CHAPTER 4

RISK AND VULNERABILITY ANALYSIS

4.0 INTRODUCTION

The purpose of this chapter is to set the broader context of vulnerabilities in terms of different indicators using risk and vulnerability analysis. Given the huge gap between the demand for and supply of drinking water in Chennai, the focus of this chapter is to understand how other additional stresses add up to the vulnerabilities caused by lack of water supply and sanitation.

This chapter tries to explain the vulnerability of water consumers belonging to different sections in Chennai (consumers living in slums and apartments), subsuming urbanisation and the kind of risks to which consumers are exposed to. Focus is laid on the various factors contributing to the general condition of vulnerability among households living across Chennai. The major attention is, however, drawn to the analysis of the additional vulnerability of the households due to lack of availability of water supply and sanitation services. Such an analysis has been carried with the aim of capturing the growing stress (due to their risky and vulnerable living conditions) of the inhabitants of Chennai as a result of unplanned and haphazard urbanisation. The analysis would also connote the differential adaptive capacity of people (consumers) as a result of mismatch in basic water supply services (dealt in Chapter 8). The focus of this study to analyse the extent to which non-availability of protected drinking water has contributed to the additional stress and vulnerability (with cumulative impact) of people living in slums. Comparison is also done between the stress and vulnerability experienced by people living in slums to the rich and middle class population living in apartments in the same locality. Cues from literature review on vulnerability suggest how this stress affects the poor more than the other sections of society. Additional vulnerability of people living in slums due to lack of protected drinking water supply (who already face a high degree of vulnerability for many other reasons) is in particular more
contextual for a mega city like Chennai that is confronted with many risks associated with climate change.

4.1 CONCEPT OF VULNERABILITY

Because of different epistemological roots, the term ‘vulnerability’ has been defined differently in various contexts. The term ‘vulnerability’ is derived from the Latin word *vulnere*, meaning ‘the wound.’ Accordingly, vulnerability in simple terms means the capacity to be wounded (Kates 1985). Chambers (1989) elaborated this notion by describing ‘vulnerability’ as “exposure to contingencies and stress and the difficulty in coping with them”. By relating the notion of vulnerability to the broader framework of risk, the following three major dimensions are involved:

1. Exposure to stresses, perturbations and shocks
2. The sensitivity of people, places and ecosystems to stress or perturbation, including people’s capacity to anticipate, cope and adapt to the stress
3. The resilience of exposed people, places and ecosystems in terms of capacity to absorb shocks and perturbations while maintaining function

Individuals, households, social groups and communities confront numerous, often interacting and complex set of vulnerabilities and the impacts of which are often compounding and cumulative. Marcus Moench et al 2008 (following the Hyogo Framework, 2005-2015, adopted by the UN at the World Conference on Disasters in 2005), defines vulnerability as a “set of conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of a community to the impact of hazards.”. Conversely, the view of vulnerability as a state (i.e. as a variable describing the internal state of a system) has arisen from studies of the structural factors that make human societies and communities susceptible to damage from external hazards (Allen, 2003). In this formulation, vulnerability is something that exists.

Vulnerability which is determined by factors such as poverty and inequality, marginalisation, food entitlements, access to insurance and housing quality are
termed as social vulnerability (Blaike et al, 1994; Adger and Kelly, 1999). For vulnerability arising purely from the inherent properties of non-human systems or systems for which the term “social” is not appropriate, the term “inherent vulnerability” might be used. Social vulnerability has been the primary focus of field research and vulnerability mapping projects, which are generally concerned with identifying the most vulnerable members of society and examining variations in vulnerability between or within geographical units that may experience similar hazards (Downing and Patwardhan, 2003). In this formulation, it is the interaction of hazard with social vulnerability that produces an outcome, generally measured in terms of physical or economic damage or human mortality and morbidity (Brooks and Adger, 2003).

The present study however raises the question “vulnerability of whom and to what effect?” Certain factors such as poverty, inequality, literacy status, health, access to resources and social status are likely to determine the vulnerability of communities and individuals to a range of different hazards (including non-climate hazards). Brooks (2003) views the above-mentioned factors as “generic” determinants of social vulnerability. Some of the other factors are the situation of dwellings in relation to river flood plains or low-lying coastal areas as determinants that are “specific” to particular hazards like floods and storm surges.

Nick Brooks has used the term “social vulnerability” in a broad sense to describe all the factors that determine the outcome of a hazard event of a given nature and severity. Social vulnerability encompasses all those properties of a system independent of the hazards(s) to which it is exposed to that mediate the outcome of a hazard event. This may include environmental variables and measures of exposure. For example, the vulnerability of a country to a given hazard occurring over its national territory will be a function of the percentage of the population living in the area affected by the hazard, but also of the extent to which individuals and sub-national scale systems within this area are exposed to its first-order impacts. Exposure and the state of the environment within a system will be socially determined to a large extent. Exposure will depend on where populations choose to (or are forced to) live and how they construct their settlements, communities and
livelihoods. Environmental variables will vary in response to human activity, as populations exploit resources and manage the environment for their benefit in the short or long term. Social vulnerability as described here encompasses elements of the physical environment as they relate to human systems, including factors such as topography and river engineering schemes (which mediate the outcome of flood events) and groundwater reserves (which may mediate the outcome of a meteorological drought by enabling people to compensate for lack of rain through irrigation).

The literature discusses the concept of vulnerability in various discourses like food security, poverty and natural hazards. (see Chandra Sekhar Bahinipati, 2011). Chandra Sekhar Bahinipati provides an understanding of people’s vulnerability to poverty and during famine and natural hazards. He says that the concept of vulnerability has been used to assess how the welfare of the people is being affected by different risks (e.g. idiosyncratic risks like ill-health of the breadwinner and covariate risks like natural hazards and war). The concept of vulnerability is said to be a synonym for the poor (Chambers, 1989), i.e., the people below the poverty line are always considered as vulnerable, because they don’t have the capacity to stand against such risks. Vulnerability is, however, viewed as beyond poverty. According to Hoddinott and Quisumbing (2003), “Vulnerability refers to ex-ante risk that a household will have at the welfare level (i.e. consumption or income) below some norm or benchmark in the future due to risk, shocks and stress, given the data relating to the current status of the household (also see Chandra Sekhar Bahinipati, 2011). Similarly, Richard C. Cicone et al (2010) defines vulnerability as the degree to which a population may suffer harm as a result of exposure to change or stress. He uses Geospatial modeling to identify populations vulnerable to natural hazards.

