source: Prepared by the authors.

On looking at the losses individually across the housing typologies, the annual loss in monsoon season for informal settlements is estimated at around INR 121.23 Crores. This is an exorbitant amount which if not lost can alternatively be utilised to upgrade living conditions of each household. Hence it is impertinent for the government to

step in order to minimise these losses through provision of affordable and properly implemented formal housing programmes for residents of informal settlements. Whereas the annual economic losses for residents of BSUP public housing comes to around INR 7.42 Crores across the city which is again a considerable amount which can be utilised elsewhere if housing and living conditions were to be improved. This is a critical city-level finding which can be compared with well implemented exemplars of public housing which leads us to the next estimation for MMGY public housing residents. The annual economic loss for MMGY public housing is estimated around INR 0.69 Crores which is due to better housing and living conditions and is affordable for its residents. This loss can be further lowered if all sites are covered by storm water drainage network. On comparing the losses between both typologies of the public housing, it is evident that the losses incurred in BSUP housing are more than 10 times of MMGY housing indicating the differences in terms of implementation and provision of infrastructure services across both typologies.

Map 5: MMGY public housing sites in Ahmedabad



Source: Prepared by the authors.

Overall, at city-level, on adding up these three losses – in public housing including BSUP and MMGY and informal settlement, the total amount comes to around INR 129.34 Crores per year - an exorbitant staggering amount to be spent by residents of these settlements due to damages in monsoon. Above these losses, many unaccounted losses are incurred in case of outbreak of diseases like dengue, chikungunya, malaria, etc. The reason behind such outbreaks may be due to the fact that areas such as the ones studied turn into breeding grounds for mosquitos which then don't discriminate

between areas with drainage or without and between poor or rich. Hence, risk all citizens at risk and must be acted upon.

5.1.2. Surat

In Surat, there is a slight deviation in the extrapolation calculations. There are 77,592 slum households and 97,267 households in public housing schemes (BSUP and MMGY included) in the city. As per the survey, around 85 per cent slum settlement residents and 43 per cent public housing residents were affected in last five years. This same assumption is used for extrapolation calculation over the city. Also, it is assumed that the other sites (slum settlements as well as public housing) will be less affected, as they are in less-intensity flood prone areas (and in safer zones), as compared to the ones taken in the current study, losses due to impacts have been reduced by 50 per cent. When calculated, it is seen that estimated cost of damage that residents bear in total comes to around INR 8.24 Crores each year (see Table 19).

Table 19: Economic losses in slum settlements and public housing in Surat

Housing Typology	Total loss suffered (Mean) (in INR)	% of HH affected	Estimated no. of HH that may be affected by the same intensity of monsoons	Estimated costs of damage (in INR Crores)
Public housing	921	43	97,267 (BSUP + MMGY)	1.92
Slums	1,916	85	77,592	6.31
			Total	**8.24**

Source: Estimated from Primary survey.

5.2 Recommendations

Based on the estimation of economic losses in both case study cities, scenario-based recommendations have been worked out in both cases.

5.2.1 Ahmedabad

Scenario 1: Move all slum households to formal housing

This is the best-case scenario in order to improve resilience of the slum dwellers. This involves construction of 162,749 DUs as per the current PMAY programme standards (i.e. 30 sq. m. carpet area). This would enable the households to build a permanent asset over time. In order to do so, approximate costs involved are discussed below:

Table 20: Scenario 1 - Construction costs + Infrastructure investments, Ahmedabad

Construction costs	
No. of DUs	162,749
Carpet area per unit as PMAY (in sq.m.)	30.00
Built up Area (BUA) per unit (30% loading assumed) (in sq. m.)	39.00
Rate of construction per sq. m. Assumed (in INR/ sq.m.)	12,000.00
Total construction cost (in INR Crores) (A)	7,616.65
Cost of construction of site development (25 % of construction cost) (in INR Crores) (B)	1,904.16
Total project cost (in INR Crores) (A+B)	**9,520.82**
Infrastructure investment	
Water supply cost per person (in INR)	5099.00
Sewerage network cost per person (in INR)	4704.00
SWM services cost per person (in INR)	391.00

Storm water drainage network cost per person (in INR)	3526.00
Population to cater (No. of persons)	727,934
Water supply cost (in INR Crores)	185.59
Sewerage network cost (in INR Crores)	123.27
SWM services cost (in INR Crores)	28.46
Storm water drainage cost (in INR Crores)	256.67
Total investment for Infrastructure (in INR Crores)	**593.99**

Source: Computed by the authors.

