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Enhancing Adaptation to Climate Change by Integrating Climate Risk into Long-Term Development Plans and Disaster Management

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FINAL REPORT for APN PROJECT

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OVERVIEW OF PROJECT WORK AND OUTCOMES

Non-technical summary

Extreme weather events affect vulnerable urban areas adversely, with substantial damage, disruption of normal economic and social activities and services and loss of human life and can also alter the medium or long-term development trajectory of the cities. Thus, disaster management is an important context for integrating adaptation into decision-making for the cities at risk. The APN-funded research project in Mumbai, Bangkok and Manila has been undertaken with the primary objective of identifying and measuring the short to medium-term impacts and responses to extreme weather events and their policy implications for long-term adaptation capacity and development planning for the cities. The project includes analysis of primary and secondary data to measure the physical, economic and social losses in the case study cities. We also examine the short to medium-term responses from the local government and citizens and evaluate if they enhance the adaptation capacity of the cities to cope with future weather events and flood risks. This analysis has policy implications for disaster management, city resilience and adaptive capacity of the cities in the long-term. The project is particularly relevant to the selected cities belonging to the developing world where natural disasters have long-term implications for development and poverty alleviation.

Objectives

The main objectives of the project were:

1. Analysis of immediate to medium-term impacts and responses in the aftermath of extreme events of flooding faced by three coastal cities, Mumbai (India), Bangkok (Thailand) and Manila (Philippines)
2. Examine the effects of short to medium-term responses to extreme events on enhancing the long-term adaptation capacity of these cities
3. Explore the policy implications of the findings for long-term disaster management, city resilience and long-term development plans

Amount received and number years supported

The Grant awarded to this project: US$ 65,000 for One Year

Activity undertaken

In order to achieve the objectives, the following activities were carried out under the project:

1. Developing a common methodology in the inception workshop held in December 2010 to identify and measure the immediate to medium-term impacts of selected weather events resulting in flooding in the three cities.
2. Measuring physical, economic and social impacts of floods with particular focus on stock and flow variables using primary and secondary data
3. Examining the short to medium-term responses of local government institutions and the community at large including households and private sector
4. Exploring the linkages of the response measures to adaption capacity in the long-term and policy implications for development planning and city resilience
5. Initiating the process for integrating post event recovery strategy with investment and development plans through stakeholder workshops that would lead to long term reduction in vulnerability and enhancement of adaptive capacity in the three cities

Results

The project findings in the three cities highlight their vulnerability to climate risks due to their geographic location, flood prone topography, large population with a major percentage living a life of poverty in informal settlements, changing land use pattern, rapid infrastructure development often by reclaiming land from sea (as in case of Mumbai) and inadequate civic amenities. The study has examined the physical, economic and social impacts of selected extreme weather events leading to flash floods in the three cities. An important finding is that the huge monetary costs of these impacts are the uninsured losses borne by households belonging to poor strata of society and the private sector mostly engaged in informal activities. The study also examines the responses of local government institutions as well as people to cope with flooding. There are a number of public and private adaptation strategies that have been identified in this report. A significant finding is that all private initiatives and responses are a direct out-of-pocket expense for the concerned individuals or establishments. There is virtually no insurance cover that helps them to deal with the adverse impacts of floods and bring about changes or improvements in the existing infrastructure. Some of the public and private responses have the potential to enhance the medium to long-term adaptation capacity of the city to cope with future floods. However, there is a need to address the larger issues of climate risks and adaptation in the long-term development planning for the cities.

Relevance to the APN Goals, Science Agenda and to Policy Processes

The project is relevant to the climate agenda of the APN. The methodology developed and used in the project to identify and analyze the immediate to medium-term impacts and responses of flooding events is expected to improving the understanding of adaptation interventions coming from the government as well as communities. The project will help in enhancing the APN agenda of identifying and developing effective methodologies in different areas of global change research and transferring the knowledge base to the scientific community and policy makers. Better characterization of post-event impacts and the recovery process would further help in improving the disaster management interventions. The findings of this project will also help inform the broader "Cities at Risk" theme being developed by START and the new ICSU international science project on Integrated Research in Disaster Risk (IRDR). The UNEP has recently launched the Asia-Pacific Climate Change Adaptation Network, supported by the UNEP regional office in Bangkok and by the governments of Japan and Sweden. This project will also contribute directly to the activities of this Network.