The degree of vulnerability depends on the degree and characteristics of risks (i.e., an external side to which a household is exposed) and the household’s ability to respond to risk (i.e., an internal side that means lack of coping capacity) (Chambers, 1989). In the context of assessing risks, these studies have assessed the risks/shocks that affect human welfare, the intensity of these shocks and the affected
entity (see Dercon et al, 2005). The ability to respond to risk, on the other hand, broadly depends on the household’s tangible asset base (e.g. tangible and intangible assets), which occurs in two stages-income smoothing/ex-ante (i.e., income diversification like buying insurance and off-farm activities and income skewing: low-risk production) and consumption smoothing/ex-post (borrowing, depleting and accumulating non-financial assets, adjusting labour supply and dropping out children from school etc. [Morduch, 1995]). In this context, these studies have assessed the sources of vulnerability, household’s coping strategies and risk attitude behavior (Binswanger, 1978; Eswaran and Kotwal, 1990; and Yamauchi et al., 2009), effectiveness of coping (Dercon and Krishnan, 2000), and options and constraints of such coping measures (Dercon, 2002). The present study analyses the risks associated with urban stress, sources of vulnerability, possible coping strategies and adaptive capacity of the households (as defined by their educational and income status) in Chennai from the above literature on vulnerability.

The above-mentioned state of the major section of the urbanites forms an important characteristic of millions of cities in developing countries like India. As stated in the literature, vulnerability as studied in this context could be defined as the degree to which a system (such as socio-ecological system) is likely to be wounded or likely to experience harm from a shock or stress in the natural or social environment (Turner et al, 2003). Vulnerability results from a combination of processes that shape the degrees of exposure to a hazard, sensitivity to its stress and impacts, and resilience in the face of those effects. The level of vulnerability varies highly and is higher among poorer people (Kasperson et al., 2001). This chapter thus tries to provide an understanding as to how urban stress can increase the risk of being poor and identify the people who are caught in the vulnerability trap.

4.2 THE VULNERABLE AND RISKY LIVING CONDITIONS OF CHENNAI’S POPULATION

To understand the risky and vulnerable living conditions to which the Chennai’s population is exposed to, a survey of households was carried out across
two different localities of the city. The entire population is susceptible to different kinds of natural hazards. The extent to which vulnerabilities could be controlled depends on certain factors or indicators, which are not the same for all sections of the population. The capacity to control the vulnerabilities is low among the poor section of the population. People who live in slums are among the poorest in Chennai and also the most vulnerable.

The risk and vulnerability associated with urbanisation is better defined by the concept of slums. The basic characteristics of slums are that they are dilapidated, poorly constructed, poorly ventilated, narrow and overcrowded, and inadequately lit. They also lack safe drinking water, toilet facilities and basic physical and social services\(^1\). These extremely unhygienic living conditions make life in the slums very risky and vulnerable. One of the immediate consequences of rapid urban expansion in developing countries is the steep rise in urban poverty. The number of urban poor in the total urban population in developing countries grew from 15% in the 1960s to 25% in the 1990s. While the urban population is expected to double in the next 10 years, the urban poor is expected to double in just 5 years.

India’s demographic trend shows that over the past decade (1991-2001), the overall growth rate stabilized at 2% and the urban growth rate was 3%, but the slum growth rate doubled at 5-6% in the same period.\(^2\) This trend is more relevant to Chennai, where informal settlements occupy one-third of the city’s space. So, around 34.5% of Chennai’s population lives in slums and squatter settlements due to poverty and lack of other better options\(^3\). The multiple dimensions of urban poverty

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1. According to Section 3 of the Slum Area (Improvement and Clearance) Act, 1956, Slums are defined as areas where buildings - 1) are in respect unfit for human habitation, 2) are by reason of dilapidation, overcrowding, faulty arrangement and design of such buildings, narrowness or faulty arrangement of streets, lack of ventilation, light, sanitation facilities or any combination of these factors which are detrimental to safety, health and mortals. Similarly, Census of India 2001 has adopted the definition of ‘slum’ areas as 1) All areas notified as ‘slum’ by State/Local Government and UT Administration under any Act; 2) All areas recognized as ‘slum’ by State/Local Government and UT Administration, which have not been formally notified as slum under any Act; 3) A compact area of at least 300 people or about 60-70 households of poorly built congested tenements, in an unhygienic environment usually with inadequate infrastructure and lacking in proper sanitary and drinking water facilities.


3. Om Prakash Mathur (2009)
to which these people are exposed to put them in a highly vulnerable position in terms of very low living standards. Thus, trapped in a vicious circle of poverty, people in the slums lead a life of poor health. Hence, a study on how vulnerable people living in slums are is felt all the more necessary.\(^4\)

The present study is an attempt to understand the vulnerability as it exists among the population of Chennai in terms of different indicators of vulnerability, which also includes vulnerability due to poor accessibility and quality of water and sanitation. \textbf{The vulnerability of the slum dwellers in Chennai city in comparison to the rich and the middle class has been attempted to provide a better understanding of the growing urban stress.}

\subsection*{4.3 RISK AND VULNERABILITY ANALYSIS}

The vulnerability or the susceptibility to different types of risks or hazards has been analysed by risk and vulnerability analysis. The primary survey carried out in North Chennai (Vysarpadi) and South Chennai (Adyar) helps in understanding the risk and vulnerable conditions of the urban poor in comparison to the middle class and rich who lead comfortable lives. The socio-economic status and environmental factors determine the extent to which people in urban areas are exposed to as a result of urbanisation. This study also tries to analyse the extent to which these vulnerabilities can be controlled. Some of the vulnerability indicators analysed are the per capita space in the domicile unit, family size, educational status, employment status, occupational status, per capita income, caste status, sanitary conditions, drinking water status, status of bathroom/toilet, connectivity to the drainage network, road space, access to transport, drainage problems during monsoon months, the location of the slum and its impacts, exposure to environmental pollution, and whether the place occupied is owned or for rent. Eleven such indicators have been used in the analysis to capture the coping capacity of different sections of the population residing in two different localities of Chennai city.