Based on certain assumptions as outlined in Table 20, a total of around INR 9,521 Crores are required for construction of DUs and on site infrastructure for shifting all slum households to formal housing. On considering provision of external infrastructure or trunk lines in terms of water supply, drainage network, solid waste management services and storm water drainage network, as guidelines given in the High Powered Expert Committee (HPEC) Report, 2011, costs for provision of these add to another INR 594 Crores. Here it should also be noted, that these costs are calculated keeping in mind the existing infrastructure provision and coverage for the slums in Ahmedabad. This amount is to be entirely borne by the government. According to the current programme guidelines, the government contributes a share of 40 per cent of the construction costs which makes the government's share of INR 3808 Crores in addition to the investment required to lay and upgrade infrastructure.

Table 21: Scenario 1- Contribution distributions and Loan calculations

Costs borne by	EWS construction (in INR Crores)	Infrastructure investment (in INR Crores)
Beneficiary (60 %)	5,712.49	0.00
Government (40 %)	3,808.33	593.99
Total	**9,520.82**	**539.99**
Loan Scenario		
Cost borne by beneficiary (in INR Crores)		5,712.49
Cost per HH (in INR)		351,000.00
Loan amount (in INR)		351,000.00
Loan period (years)		20
Annuity (in INR)		37,090.51
EMI to be paid (in INR)		3,090.88
Average income (in INR)		9,490.74
EMI as % of monthly income (%)		32.57

Source: Computed by the authors.

Based on the calculations shown in Table 21, investment required from the government is around INR 4,402 Crores and INR 5,713 Crores from the beneficiaries for 162,749 households. Considering per household contribution required of INR 3.51 lakhs, it is highly unlikely that the slum dwellers would have such an amount to pay at once, thus would resort to loans from banking sector. Considering the maximum period for which housing loans are available of 20 years, the equated monthly income (EMI) to be paid is around INR 3,091 which would be around 33 per cent of the average monthly income of slum dwellers.

Scenario 2: Upgrade and provide infrastructure to all the slums

This involves up-gradation of major infrastructure provision in slums only and not construction of new housing by the government. The focus of the authorities is on improving the resilience of slum dwellers by providing infrastructural improvements, i.e. provision of external infrastructure or trunk lines in terms of water supply, drainage network, solid waste management services and storm water drainage network. The standards and costs involved are discussed in Table 22.

Table 22: Scenario 2 - Infrastructure investment requirements, Ahmedabad

Infrastructure investment	
Water supply cost per person (in INR)	5,099.00
Sewerage network cost per person (in INR)	4,704.00
SWM services cost per person (in INR)	391.00
Storm water drainage network cost per person (in INR)	3,526.00
Population to cater (No. of persons)	727,934
Water supply cost (in INR Crores)	185.59
Sewerage network cost (in INR Crores)	123.27
SWM services cost (in INR Crores)	28.46
Storm water drainage cost (in INR Crores)	256.67
Total investment for Infrastructure (in INR Crores)	**593.99**

Source: Computed by the authors.

Considering the per capita cost for each infrastructure component as per the guidelines given in the HPEC Report, 2011, the total infrastructure investments for the entire slum population comes to around INR 594 Crores. These costs are calculated keeping in mind the existing infrastructure provision and coverage for the slums in Ahmedabad. This amount is to be entirely borne by the government and does not involve any cost to be borne by the beneficiary households.

Scenario 3: Strategically relocate, redevelop and upgrade

Based on the tenability and quality of housing and related services, this scenario involved strategic decision on the development strategies of relocation, redevelopment and infrastructure up-gradation or a combination of these. In order to do so, the slum settlements have been divided into categories (see Table 23).