Self evaluation

The project has achieved its stated objective of analyzing the short to medium-term impacts and responses in the aftermath of extreme weather events leading to floods in the three cities. The case studies developed here further examine if the response measures undertaken by both local administration and communities has the potential to enhance the adaptation capacity of the city in the long-term. There are critical policy implications of the findings of this study, in particular, the huge monetary burden of the impacts of floods which is borne by the community in the absence of insurance coverage and other compensation or aid. Responses also mean the cost related private adaptation. Such private costs, especially the costs borne by the poor and vulnerable sections in these cities and informal sectors often go unaccounted for in usual damage impact assessment studies.

Potential for further work

The findings of the project are quite relevant for the three cities which are in transition and on a development path. It is extremely important that these findings are shared with the larger audience of policy makers, academia and local community to initiate a meaningful dialogue on climate risks, general perceptions about the adaptive capacity and how adaptation can be mainstreamed in policy processes. Therefore, the project should culminate in journal articles as well as be presented in different forums to make it more relevant. The next logical step would also be to study the policy processes further, especially the formulation of development and investment plans in the cities to understand how climate risks and adaptation can be incorporated into these plans.

Publications

Not available now but we would be publishing two articles in peer-reviewed journals where all the collaborators would contribute.

References

1. Sherbinin A., Schiller A. and Pulsipher A., (2007), The Vulnerability of Global Cities to Climate Hazards, Environment and Urbanization, Vol. 19(1), Sage Publications on behalf of International Institute for Environment and Development
2. Hallegatte S., Coastal Cities, Climate Change Vulnerability and Adaptation, OECD Project led by Jan Corfee-Morgot, available at www.oecd.org/dataoecd/31/34/44104953.pdf
3. OECD (2008), Ranking Port Cities with High Exposure and Vulnerability to Climate Extremes: Exposure Estimates, Environment Working Papers No. 1
4. Hallegate, S. et al. (2010), " Flood Risks, Climate Change Impacts and Adaptation Benefits in Mumbai: An Initial Assessment of Socio-Economic Consequences of Present and Climate Change Induced Flood Risks and of Possible Adaptation Options", OECD Environment Working Papers, No. 27, OECD Publishing. doi: 10.1787/5km4hv6wb434-en
5. World Bank (2004), Understanding the Economic and Financial Impacts of Natural Disasters, Disaster Risk Management Series No. 4, The World Bank, Washington DC
6. Birkmann, Jorn (2009). Assessing Vulnerability in the Context of Multiple-Stressors. United Nations University, Institute for Environment and Human Security
7. IPCC (2001): Climate Change 2001: Impacts, Adaptation and Vulnerability: Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press.
8. Klein, R.J.T. and R.J. Nicholls. 1998. Coastal zones. In Handbook on Methods for Climate Change Impact Assessment and Adaptation Strategies, I. Burton, J.F. Feenstra, M.L. Parry, J.B. Smith, and R.S.J. Tol (eds.). Version 2. United Nations Environment Programme and Institute for Environmental Studies, Amsterdam, pp. 7-1 to 7-35.
9. ADB/JICA/World Bank (2010). Climate Risks and Adaptation in Asian Coastal Megacities, p.23. Retrieved at: http://siteresources.worldbank.org/EASTASIAPACIFICEXT/Resources/226300-1287600424406/coastal_megacities_fullreport.pdf
10. Nicholls, R.J., Hanson, S., Herweijer, C., Patmore, N., Hallegatte, S., CorfeeMorlot, J. Chateau, J. and Muir-Wood, R. (2008). Ranking Port Cities with High Exposure and Vulnerability to Climate Extremes. OECD Environment Working Papers No. 1.