An analysis of the major factors accounting for the vulnerability of the slum dwellers in relation to the flat dwellers has been studied using the vulnerability index\(^4\) Kamla Gupta et al(2009)
(drawn from the vulnerability index used by S. Janakarajan for Tamil Nadu field sites).

Various scores are assigned to each indicator based on the susceptibility to such risk. The higher the vulnerability, the higher the score and vice-versa. For instance, a big family indicates that the vulnerability is high. A vulnerability score of 10 would mean that the family is highly vulnerable. Similarly, households belonging to Scheduled Castes (SCs) are highly vulnerable with a vulnerability score of 10. The vulnerability score is 8 for Most Backward Castes (MBCs) and 6 for Backward Castes (BCs). People from the Other Castes (OCs) are less vulnerable, with a score of 4. Eleven indicators have been used with their classification of vulnerability based on the vulnerability scoring pattern as given in Appendix II.

4.4 FACTORS CONTRIBUTING TOWARDS THE VULNERABILITY OF HOUSEHOLDS

4.4.1 Caste

Caste plays an extremely important role in the Indian social hierarchy. For several social, economic and historical reasons, caste hierarchy has developed deeper roots in the Indian social system. These roots have manifested themselves into several inequities, atrocities against specific communities and poverty. Furthermore, in the specific Indian context, caste and class have a very close nexus in which the poor by and large belong to the lower castes (D.D.Kosambi, 1975, Chandra, Ramesh, 2005).

The caste factor adds to the vulnerability of poor households living in the Vysarpaadi slums of North Chennai. In these slums, 23 out of 60 households are SCs, thereby having a vulnerability score of 10. Also, 32 out of 60 households in

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5 The term “Scheduled Castes” has been defined in Article 366(24) read with Article 341(1) as: “Scheduled Castes” means such castes, races or tribes or parts of or groups within such castes, races or tribes as are deemed under Article 341 to be scheduled castes for the purposes of this Constitution.” (Demands for Amending Constitution (Scheduled Castes) ORDER, 1950, Chapter 9, Communalism Combat, April 2010)
Vysarpadi are BCs\textsuperscript{6}, with a vulnerability score of 4. The remaining 5 households belong to OCs\textsuperscript{7}, with a vulnerability score of 2. In terms of caste, a large part of flat dwellers in Vysarpadi (11 out of 30 flat dwellers) are highly vulnerable, with a vulnerability score of 10; 14 out of 30 flat dwellers have a vulnerability score of 4 and the remaining 5 have a vulnerability score of 2. \textbf{The above details show that there is not much of a difference in vulnerability among different social groups in Vysarpadi with regards to caste.}

Compared to the slums in North Chennai, the vulnerability with regards to caste is different for slum tenements and for those living in apartments is different in South Chennai. In Mallippu Nagar slum in Adyar, the vulnerability is high for 19 out of 53 households who are SCs (vulnerability score of 10); 29 households are moderately vulnerable with a vulnerability score of 4; the remaining 5 households having a vulnerability score of 2. While the flat dwellers in Adyar (18/30) are less vulnerable in terms of Caste with the vulnerability score of 2; 11/30 of the households having vulnerability score of 4 and 1/30 with the score of 10.

Thus in terms of vulnerability due to caste, similarity is noticed among the three categories of study groups: households belonging to slums and flats in Vysarpadi and slum tenements in Adyar.

\textbf{4.4.2 Family Size}

\textbf{A large family size would mean that the household is vulnerable in terms of sharing the living space and income.} The average family size of a slum household in Chennai is 5. Both the survey results and the records gathered from the corporation office in the study area support this fact. There are also families with more than five residing in small domicile units. For instance, in the Vysarpadi slums

\textsuperscript{6} The citizens of India who are economically and socially backward other than SC, ST and FC are termed as backward classes by the Mandal Commission, constituted under Article 340 by an order made by the President of India in 1979. In the constitution of India, OBCs are described as "socially and educationally backward classes", and government is enjoined to ensure their social and educational development (O.P. Sudrania, 2012 and Sandeep Mukherjee (2000), Unit 2: Reservation in Promotion, ISTM, New Delhi).

\textsuperscript{7} OCs are the classes of Indian citizens other than those belonging to SCs, STs and BCs and are not eligible for any reservation benefits specified in Article 16(4). They belong to the forward class due to historical reasons.
in North Chennai, 28 out of 60 households have an average family size ranging between 5 and 7, with a vulnerability score of 6. However, in the case of apartment dwellers in Vysarpadi, 16 out of 30 households have a family size ranging between 3 and 4, with a vulnerability score of 4. This shows that compared to people living in slums, most households belonging to the upper and middle class are less vulnerable in terms of family size.

Similarly in the Adyar slums, 27 out of 53 households have an average family size ranging between 3 and 4 and 19 out of 53 households have an average family size between 5 and 7, while in the Adyar flats, 22 out of 30 households have a family size ranging between 3 and 4, with a low vulnerability score of 4. The data pertaining to family size, therefore, shows that compared to people living in apartments, the poorest of the poor who live in slums are the most vulnerable.

How the size of a poor family could contribute to vulnerability can be better understood in light of the per capita domicile space and income of the households.

4.4.3 Per Capita Domicile Space

An individual’s per capita space residing in the slums is around 24 sq ft, or sometimes even less. This means the area of an average dwelling in the slums is around 120 sq ft. As the family size increases, the per capita domicile space decreases. The floor space of the tenements on an average is understood to be 120 sq ft in both Vysarpadi and Adyar. Compared to this, the upper and middle class households live in a per capita space ranging from 600 to 1200 sq ft. This would mean that each member occupies a per capita domicile space of 120 to 280 sq ft (average family size being 5). However, the flat dwellers throughout Chennai are not equally averse to vulnerability due to low domicile space. For instance, comparing the two study areas (Adyar and Vysarpadi), flat dwellers in Vysarpadi is comparatively more vulnerable as far as the living space is concerned. This is due to the lesser space available here (around 500 to 600 sq ft) compared to flats in Adyar.