Table 23: Scenario 3: Categorization of slum settlements in Ahmedabad

Action to be undertaken	**No. of settlements**	**No. of HH**
Slums to be delisted (developed by AMC)	53	10,530
Non-tenable slums (relocation)	162	37,674
Tenable slums (on high value land)	34	12,635
In-situ redevelopment	442	1,01,910
Total	**691**	**1,62,749**

Source: Slum Free City Plan of Ahmedabad (2015)

The settlements which have already been developed by the AMC are to be delisted followed by relocation of non-tenable as it is not possible to consider them for in-situ redevelopment. Settlements located on high value land are to be looked separately as they have the potential to be redeveloped under Public Private Partnership (PPP) model which would mean minimum investment for the government. And the

remaining slum settlements would be considered for in-situ redevelopment, which is a major part of total number in the city. The costs involved for each category excluding delisted settlements are discussed below.

i. Non-tenable slum settlements:

Considering the basic assumption of INR 12,000 rate of construction per sq. m., the total cost of construction (housing plus site development) comes to around INR 2,204 Crores. Also, on including costs for provision of external trunk infrastructure as per guidelines provided in HPEC Report, 2011, this component comes to around INR 138 Crores which is to be entirely borne by the government. Considering 40 per cent government share, total costs to be borne by the government in this particular case comes to around INR 1020 Crores (see Table 24). While beneficiary contribution for 37,674 households would be around INR 1322 Crores.

Table 24: Investments required for non-tenable settlements, Ahmedabad

Construction costs		
No. of DUs		37,674
Carpet area per unit as PMAY (in sq.m.)		30.00
Built up Area (BUA) per unit (30% loading assumed) (in sq. m.)		39.00
Rate of construction per sq. m. Assumed (in INR/ sq.m.)		12,000.00
Total construction cost (in INR Crores) (A)		1,763.14
Cost of construction of site development (25 % of construction cost) (in INR Crores) (B)		440.79
Total project cost (in INR Crores) (A+B)		**2,203.93**
Infrastructure investment		
Water supply cost per person (in INR)		5,099.00
Sewerage network cost per person (in INR)		4,704.00
SWM services cost per person (in INR)		391.00
Storm water drainage network cost per person (in INR)		3,526.00
Population to cater (No. of persons)		169,533
Water supply cost (in INR Crores)		43.22
Sewerage network cost (in INR Crores)		28.71
SWM services cost (in INR Crores)		6.63
Storm water drainage cost (in INR Crores)		59.78
Total investment for Infrastructure (in INR Crores)		**138.34**
Costs borne by	**EWS construction (in INR Crores)**	**Infrastructure investment (in INR Crores)**
Beneficiary (60 %)	1,322.36	0.00
Government (40 %)	881.57	138.34
Total	**2,203.93**	**138.34**

Source: Computed by the authors.

ii. Tenable slums (on high value land):

As these slum settlements are located in high value, land these are to be looked separately as they have the potential to be redeveloped under Public Private Partnership (PPP) model which would mean minimum investment for the government. But, an important aspect of government's role in this case is the provision of external infrastructure or trunk lines in terms of water supply, drainage network, solid waste management services and storm water drainage network. These have been computed below (see Table 25).

Table 25: Investment required for tenable slums, Ahmedabad

Infrastructure investment	
Water supply cost per person (in INR)	5,099.00
Sewerage network cost per person (in INR)	4,704.00
SWM services cost per person (in INR)	391.00
Storm water drainage network cost per person (in INR)	3,526.00
Population to cater (No. of persons)	56,858
Water supply cost (in INR Crores)	14.50
Sewerage network cost (in INR Crores)	9.63
SWM services cost (in INR Crores)	2.22
Storm water drainage cost (in INR Crores)	20.05
Total investment for Infrastructure (in INR Crores)	**46.40**

Source: Computed by the authors.

Assuming per capita cost for each infrastructure component as per the guidelines in the HPEC Report, 2011, these costs come to around INR 46 Crores which is to be fully borne by the government. Here it should be noted that these costs are calculated keeping in mind the existing infrastructure provision and coverage in the slums in the city.

iii. In-situ redevelopment:

The remaining slum settlements, a major part of total number of slums, are to redeveloped in-situ. The costs and standards involved for these have been computed in Table 26. Considering the basic assumption of INR 12,000 rate of construction per sq. m., the total cost of construction (housing plus site development) comes to around INR 5,962 Crores. Also, on including costs for provision of external trunk infrastructure as per guidelines provided in HPEC Report, 2011, this component comes to around INR 374 Crores which is to be entirely borne by the government (see Table 26). These costs are calculated keeping in mind the existing infrastructure provision and coverage in the slums in the city.