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TECHNICAL REPORT

Preface

It is now widely accepted that impacts of future climate change will often be observed through changes in the magnitude and frequency of existing climate-related hazards. Therefore, disaster risk reduction and management are important strategies for integrating or mainstreaming adaptation into decision-making. The project has undertake a detailed analysis of the immediate to medium-term post-disaster impacts and responses in the aftermath of extreme weather events (flooding) in three Asian cities of Mumbai (India), Bangkok (Thailand) and Manila (Philippines). We quantify the impacts and evaluate if short to medium-term responses enhance the adaptation capacity of the cities for future climate risks.

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1.0 Introduction

It is now widely accepted that impacts of future climate change will often be observed through changes in the magnitude and frequency of existing climate-related hazards in the form of extreme weather events. Therefore, disaster risk reduction and disaster management is an important context for integrating or mainstreaming adaptation into decision-making for the cities at risk.

Extreme weather events affect vulnerable urban areas (cities) adversely, with substantial damage and disruption of normal economic and social activities. The loss of physical, economic and financial resource base is also supplemented by the loss of economic and social services. This combination of stock and flow effects can potentially alter the medium to long-term development trajectory of the city. Most of the existing natural hazards and impacts literature focuses on short-term and immediate damage to human, built and natural capital, as measured by indicators such as mortality and insured losses to private and public property and infrastructure. Very few studies have critically examined the process and outcomes associated with immediate to medium-term responses from the governments as well as communities to understand the relation between short-term damage, short to medium-term responses and longer-term adaptive capacity in the affected cities. Effective adaptation planning requires not only the mitigation of immediate losses but also an enhancement of the speed and extent of post-disaster recovery. Of additional importance is the need to ensure that the post-event recovery leads to long-term reduction in vulnerability and enhancement of adaptive capacity.

This research project aims to fill this research gap by undertaking an analysis of the immediate to medium-term post-disaster recovery scenario in the aftermath of extreme weather events of flooding faced by vulnerable cities in three Asian developing countries, namely, Mumbai (India), Bangkok (Thailand) and Manila (Philippines). The selected Asian cities fall under the densely populated low lying coastal areas described by the IPCC Fourth Assessment report as 'key societal hotspots of coastal vulnerability'. With millions of people residing in these cities, the risk to life and property increases manifold with vulnerability to extreme weather events such as flooding. Incidentally, many instances of severe flooding due to heavy intensity precipitation have been recorded in these cities in recent years, including the unprecedented floods in Bangkok in 2011.

The main objectives of the research project are:

1. Analysis of immediate to medium-term impacts and responses in the aftermath of extreme events of flooding faced by three coastal cities, Mumbai (India), Bangkok (Thailand) and Manila (Philippines)
2. Examine the effects of short to medium-term responses to extreme events on enhancing the long-term adaptation capacity of these cities
3. Explore the policy implications of the findings for long-term disaster management, city resilience and long-term development plans

The project has developed three case studies for the selected cities. Each of the studies have measured the physical, economic and social impacts of selected extreme weather events of flooding, identified the public and private responses in the short to medium-term and explored their policy implications for long-term adaptation capacity, city resilience and investment and development plans. Each study is based on the analysis of primary and secondary data pertaining to the selected events of flooding and their resultant physical, economic and social impacts. The impacts considered here include loss of life, injuries, damage to property and infrastructure, damage to economic stocks like physical capital, inventory and indirect impacts on flow variables like income, investment, employment and disruption of essential services. After measuring these impacts, the analysis has focused on the immediate to medium-term post recovery scenario, wherein, we have examined the responses of the civic administration as well as citizens themselves to cope with future floods. The findings have significant policy implications for integrating adaptation strategies with long-term investment and development plans for the cities at risk. This exercise is particularly relevant to these cities belonging to the developing world, where natural disasters have long-term implications for not only economic development but poverty alleviation as well.