Slum households in Vysarpadi are exposed to high vulnerability in terms of per capita domicile space with 52 out of 60 households having a vulnerability score
of 10. Most tenements share a per capita domicile space of less than 40 sq ft. Compared to the slum tenements, most flat dwellers (18 out of 30 flats) in the same locality share a per capita domicile space of 100 to 199 sq ft, with a vulnerability score of 6.

In Adyar, most slum dwellers (41 out of 53), like their counterparts in Vysarpadi, have a per capita domicile space of less than 40 sq ft. However, predictably, the vulnerability is less for the rich and middle class in Adyar, with half of the sample households having a per capita domicile space of 200 to 399 sq feet (vulnerability score of 4). The other half has a per capita domicile space of 400 sq ft and above (vulnerability score of 2).

4.4.4 Number of People above Age 60

Households having more number of people above the age of 60 (60 which is the retirement age in India in the public sector) are highly vulnerable. In the absence of any social security measures and increased health expenditure, such households would feel more vulnerable given their limited income levels.

As far as the households in the Annai Sathya Nagar slums in Vysarpadi are concerned, around 25% of the households (15 out of 60 households) are highly vulnerable due to the age factor, with a vulnerability score of 6. The age factor constitutes 7.5% to 9.6% of the total vulnerability. Their high total vulnerability scores ranging from 62 to 80 reveal the fact that they are either highly or gravely vulnerable. Apart from this, 20 out of 60 households have a vulnerability score of 4 and 2 out of 60 households have a vulnerability score of 2 due to the age factor.

Vulnerability due to age is even higher for people residing in apartments in Vysarpadi. Here, 9 out of 30 households have a vulnerability score of 6, one household has a vulnerability score of 8, 2 have a score of 4, and the remaining 18 households have a score of 1. Not only the households in apartments in Vysarpadi, have high vulnerability score in terms of people belonging to the unproductive group, but also the proportionate share of the above factor in the total
vulnerability score of 38-48 is high (12% to 15%) compared to the slum household in the same area.

The vulnerability due to the presence of people above 60 years of age is equally high for the Mallipu Nagar slums in Adyar. Around 22.6% of the households were found to be highly vulnerable. Here, 12 out of 53 households have a vulnerability score of 6; 8 households have a score of 4 and 33 households are less vulnerable with a score of 1. These are also the households with a high total vulnerability score ranging from 63 to 82. The proportionate share of the age factor ranges from 7.3% to 9.5%.

The upper and middle-class households in Adyar are equally exposed to vulnerability due to the age factor; 10 out of 30 households have a vulnerability score of 6, 6 households have a score of 4 and 14 households have a score of 1. The vulnerability due to family members in the unproductive age group accounts for 17% to 25% of the total vulnerability score of 24 to 34.

Thus the proportionate share of the above indicator in total vulnerability of the households is more among the upper and middle class living in the apartments respectively compared to the slum households in Vysarpadi and Adyar.

4.4.5 Children below 5 Years of Age

Vulnerability in households is high if children below 5 years are more in number. If children are exposed to an unhealthy environment, they become more susceptible to health risks. Access to free healthcare facilities is mostly more than 2 km away and people in slums mostly depend on private doctors to treat children’s ailments. Expenditure on children’s education is also a factor. Given the limited income, these factors add to the vulnerability levels of slum households.

Due to the above-mentioned factors, it is not surprising that the vulnerability of the slum households in Adyar and Vyasarpadi are high compared to the upper and middle class who live in apartments.
Vulnerability due to children below 5 years is noticed a lot in the slum households in Vysarpadi. Nearly 46% of the sample households are exposed to this factor. Here, 25 out of 60 households have a vulnerability score of 6 and 3 out of 60 households have a score of 8. However, the vulnerability in the flats of Vyasarpadi, due to the presence of children below 5 years, is low. Only 13% of the households (4 out of 30 households) are found to be highly vulnerable and the rest are less vulnerable (23 out of 30 households have a score of 1, 3 have a score of 4).

Unlike North Chennai, vulnerability due to the presence of children below 5 years is found to be low in the Adyar slums. Only 28% (15 out of 53 households) of the households are vulnerable due to the maximum number of children below 5 years. The rest of the households (38 out of 53) are less vulnerable and share a vulnerability score of 1 and 4.

Similarly, the households in the apartments of Adyar have low vulnerability due to the presence of children below 5 years: Only one among the sample households (.03%) is found to be vulnerable in terms of the above parameter. The rest of them are less vulnerable (21 out of 30 households have a vulnerability score of 1; the remaining 8 have a score of 4).

4.4.6 Educational status

It has been pointed out in the literature that a good educational status plays a big role in reducing the vulnerability to poverty. This would mean that households with inadequate or no education are more vulnerable compared to households with higher education. The present study uses data gathered from a primary survey across Chennai for identifying the vulnerable section of the population. According to the findings of the survey, literacy rates are the lowest in the slums. In the slums in North Chennai, the vulnerability due to poor educational status is relatively high with 41 out of 60 households having a vulnerability score of 10; 15 out of 60 households have a score of 8 and the remaining 4 households have a score of 6.

Even the households living in the apartments in Vysarpadi are not free from vulnerability due to lack of access to education. Only 3 out of 30 households are less
vulnerable with a score of 2, 13 households have a vulnerability score of 4, 8 households have a score of 8, 5 households have a score of 6, and one household has a score of 10.

Lack of access to education is also seen, understandably, among the slum dwellers in Adyar. Here, 31 out of 53 households have a vulnerability score of 10, 14 have a score of 8, 7 have a score of 6 and one household has a score of 4. Comparatively, the apartments in Adyar are less vulnerable in terms of access to education. Here, 10 out of 30 households have a low vulnerability score of 2, one household has a score of 6, and 19 households have a score of 4.

**4.4.7 Per Capita Income**

Per capita income is an important indicator that aids in analysing the socio-economic status of the slum dwellers vis-à-vis the upper and the middle class living in apartments. A lower income means higher vulnerability and risky living conditions. As far as the slum households in Vysarpadi are concerned, the incidence of vulnerability due to low per capita income is high with 28 out of 60 households having a vulnerability score of 10; 22 out of 60 households have a score of 8, 8 households have a score of 6; two households have scores of 4 and 1. Half of the slum households in Vysarpadi earn a monthly income of less than Rs. 5000. Around 35 out of 60 households in the Vysarpadi slums are casual labourers earning Rs. 2000 to 6000 per month. A household’s low income status makes it highly vulnerable.