Table 26: Investment required for In-situ redevelopment, Ahmedabad

Construction costs	
No. of DUs	1,01,910
Carpet area per unit as PMAY (in sq.m.)	30.00
Built up Area (BUA) per unit (30% loading assumed) (in sq. m.)	39.00
Rate of construction per sq. m. Assumed (in INR/ sq.m.)	12,000.00
Total construction cost (in INR Crores) (A)	4,769.39
Cost of construction of site development (25 % of construction cost) (in INR Crores) (B)	1,192.35
Total project cost (in INR Crores) (A+B)	**5,961.74**
Infrastructure investment	
Water supply cost per person (in INR)	5,099.00
Sewerage network cost per person (in INR)	4,704.00
SWM services cost per person (in INR)	391.00
Storm water drainage network cost per person (in INR)	3,526.00
Population to cater (No. of persons)	4,58,595
Water supply cost (in INR Crores)	116.92
Sewerage network cost (in INR Crores)	77.66
SWM services cost (in INR Crores)	17.93
Storm water drainage cost (in INR Crores)	161.70
Total investment for Infrastructure (in INR Crores)	**374.21**

Costs borne by	EWS construction (in INR Crores)	Infrastructure investment (in INR Crores)
Beneficiary (60 %)	3,577.04	0.00
Government (40 %)	2,384.70	374.21
Total	**5,961.74**	**374.21**

Source: Computed by the authors.

Thus, in Scenario 3, the total amount of beneficiary contributions totals to around INR 4,899 Crores (i.e. INR 1,322.36 Crores for relocating non-tenable settlements + INR 3,577.04 Crores in case of in-situ redevelopment). Considering per household contribution required of INR 3.51 lakhs, it is highly unlikely that the slum dwellers would have such an amount to pay at once, thus would resort to loans from banking sector. Considering the maximum period for which housing loans are available of 20 years, the equated monthly income (EMI) to be paid is around INR 3,091 which would be around 33 per cent of the average monthly income of slum dwellers (see Table 27).

Table 27: Loan calculations

Loan Scenario	
Cost borne by beneficiary (in INR Crores)	4899.40
Cost per HH (in INR)	3,51,000.00
Loan amount (in INR)	3,51,000.00
Loan period (years)	20
Annuity (in INR)	37,090.51
EMI to be paid (in INR)	3090.88
Average income (in INR)	9,490.74
EMI as % of monthly income (%)	32.57

Source: Computed by the authors.

Scenario 4: Up-gradation of BSUP Housing

With regards to BSUP public housing, it is imperative that the local government provides necessary infrastructure wherever absent as well as upgrades the existing infrastructure to an acceptable level. The investment required for this has been computed in Table 28.

Table 28: Investments required for infrastructure up-gradation in BSUP housing, Ahmedabad

Infrastructure investment	
Water supply cost per person (in INR)	5,099.00
Sewerage network cost per person (in INR)	4,704.00
SWM services cost per person (in INR)	391.00
Storm water drainage network cost per person (in INR)	3,526.00
Population to cater (No. of persons)	91,674
Water supply cost (in INR Crores)	46.74
Sewerage network cost (in INR Crores)	43.12
SWM services cost (in INR Crores)	3.58
Storm water drainage cost (in INR Crores)	32.32
Total investment for Infrastructure (in INR Crores)	**125.78**

Source: Computed by the authors.

Based on the current conditions and population currently residing in BSUP public housing, around INR 126 Crores of investment. This includes the cost of upgrading the BSUP public housing to the level of MMGY public housing which if had been implemented earlier would have been avoided and the investments required would had been lower.

Scenario 5: Up-gradation of BSUP Housing

Also, it is evident that there is scope for providing some missing infrastructure in MMGY housing schemes. Since these housing schemes have sufficient level of services such as water supply and Solid Waste Management (SWM), no investment is required in these sectors at this stage. The required investment for MMGY public housing has been computed below in Table 29.