Better understanding of the process of responding to climate-related hazards, including aspects such as relief and recovery is important for planning and implementing adaptation interventions. Given the rapid growth of urban infrastructure in Asian cities, it is important to ensure that this growth enhances climate resilience and adaptive capacity and is done in a manner sensitive to the possibilities of mal-adaptation. Therefore, the project is relevant to the climate agenda of the APN. The project has developed a methodology to identify and analyze the immediate to medium-term stock and flow impacts of flood events and has also tried to put a monetary tag on the uninsured losses which normally go unaccounted for in damage assessment exercises. We hope that the findings of the project will contribute to improving the understanding of vulnerability and the actual design and implementation of adaptation interventions by integrating climate risk considerations into decision-making at different levels.

The project teams located in the three countries have jointly developed the methodology and have gathered the relevant data pertaining to impacts and responses in the respective cities. The methodology used here and the findings of the study are being shared with the policy makers, local government institutions and other stakeholders including the scientific and research community and local people through workshops and proposed publications in the pipeline. Vulnerability and adaptation to climate change have been recognized as important areas for scientific and institutional capacity-building. By linking leading institutions in the region, the project also presents an opportunity to strengthen the research capacity. In addition, the project has also directly engaged the local and regional decision-makers while carrying out the case studies which would help in better understanding and articulation of adaptation needs and options for future.

This project report gives a detailed description of the methodology used in the case studies in the next section. Section 3 presents the results of the case studies and discusses the main findings. This is followed by conclusions in Section 4 and future directions for research in Section 5.

2.0 Methodology

As described earlier, this research project has developed three case studies for Mumbai, Bangkok and Manila. The project teams located in the three countries have jointly developed the methodology and have gathered the relevant data pertaining to impacts and responses in the respective cities. Each of the studies have measured the physical, economic and social impacts of selected extreme weather events of flooding, identified the public and private responses in the short to medium-term and explored their policy implications for long-term adaptation capacity, city resilience and investment and development plans. Each study is based on the analysis of primary and secondary data pertaining to the selected events of flooding and their resultant physical, economic and social impacts. The case studies also identify the immediate to medium-term post disaster responses of the civic administration as well as citizens to cope with future floods. The following activities have been carried out under this project in each of the cities:

1. Measuring physical, economic and social impacts of floods with particular focus on stock and flow variables using primary and secondary data
2. Examining the short to medium-term responses of local government institutions and the community at large including households and private sector
3. Exploring the linkages of the response measures to adaption capacity in the long-term and

policy implications for development planning and city resilience

4. Initiating the process for integrating post event recovery strategy with investment and development plans through active engagement and dialogue with the policy makers and other stakeholders through information dissemination and workshops that would lead to better understanding of adaptation needs in future

We describe the methodology used for the case studies in detail in this section. The following sub-sections give details like brief description of the selected extreme flood events, methodology used in the respective cities, study areas, primary and secondary data sources and analytical techniques used.

2.1 Mumbai

Mumbai (formerly known as Bombay) is one of the largest mega cities with the population of more than 12 million. The city is the financial capital of India with a large commercial and trading base. With per capita income thrice that of the national average, Mumbai makes huge contribution to the total tax revenues of the country. The city is an important international sea port and strategic from defense perspective. Unfortunately, the city is also acutely vulnerable to climate risks due to its location on the sea coast, flood prone topography and the landmass composed largely of reclaimed areas. In recent years, Mumbai has been experiencing many weather events, including the extreme weather event in July 2005 that led to unprecedented floods, massive damages, loss of life and property and affected the economic and social activities adversely. Such events tend to have long-term consequences for economic development and poverty alleviation in the city where majority of the residents (60% in case of Mumbai) live in slums and squatter settlements.

The extreme weather event of July 2005 has been selected in this case study to examine the impacts and responses and to study the policy implications for long-term adaptation capacity. On July 26, 2005, Mumbai was struck with a heavy storm. India Meteorological Department (IMD) weather station recorded 944mm rainfall (45% of the annual average rainfall in Mumbai) over a 24-hour period, with the highest precipitation (380 mm) for a few hours between 2.30 pm and 7.30 pm. This unprecedented rainfall coinciding with the high tide brought the city to a standstill. 22% of the city was submerged that day with very heavy flooding in the suburbs.