The poor economic status invariably results in households in slums not being able to afford basic drinking water and sanitation, making them highly vulnerable. In fact, the households in Annai Sathya Nagar slums in Vysarpadi have been receiving poor quality water for the past one year. Most often, drinking water gets mixed with drainage water. As these households don’t have too many options other than to drink such contaminated water, their vulnerability increases. Some of the households buy mineral water for drinking, even though they can’t afford it, making them equally vulnerable.
Like in Vysarpadi, slums in Adyar are also highly vulnerable due to poor economic status. Here, 29 out of 53 households have a vulnerability score of 10, 17 out of 53 have a score of 8 and 7 households have a score of 6.

Juxtaposed to the households living in slums, the upper and middle class households living in apartments enjoy a comparatively better standard of living. It is obvious that households with higher income lead better lives, with better food, shelter, clothing and health, making them less vulnerable. The better economic status of the upper and middle class living in Adyar and Vysarpadi help them cope with the insanitary surroundings and poor water quality\(^8\). Many of the apartments in the northern part of Chennai are locationally vulnerable. The households and flat premises here are inundated with water during rain, and the water gets mixed with garbage dumped adjacent to the apartments. However, the higher economic status of these households allows them to adopt good coping mechanisms like mosquito repellants and insect repellants, thereby avoiding mosquito-borne diseases. Similarly, during water scarcity or availability of poor quality water, these households buy water from private tankers. Thus, they avoid the risk of water-borne diseases. A particular household has claimed to be spending Rs.33000, on an average, on the treatment of diseases caused by poor sanitation.

Except for 9 out of the 30 households in Vyasarpadi, who fall in the income bracket of Rs.10,000 to 15,000 per month, the rest of the sample apartment households belong to the income range of Rs. 20,000 to 45,000. The flat dwellers in Vysarpadi are comparatively better off than the slum dwellers in terms of their income earned. Here, one out of 30 households has a vulnerability score of 8, 8 households have a score of 6, 10 households have a score is of 4, 6 households have a score of 2 and 5 households have a score of 1.

The upper and middle-income households in Adyar, however, experience less vulnerability in terms of income earnings, where with 17 out of 30 households have a vulnerability score of 1, 6 households have a score of 6, 4 households have a

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\(^8\) The survey was conducted in Vysarpadi and Adyar for elucidating the responses of the consumers to poor water quality, accessibility and poor sanitary services. The responses of the households helped in understanding the coping mechanism adopted by them to avoid getting affected by poor water quality and sanitation services.
score of 4 and 3 households have a score of 2. The average monthly income of an
apartment household in Adyar is Rs. 36,434. Households belonging to the monthly
income bracket of Rs. 15000 to 40,000 could be considered as the middle income
class. The rest of the households who belong to the Rs. 50,000 and above could be
classified as rich.

After the above analysis, we can come to the conclusion that slum dwellers
in these areas are comparatively more vulnerable than those living in flats and
apartments. Access to livelihoods and the living condition of the poor living in
slums are low compared to the rich and middle class living in the apartments. Their
vulnerability could be better understood in terms of the location of the house /
dwelling.

4.4.8 Location of the slums and Access to Housing Facility

The slums that were surveyed in North Chennai (Annai Sathya Nagar slum
in Vysarpadi) and South Chennai (Mallippu Nagar slum in Adyar) are located near
waterways like Cooum and Buckingham Canal (Figure 4.1 below).

Slums are often located on encroached lands (government lands or
poramboke lands [barren lands] occupied by immigrants illegally; these lands are
found near drains, dumping grounds, roadsides or railway lines) making them prone
to a number of vulnerabilities like displacement, disease or accidents. The Mallippu
Nagar slum, located adjacent to large open drains, has a greater incidence of diarrhea
and other water-borne diseases (Chelala C, 2000). Slums with inadequate housing
are more likely to have worse health indicators. Improper housing in terms of lack of
ventilation, overcrowding, lack of cleanliness, and dampness leads to faster spread
of many communicable diseases like measles and TB (Agarwal S. et al, 2005).

Vulnerability is high for those living in slum tenements in Vysarpadi, where
53 out of 60 households have a vulnerability score of 8, 5 out of 60 have a score of
10 and one out of 60 has a score of 9. Life is better for those residing in apartments
in Vyasarpadi. This is indicated by their lower vulnerability scores, where 19 out of
30 households have a vulnerability score of 4 and 11 out of 30 households have a score of 2, showing less vulnerability than the poor living in slums.

Similarly, Mallipu Nagar slum, the study area, is highly vulnerable because of its location near the Adyar River, which is Chennai city's dumping ground. Because of the high amount of waste being dumped, the tenements face a huge risk of infection due to the high insanitary environment. Diseases carried by mosquitoes and other infectants are very common among the respondents. Moreover the groundwater is polluted due to the polluted river nearby. The above factors make the slum dwellers highly vulnerable, where 50 out of 53 households have a vulnerability score of 8 and 3 households have a score of 10. The middle and upper class households in this area are exposed to less vulnerability because of better access to housing facilities; 28 out of 30 households have a vulnerability score of 2 and 2 households have a score of 4.

**Figure 4.1: Showing Locational Vulnerability**

![River Cooum which is heavily polluted](image)
4.4.9 Basic Services (Water Supply and Sanitation)

Adding to the general vulnerability condition, poor availability and access to water supply and sanitation services has a direct impact on the health status of the community. Child mortality and morbidity, diarrhea in particular, has been associated with poor water quantity and quality, lack of sanitation and poor hygienic practices (USAID, 2004). Water scarcity is said to compound the vulnerability of the non-beneficiaries (OCHA, 2010). Thus the sections of the population who are adversely affected by a shortage in water accessibility are said to be more vulnerable. As far as the slum dwellers are concerned, they are exposed to risks due to poor sanitation and water accessibility, making them the most vulnerable. Their vulnerability is compounded by the fact that they are economically backwards.

In Vysarpadi slum, the vulnerability score for 53 out of 60 households, due to lack of access to drinking water, is 5 and 6 out of 60 households have a score of 2. However, the vulnerability is comparatively lower among the flat dwellers in Vysarpadi due to their adaptive capacity, where only 6 out of 30 households have a vulnerability score of 4; the remaining 14 households have a score of 2 and 10 households have a low vulnerability score of 1.