Table 29: Investments required for infrastructure up-gradation in MMGY housing, Ahmedabad

Infrastructure investment	
Water supply cost per person (in INR)	5,099.00
Sewerage network cost per person (in INR)	4,704.00
SWM services cost per person (in INR)	391.00
Storm water drainage network cost per person (in INR)	3,526.00
Population to cater (No. of persons)	17,294
Water supply cost (in INR Crores)	0.00
Sewerage network cost (in INR Crores)	8.13
SWM services cost (in INR Crores)	0.00
Storm water drainage cost (in INR Crores)	6.10
Total investment for Infrastructure (in INR Crores)	**14.23**

Source: Computed by the authors.

Overall, based on the above five scenarios with detailed cost calculations of required investments and government expenditures, the best case scenario would be Scenario 2 which involves up-gradation and provision of infrastructure to all slum settlements along with Scenario 4 and 5 (i.e. up-gradation of infrastructure in BSUP and MMGY public housing). However the strategic scenario to be adopted would be Scenario 3 which offers a permanent solution to the residents of informal housing in the city as well as enables them to build an asset for themselves which would help them to move out of vicious circle of poverty.

Based on these required investments, it is evident that the government needs to undertake huge investments to cater to the needs of urban poor and build their resilience in case of climate-induced events. In addition to these, some other recommendations include:

- Universal coverage of storm water drainage network in the entire city so that even the low-lying parts of the city are covered and in case of torrential rainfall the water can drain off. These simultaneously need to be designed for such a capacity of water discharge.
- Planning and implementing authorities need to pay critical attention to location of public housing sites, as seen in the case studies also. At present, these housing schemes are located in low-lying areas with poor infrastructure and services which affect the residents in case torrential rainfall. Since most of the public housing residents (LIG and EWS) don't have the capacity to recover from such an event owing to their low incomes and saving capacities which makes their survival all the more difficult.
- Adequate attention is required with regards to the quality of public housing as it directly affects lives of the residents. A mere provision of borewell for water supply is not enough in a public housing site located in an industrial area which already has many existing negative externalities for the residents. Also, social infrastructure such as *anganwadi* and dispensaries built in BSUP sites are neither operational as per the residents which increases their expenditures towards the same. In order to reduce the losses incurred by the resident of the BSUP housing sites currently, not only the social infrastructure needs to operational but improved basic infrastructure provisions needs to be implemented by the involved agencies.
- Relocation of slum settlements should not be too far off from the original location as it will ensure minimum disruption of social circles of slum dwellers as well as ensure no additional costs for transportation. This is an important aspect because many BSUP residents reported during the survey that they had to give up their previous employment and switch to a much lower paying job because it was not feasible for them to travel far each day. This had a negative impact on their earnings and further increased their already high vulnerability.
- Also, the local government needs to spring into action and provide better healthcare and take precautionary steps so that the areas which are currently affected by water logging do not become mosquito breeding grounds.

5.2.2 Surat

Based on the economic losses calculations in case of Surat, there are two possible scenarios.

Scenario 1: Relocation of all slum settlement residents to public housing

If all the residents of slum settlements are relocated into public housing, then the cost due to losses reduce to INR 3.46 Crores each year - A clear difference of INR 4.78 Crores per year that can be saved annually in case residents of this transition.

Table 30: Extrapolation of losses due to water-logging if all slums are relocated in public housing at city-level, Surat

	Total loss suffered (Mean) (in INR)	% of HH affected	Estimated no. of HH that may be affected by the same intensity of monsoons	Estimated costs of damage (in INR Crores)
Public housing	921	43%	174,859 (BSUP + MMGY)	3.46

Source: Estimated from Primary survey.

Based on these calculations, the distribution of the costs needs to be seen if this relocation has to be done. It comes out that around INR 193 Crores per year and INR 108.93 Crores per year need to be invested by the government and residents to move into public housing, as shown in Table 31.