In order to measure the stock and flow impacts of the July 2005 events and analyze the response strategies, the study has used both primary data collected from communities and secondary data collected from government institutions. The impacts include stock variables like loss of life, injuries, damage to property and infrastructure, damage to physical capital and inventory and health impacts as well as flow variables like loss of income, investment, employment and disruption of essential services like water and electricity. Similarly, response strategies are identified at both the institutional and community level. The study then focuses on the policy implications of the response efforts for disaster management, city resilience and adaptive capacity in the long-term.

The methodology used in Mumbai case study is outlined here:

1. **Primary data** were collected from households and commercial and small industrial establishments in Mumbai by administering a detailed questionnaire in six wards (administrative units) of Mumbai.

    a. Six flood prone wards in Mumbai – ***F North, F South, H East, K East, L and P North*** – selected for the survey. These wards were most affected by July 2005 floods. They are low-lying and reclaimed areas or fall in the river flood plain making them more vulnerable to flash floods.

b. Detailed questionnaires were administered to 1168 households and 792 commercial and small industrial establishments spread over the six wards. The sample selected from the six wards is given in Table 1 below.

c. Survey questionnaires pertain to impacts of July 2005 floods, community and administration response, costs of damage and repairs/replacements, response measures undertaken in the aftermath of July 2005 and experience of subsequent flood events

Table 1: Ward-wise details of the sample selected in Mumbai

Wards	Total population	Households	Commercial & Industrial
F North	5,24,393	177	102
F South	3,96,122	103	149
H East	5,80,835	176	98
K East	8,10,002	241	139
L Ward	7,78,278	231	204
P North	7,98,775	240	100

2. Information was also collection through **unstructured interviews** of selected local government officials working at the ward level, with Disaster Management Cell (DMC) and key planners.

   a. Personal interviews were carried out based on open-ended questions to understand their views on flooding events in Mumbai, climate risk perception, current adaptation events, level of preparedness and enhancing long-term coping capacity through short and medium-term measures undertaken by the local government

3. **Secondary data** were collected from the DMC and other relevant departments within Municipal Corporation of Greater Mumbai (MCGM), the civic authority, as well as private sector electricity utility to understand the magnitude of impact on city infrastructure and provision of services, relief and recovery efforts, disaster management priorities and practices and overall development planning process.

The study reported the costs of damage to physical infrastructure as per the damage assessment reports of MCGM. For the primary data analysis, descriptive statistics were used to understand the average costs of damages to physical infrastructure, appliances and inventory as well as economic losses for households and commercial and small industrial establishments. These costs were extrapolated using certain assumptions to arrive at rough and indicative estimates of the total costs of direct impacts on households and other establishments due to July 2005 floods. The important point to be noted here is that these are uninsured losses and hence are normally not taken into account when damage assessment is done.

For the indirect impacts like non-availability of goods and services and disruption of essential services like electricity, we used the proxy variables such as daily octroi collection at entry points into the city and daily electricity supply in the suburbs by a private utility.

2.2 Bangkok

Bangkok, the capital of Thailand since 1782, is not only the country's political centre, but also its administrative and economic heart. Located on the lower plain of the Chao Phraya River Basin, the city is now a sprawling urban agglomeration and one of Asia's emerging megacities. The sheer pace of its spatial and demographic growth has meant that Bangkok itself has had to be continuously redefined. The city is now classified as the Bangkok Metropolitan Region (BMR), an area of around 1,569km^2 that includes the five adjacent provinces of Samut Sakon, Nakhon Pathom, Nonthaburi, Pathum Thani and Samutprakarn. According to the National Statistics Office (NSO), Bangkok's population in 2009 was at 5.701 million but other figures put the population at almost 10 million or even more, when unregistered migrants are factored in. Much of Thailand's industrial and commercial capacity is concentrated within metropolitan Bangkok, as well as the bulk of its communications and transport infrastructure. In 2006, the year of this case study, the BMR generated 43% of Thailand's GDP.