Similarly, the vulnerability due to lack of access to drinking water is high for the slum tenements in Adyar. Here, 41 out of 53 households have a vulnerability score of 5. However, 11 households have a score of 2 and one household has a score of 1 due to their adaptive capacity. Adaptive capacity to lack of drinking water is relatively high for those living in apartments in Adyar. This is reflective in their lower vulnerability scores, where 15 households have a vulnerability score of 1 and 11 households have a score of 2. Only 4 households have a score of 4.

4.4.10 Sanitation Coverage

Because of the proximity to the polluted Adyar river and lack of proper sanitation, the tenements near Mallippu Nagar slum are highly vulnerable to

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9 Lack of access to drinking water refers to lack of access to potable water (water that is safe for drinking and cooking).
diseases\textsuperscript{10}. Not all the households have access to toilet facilities. Given their meager income, the households cannot afford to spend on public toilets located near the slum, resulting in insanitary conditions near their homes.

In terms of lack of accessibility to toilet facilities\textsuperscript{11}, sanitation coverage is poor in Adyar slum. Majority of households in the slum (31 out of 53 households) use community toilets located within the slum. Thus these households are vulnerable in terms of sanitary coverage with a vulnerability score of 5. Lack of affordability and availability (limited numbers of community toilets are available within the slum) forcing people to defecate in the open. Apart from the lack of availability of adequate toilet facilities, flooding during rainy season leads to unhygienic conditions, which lead to poor sanitation in Mallippu Nagar slum in Adyar. From all these factors, one can conclude that Mallippu Nagar slum is highly vulnerable in terms of sanitation coverage.

As far as accessibility to toilet facility is concerned, the households in Vysarpadi slum are found to be less vulnerable compared to Adyar slum. Only 5 out of the 60 sample households use community toilets. The majority of the households (55 out of 60 households) are found to have toilet facilities within their own premises. However, according to the conditions laid down by Water Aid India (2005) for assessing sanitary coverage, Annai Sathya Nagar slum in Vysarpadi is found to be equally vulnerable as the Adyar slum. Foul smells, flies/mosquitoes, flooding during rainy season, insufficient water for hygienic use are some of the

\textsuperscript{10} Lack of sanitation in the context of the present study refers to lack of drainage to carry the filth and sewerage. It would also mean lack of accessibility to toilets within their premises, leading to open defecation. According to the study by Water Aid India (2005), the following points are noted for assessing sanitation coverage: 1. Technology must be used for the disposal of faeces in an environmentally safe way. 2. The toilets must be free of foul smell and flies/mosquitoes. There should be no flooding during the rainy season and the toilet should always have sufficient water for usage. There should also be adequate privacy for women. 3. It should be made sure that the toilets are actually used. Open defecation in spite of adequate toilets being present should be avoided. 4. The toilet must be located within a reasonable distance from home. 5. The usage of the toilet should be followed by hygienic practices like hand-washing with soap or cleaning liquid.

\textsuperscript{11} Lack of accessibility to toilet facility is considered as the major factor for assessing sanitation coverage in the present risk and vulnerability analysis. The households with lack of access to toilets are assigned a vulnerability score of 10 (practicing open defecation), households using community toilets have a vulnerability score of 5 and households having access to toilets at home are less vulnerable with a vulnerability score of 1.
problems confronted by the households in the Vysarpadi slum. Despite the availability of underground drainage, the informants have reported the blockage in the drains as a major sanitation problem, thus preventing the free flow of sewerage. So, the households are forced to do their washing of clothes and utensils using highly contaminated water, thereby making them highly vulnerable.

Contrary to the households in slums, the people living in apartments in Vysarpadi and Adyar are found to have better accessibility to toilet facilities and drainage facilities. As a result, the vulnerability scores for households in these areas, in terms of sanitation coverage, are low.

The occupants of both Vysarpadi and Adyar slums are highly vulnerable to diseases and contamination due to the highly unsanitary conditions. Although Adyar slum is located near the Adyar River, the one advantage it has is that it is located in the southern part of Chennai. This part of the city has better road networks, thereby facilitating infrastructural facilities to Adyar slum. Unfortunately, Vysarpadi Slum is located in the northern part of the city, which has poor road network. This results in the area losing out on good infrastructural facilities. However, despite this advantage, the Adyar slum is highly vulnerable.

4.4.11 Access to health care

Lower income households, especially those living in the slums, are invariably bereft of proper education and are therefore not informed about the coping mechanisms available to them. Their poor income status doesn’t allow them to spend on buying quality water from private water suppliers and spend money on coping with the insanitary environment. So, it is not surprising that the slums in Vysarpadi and Adyar have a similar vulnerability score of 6 compared to the flat dwellers in these two areas, who have scores of 2. The vulnerability score of 6 among the slums indicates that the households are prone to water-related diseases and don’t have access to quality healthcare in private clinics. The low vulnerability

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12 Access to healthcare could be defined as the availability of free medical care in a government hospital or dispensary located within a radius of 2 to 3 km. It would also mean whether the households are informed about various health insurance schemes and availability of private doctors and medical services nearby and in other parts of the city.
score of 2, among flats, indicates that the households are not prone to water-related diseases and have access to quality healthcare.

The susceptibility to the above indicators of vulnerability is different for the four categories of population this study has undertaken: the households of Mallippu Nagar slum in Adyar, the households in the apartments in Adyar, the households of Annavi Sathyana Nagar slum in Vysarpadi, and the households in the apartments in Vysarpadi. In terms of caste, high vulnerability is incident on the three categories of study viz; the slum households in Adyar and Vysarpadi and those living in apartments in Vysarpadi. This is not so for the households in the apartment in Adyar.

As far as family size is concerned, slum households are highly vulnerable compared to the middle and upper class who live in apartments. A big family size makes the per capita domicile space available to the slum dwellers lower. With the average dwelling size of the tenements measuring an area of 120 sq. ft, each individual member has to manage with just 24 sq. ft (with a family size of 5). The space gets even lower, to 17 to 20 sq. ft, when the family size increases to 6 or 7.