Scenario 2: Relocation of only 60 per cent slums falling in flood-prone area

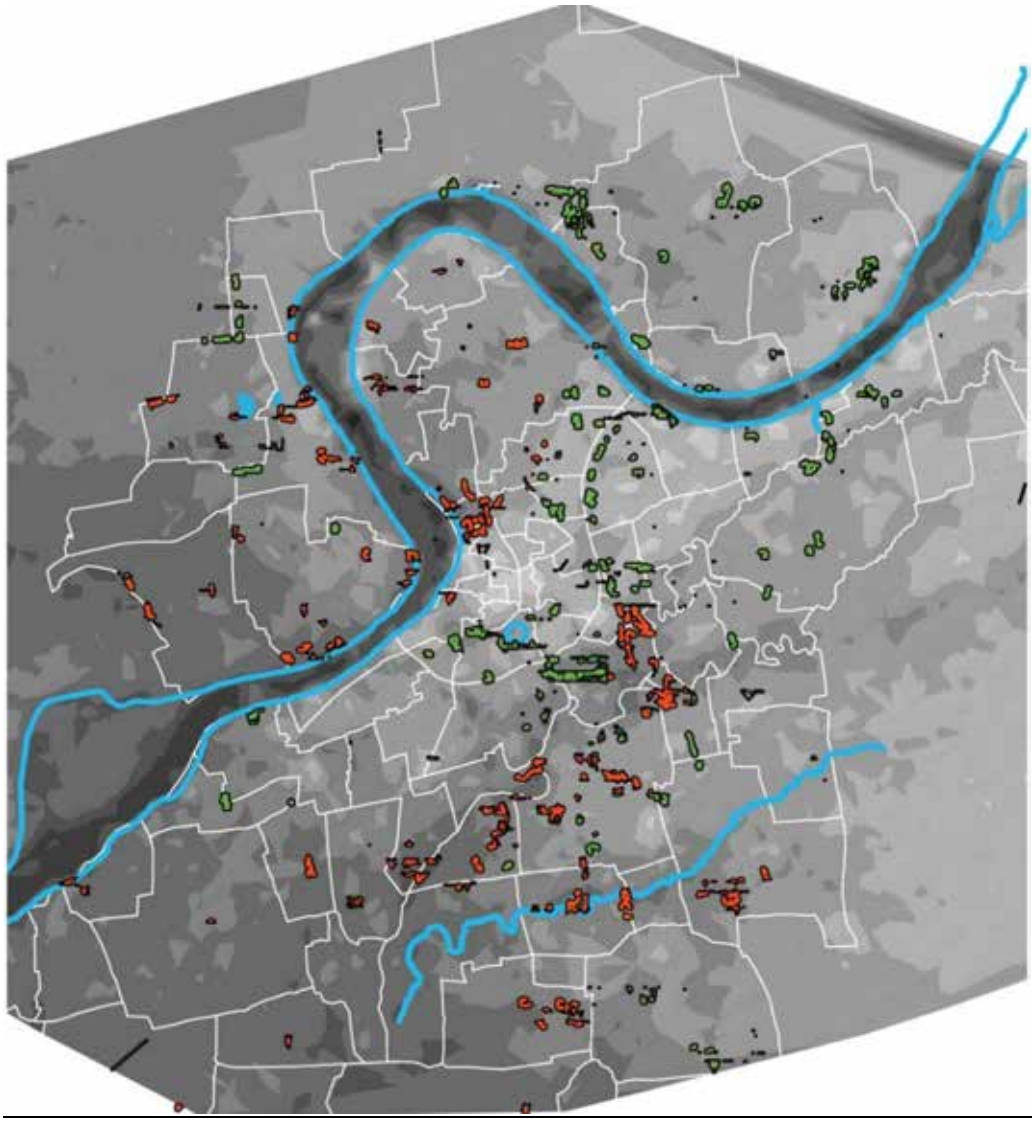
In such a scenario wherein slums in flood-prone area are only to be relocated while others not falling in critical flood-prone area can be just upgraded with infrastructure – which we assume to be 60 per cent slums falling in flood-prone area and rest fall out of it (see Map 6).

Table 31: Distribution of costing between government and residents, Surat

No. of slums	Rate of new DU (INR/ sq. ft.)	Total Project cost (in INR Crores)	Total Infrastructure cost (in INR Crores)	Govt. share (per year for 10 years) (in INR Crores)	Share by residents (per year for 20 years) (in INR Crores)
77,591	1,200	3631.25	479.04	193.15	108.93
Scenario – Assuming relocation of 60 per cent of slums from flood-prone areas					
46,555	1,200	2178.77	287.43	193.15	65.32

Source: Computed by the authors

Map 6: Slums spatially located upon the flood-prone map of Surat



Source: Prepared by the authors.

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