This economic primacy, together with the expanding population, is a major dimension in the city's increasing vulnerability and exposure to flooding. When a major flood event affects Bangkok, it not only threatens the political and administrative functioning of the capital, but also puts much of the country's factories and industrial parks at risk, and by extension, the homes and livelihoods of hundreds of thousands of the city's residents. A second important element in Bangkok's development is its transition from a water-based urban form, when the city fabric was designed sympathetically around its natural climate and hydrology, to an impermeable 'concrete pad'. This has weakened its capacity to cope with heavy rains.

This study examines the impact of the 2006 floods, with a focus on four districts in the eastern region of Bangkok: ***Minburi, Nong Jork, Lat Krabang and Klong Samwa***. During the 2006 flood, these districts were among the worst hit. As with other instances of flooding in Bangkok, the circumstances that led to the city's inundation in 2006 were both unique and generalised. Heavy precipitation, large volumes of runoff from the north of the country and significant sea level rises due to seasonal high tides were all contributing factors. In response, the floodwater was managed by allowing the agricultural land north of the city to flood and also channelling the water to the east of the city, where the case study districts are located. In 2006, Thailand was affected by a number of tropical depressions between the months of August and October. These resulted in short periods of intense precipitation across Thailand during this period, on 27-31 August, 9-12 September and 18-23 September. The last, the 'Xangsane' typhoon, occurred on 1-3 October. This triggered intense flash precipitation in Bangkok. 24 hours of heavy localized rain caused the city to be inundated as its drainage system was unable to cope with rainfall exceeding 60mm/hour.

Estimating the full extent of the 2006 flooding and its impact requires a detailed and wide-ranging assessment of its effects. This study aims to develop, through a variety of measurements and proxies, a more comprehensive picture of the impacts of the 2006 flooding on communities in the four study districts. This case study uses the methodology outlined below:

1. **Secondary data:** A diverse selection of secondary data, such as damage profiles, relief subsidies and mental health assessments were used in this study. The study draws on previous studies and assessments on the 2006 flood, some conducted in its immediate aftermath, that together illustrate some of the long-term consequences of the disaster for economic growth and social development in the case study districts.

2. However, the available resources are relatively limited and so a full taxonomy of its effects is not possible. The quantifiable measurements are therefore confined to the aspects listed below:

Physical:	Total inundated area
	Damage to property and infrastructure
	Loss of agricultural produce
Environment:	Water quality
	Sanitary level
Social:	Psychological assessment

3. Secondly, fieldwork was undertaken in the case study districts, using **semi-structured interviews** with residents to gain a better qualitative understanding of the 2006 flooding.

4. The **primary data** were collected in the four selected districts of Nong Jork, Minburi, Ladkrabang and Khlongsamwa, all located outside the King's dyke in eastern Bangkok. A total of 380 surveys were undertaken to assess flood-related impacts across four main sectors: 300 household samples, 50 agricultural samples, 28 business samples and 2 industrial samples, namely the Bangchan and Ladkrabang industrial estates, the only ones in the study area.

In order to gauge the true effects of the flooding, the researchers designed a series of proxies to better measure the impacts, direct and indirect, on livelihoods and the local economy as seen in Table 2 below. This involved synthesizing existing data at the national level, together with the primary data gathered through the fieldwork.

Table 2: Proxies for gauging flooding effects, by sector in Bangkok

Sector	Proxies
Household	Flood level / Flood duration / Cost of physical damage / Work absence / Health (physical and mental)
Agricultural	Flood level / Flood duration / Cost physical damage / Work absence / Product price
Business	Flood level / Flood duration / Cost of physical damage / Work absence / Stock / Custom and trade
Industrial	Household surveys. Flood prevention plan

2.3 Manila

Metro Manila or the National Capital Region (NCR) is the center of political, economic, and socio-cultural activities of Philippines. Its strategic location by Manila Bay and the mouth of the Pasig River accounts for the growth of the capital city. Being near a river and a good harbor made possible the development and expansion of the city of Manila to its suburbs in the last 30 years. With large in-migration and rapid population growth, the city expanded to the suburbs, surrounding municipalities, and to risky areas for habitation (e.g., swampy areas, near or above esteros or water canals, along the river and earthquake fault lines). Socio-economic forces like land use, infrastructural development, building practices, urban development policies and programs have greatly shaped the settlement patterns of the city. In 2007, the National Statistics Office (NSO) reported that Metro Manila has 12 million residents but the average daytime population is about 16 million. In third world cities like Metro Manila where urban growth and sprawl remains largely unregulated, the vulnerability of populations, especially marginal sectors, to climate change-related effects like floods is quite high, reducing their potential for adaptation and resilience.