However, in the apartments, the per capita domicile space is comparatively better, where each member is able to occupy a floor space of 400 sq. ft in Vysarpadi and 200 to 399 sq. ft in Adyar. This was found in half the sample apartment households in Adyar.

All the four categories are equally vulnerable to the presence of family members above 60 years of age. Not only that, the proportionate share of the above indicator in the total vulnerability score is high among the rich and the middle class living in the apartment in relation to the slum dwellers.

With regards to the number of children below 5 years in the family, Vysarpadi slum is found to be highly vulnerable compared to Adyar slum. Very few sample households in the apartments of Adyar and Vyasarpadi are vulnerable in this regard. The households living in apartments in Adyar are in a better position
compared to the other categories, where the vulnerability due to the presence of children below 5 years is found to be almost negligible.

As far as the rest of the indicators (educational status, per capita income, basic services, sanitation coverage and healthcare) are concerned, the slum households are found to be highly vulnerable in comparison to the upper and middle class living in apartments in Adyar and Vyasarpadi.

4.5 RISK AND VULNERABILITY SCORES

If the total vulnerability score for a household is more than 75, the household may be said to be gravely vulnerable. If the total score for a household is between 51 and 75, the household may be said to be highly vulnerable.

If the total score is between 25 and 50, the household may be said to be moderately vulnerable.

The household may be said to be less vulnerable, if the total score is less than 25.

Vulnerability indices could be made at the individual household level, at the caste or community level and at the locational level (table 4.1).

Table 4.1: Showing Vulnerability Scores

<table>
<thead>
<tr>
<th>Caste</th>
<th>Vysarpadi Slum</th>
<th>Flats</th>
<th>Adyar Slum</th>
<th>Flats</th>
</tr>
</thead>
<tbody>
<tr>
<td>SC</td>
<td>68 (HV)</td>
<td>42 (MV)</td>
<td>70 (HV)</td>
<td>32 (MV)</td>
</tr>
<tr>
<td>BC</td>
<td>63 (HV)</td>
<td>37 (MV)</td>
<td>63 (HV)</td>
<td>28 (MV)</td>
</tr>
<tr>
<td>OC</td>
<td>65 (HV)</td>
<td>31 (MV)</td>
<td>60 (HV)</td>
<td>28 (MV)</td>
</tr>
<tr>
<td>Average</td>
<td>65 (HV)</td>
<td>38 (MV)</td>
<td>65 (HV)</td>
<td>28 (MV)</td>
</tr>
<tr>
<td>Locational Average</td>
<td>56 (MV)</td>
<td></td>
<td>51 (MV)</td>
<td></td>
</tr>
</tbody>
</table>

Note: HV stands for highly vulnerable (51-75), MV for moderately vulnerable (25-50)
4.5.1 At the Household Level

The vulnerability score ranges from the upper limit of 80 (for SCs) to a lower limit of 52 (BCs) in Vyasarpadi slum. Out of 60 households, 2 are gravely vulnerable. The remaining 58 are highly vulnerable with a score of 51 to 75. Compared to this, households living in flats in Vyasarpadi have a vulnerability score ranging from 27 to 48 (MV). All the 30 sample households are moderately vulnerable and have a score less than 48.

As far as Adyar slum is concerned, the households have a score ranging from 82 (upper limit) to 52 (lower limit). Out of 53 households, 6 are gravely vulnerable and the score ranges between 76 and 82. The rest of the households are all highly vulnerable. Compared to Adyar slum, Vysarpadi slum only has two households that are gravely vulnerable, where the highest VS is only 80.

Unlike Adyar slum, the households in Adyar flats have scores ranging from 20 to 36. Four households are less vulnerable, with scores ranging between 20 and 22. They seem to enjoy better living standards. Factors like better income, high domicile space, and better access to drinking water and sanitation make them less vulnerable compared to the households in the rest of the categories.

4.5.2 Community Level

SCs in Vysarpadi slum have vulnerability scores ranging from 57 to 80. Two out of 23 SC households are gravely vulnerable. Two households have vulnerability scores of 57 and 59, 12 households have a vulnerability score of over 71, and the rest are all above 62. The average score is 68. This is above the slum average of 65, indicating their exposure to high vulnerability.

The vulnerability scores of households belonging to SCs in Vyasarpadi flats range from an upper limit of 48 to a lower limit of 34. Their average score is 42, which is much less than the SCs in Vyasarpadi slum.

In Adyar slum, households belonging to SCs have an average score of 70, with the upper and lower limit ranging between 82 and 59. Out of 19 SC households
, 5 of them are gravely vulnerable with an average score ranging between 77 and 82. The rest are highly vulnerable. Vulnerability of the SCs in Adyar slum is comparatively higher than that of those in Vyasarpadi slum. Compared to this, the SCs in Adyar flats is 1/30 households HHs with a VS of 32, indicating moderately vulnerable, however, less than that of those in Vyasarpadi.

Households of BCs in Vyasarpadi slum have upper and lower limit vulnerability score ranging between 72 and 52. The average score for BC households is 63, indicating high vulnerability. Except for 6/32 BC households, VS stands less than 68. The households in flats who constitute this category have average VS of 39. Their upper and lower limits of VS range between 47 and 29. Out of a sample of 30 households in Vyasarpadi, 14 households belong to BC and they are all moderately vulnerable. BC households in Adyar slum have average VS of 63, the upper and lower limits being 76 and 53.

In Adyar, 29 out of 60 households belong to BCs and they are highly vulnerable except for one HH. However, 11/30 sample households HHs are BCs in Adyar flats. Their average VS is 28 and the upper and lower VS limits are between 34 and 21. All the households in Adyar are moderately vulnerable, but less than that of the BCs in the other categories.

OCs in Vyasarpadi slum have a vulnerability score of 65 with upper and lower limits of 72 and 57 respectively. Out of the entire sample of 60 households in Vyasarpadi slum, 5 of them are OCs. Comparatively, in the flats in Vyasarpadi, 5 out of the 30 sample households are OCs. Their average vulnerability score is less than the average score for OCs in Vyasarpadi slum. The upper and lower limit scores are between 39 and 27, indicating moderate vulnerability.

In Adyar slum, 5 out of 53 households are OCs. Their average vulnerability score is 60. The upper and lower limits are between 69 and 52, indicating high vulnerability. Out of the 30 sample households in Adyar, 18 households are OCs. Their average VS is 28 and the upper and lower limits are between 34 and 22, indicating moderate vulnerability. Some of them are even less vulnerable (5/18).
4.5.3 Locational Vulnerability

In terms of location (constituting those living in both slums and flats), Vysarpadi has an average vulnerability score of 56, whereas for Adyar the score is 51. The vulnerability index shows less vulnerability. Understandably, the slums in both areas are more vulnerable compared to flats. Some of the slum households are gravely vulnerable as shown by the vulnerability scores; 6 out of 53 households in Adyar and 2 out of 60 households in Vyasarpadi are gravely vulnerable, although the average vulnerability scores for both the areas are less.

Taking into account all the points discussed in this chapter, slums in Chennai are found to be highly vulnerable compared to the upper and middle class inhabitants living in flats and apartments. The literature derived from the Intergovernmental Panel on Climate Change (IPCC) suggests how the risk and vulnerability of the people living in slums increases due to climate change, apart from the other indicators of vulnerability. People are affected by food insecurity, unemployment, poor living conditions, lack of basic facilities like water and sanitation, poor healthcare facilities, lack of proper education and environmental insecurity. With the threat of adverse climate change looming, people's vulnerability is bound to go up, more so for the urban poor. However, with better income and employment, it is possible for people to adopt better coping and adaptive strategies.

4.6 VULNERABILITY TO CLIMATE CHANGE: THE FUTURE OF URBAN CHENNAI

The IPCC Third Assessment Report (TAR) describes vulnerability as “The degree to which a system is susceptible to, or unable to cope with, the adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.” (IPCC, 2001, P.995) (IPCC Def.1). Vulnerability is also described as the “degree to which a system is susceptible to injury, damage, or harm (IPCC Def.2) given in Chapter 18 of the TAR, cited from Smith et al. (1999).
Going by both the above-mentioned definitions, adverse climate change is expected to increase the frequency and intensity of current hazards, an increased probability of extreme events and spur the emergence of new hazards and vulnerabilities with differential spatial and socio-economic impacts. This is expected to further degrade the resilience and coping capacities of poor and vulnerable communities, who make up from a quarter to half of the population of most Indian cities (Satterthwaiet al, 2007). Hundreds of millions of urban dwellers in Indian cities are at risk from the direct and indirect impacts of climate change.

Some of the climate risks to which Chennai is exposed to are groundwater depletion, salinity intrusion, sea level rise and coastal flooding. The monsoon rainfall is highly seasonal in the city, resulting in floods, particularly because the drainage system is insufficient and the natural flood water evacuation systems such as canals, paddy fields and wetlands have been encroached and destroyed (Nair et al, 2009). Adding to this is the problem of severe water shortage and the fact that the water bodies on which the city of Chennai depends on are facing water shortage associated with climate anomalies and anthropogenic impacts. An unscientific storage system followed in Chennai has resulted in tremendous water loss due to evaporation. Rising demands create more dependency on groundwater and the current rate of extraction using tube wells is not at all sustainable. Climate change is likely to decrease the water supply in the cities. Extremes in climate thus add to the water insecurity and further deteriorate the urban environment. Most of the existing water supply in the cities were designed decades earlier and are now highly inadequate to meet the increasing demands. According to the World Bank (2001), Chennai and Delhi are ranked as the worst performing cities in terms of hours of water availability per day, while Mumbai and Calcutta are ranked the second and forth worth performers respectively. Thus climate change adds up to the current problems of Chennai and makes it more vulnerable.

The different categories of population in the urban areas will not be equally vulnerable to the impacts of climate change. People with high adaptive capacity will be less vulnerable; people who are the most vulnerable will be the urban poor, slum dwellers and the low-income category population who have very low adaptive
capacity. Recent research highlights an urgent need to improve our understanding and action on climate variability and adaptation in urban areas as an urgent priority, particularly where poverty levels and population growth rates are the highest (Huq et al, 2007b).

In urban areas, the increasing strain is noticed on water and sanitation infrastructure. Water is not only scarce in the cities but also not of potable quality. Moreover, access is denied to the large section of the population, especially the poor who are vulnerable in terms of their social, economic and environmental status, which ultimately impacts their health. The poor are exposed to diseases and ailments due to lack of availability of potable water and poor sanitary conditions. With increased water scarcity, generally healthy communities face health risks and the weak or ill are exposed to increased vulnerability (OCHA, 2010). According to the above study, more than 85% of major diseases are related to exposure to environmental risk factors such as poor sanitation, air pollutants, and a lack of access to clean water. Globally, diarrhea is the leading cause of illness and death and 88% of diarrhea-related deaths stem from lack of access to clean water and sanitation. Furthermore, filariasis, Schistosomiasis, guinea worm, and other water-borne diseases affect 200 million people across 74 countries worldwide. Currently 1.1 billion people are denied access to safe and potable water and are forced to risk exposure to bacteria due to consumption of poor quality water. With increased physical water scarcity, it is projected that more than 5 million people – or 67% percent (over two-thirds) of the world’s population – will be without access to adequate sanitation in 2030. The challenge of containing disease outbreaks such as cholera and tuberculosis becomes increasingly difficult without adequate sanitation facilities. Finally, with an estimated 5 billion people predicted to be living in urban settlements by 2025, the urban boom may further strain water resources and increase the risk of disease outbreaks.

Hence, assessing the extent of vulnerability to which the slum dwellers are exposed to in comparison with those living in apartments (the upper and the middle class) is felt necessary in urban centers like Chennai. This chapter has tried to capture the stress experienced by different sections of the population in terms of
socio-economic and environmental variables. In light of the stress, especially on water and sanitation, the steps taken by various stakeholders, i.e., the government, the market and the consumers themselves need to be understood. Chapters 5, 6 and 7 deal with the responses of the various solidarities\(^\text{13}\) (stakeholders) to lack of or inadequate and irregular water supply in Chennai. Before analyzing the response of the various solidarities (stakeholders), an analysis of the demand for and supply of drinking water is studied for the past three or four decades, which gives an idea of the urban water scenario in Chennai city. The next chapter thus details about the demand for and supply of drinking water in Chennai.

\(^{13}\) Michael Thompson (2008)