This study was carried out in Metro Manila, in the Pasig-Marikina flood basin, with special focus on the cities of Marikina and Pasig. These cities suffered extreme flooding brought about by the tropical storm, Ondoy in late September 2009 and Pepeng in early October 2009. In this study, the impacts and responses to Ondoy in these cities were compared to another flooding event in 2011, the heavy rains and floods brought by Pedring and Quiel in September 2011 and early October 2011. Until tropical storm Sendong hit northen Mindanao and Eastern Visayas in December 2011, these were considered the worst to have brought extreme flooding to the national capital.

The study utilized the following main data sources:

1. **Secondary data sources:** The main secondary source utilized here to complement the current APN survey is the 2008 climate change household survey conducted by the author in the three flood plains of Metro Manila.

2. **Household and commercial surveys:** This study interviewed 200 households[1], sampled from those severely flooded communities in the extreme flooding of Ondoy in late September and Pepeng in early October 2009 located in the flood basin of the Pasig-Marikina River Basin, one of the three flood basins of Metro Manila (see map below). The other two flood basins are located in the cities of Kaloocan, Malabon, Navotas, and Valenzuela (KAMANAVA) and in the city of Taguig and the municipality of Pateros known as the West Mangahan area. These areas often experience flooding coming from the nearby riverine systems and the regular tidal/storm surges (see figure 1 below). To obtain the losses/damages and responses at the commercial-industrial level, the study conducted a survey of 100 commercial-industrial units or 50 in each of the cities.

The above data sources were supplemented with key informant interviews and Focus group discussions (FGDs) among local and national officials, civil society leaders, influential private sector leaders, and community leaders/residents. Overall, the study assessed the vulnerability of Metro Manila residents and commercial-industrial establishments to extreme flooding in 2009 (Ondoy and Pepeng), their adaptive responses and potentials for mainstreaming these adaptations to urban planning, governance, and to medium/long-term development.

[1] Originally, the study planned to interview 300 households obtained through systematic sampling with a random start but had to reduce this to 200 because the people were tired of being interviewed about the effects and their responses to Ondoy. In the same manner, 100 owners/managers of commercial and industrial units were expected to be interviewed in both cities but in the end we were able to process 87 interview protocols because 13 respondents had several call backs that eventually we dropped them out of the sample.

3.0 Results & Discussion

The project findings in the three cities highlight their vulnerability to climate risks due to their geographic location, flood prone topography, large population with a major percentage living a life of poverty in informal settlements, changing land use pattern, rapid infrastructure development often by reclaiming land from sea (as in case of Mumbai) and inadequate civic amenities. The study has examined the physical, economic and social impacts of selected extreme weather events leading to flash floods in the three cities. An important finding is that the huge monetary costs of these impacts are often the uninsured losses borne by households belonging to poor strata of society and the private sector mostly engaged in informal activities. The study also examines the responses of local government institutions as well as people to cope with flooding. There are a number of public and private adaptation strategies that have been identified in this report.

We describe in this section the results of the analysis carried out using primary and secondary data in the three cities. The following sub-sections give details of the stock and flow impacts, the estimates costs of the damage during the extreme weather events on households and other establishments and response strategies adopted by local governments and people on their own (prominently in case of Mumbai).

3.1 Findings of Mumbai study

MCGM, the civic authority, undertook damage assessment exercise in the immediate aftermath of July 2005 floods and submitted the report to seek financial assistance from the central government under the CRF (Central Relief Fund). This exercise has estimated the cost of damages to municipal infrastructure including municipal buildings, water supply systems, roads and storm water drains to the tune of Indian Rupees (INR) 2475 Million or US$ 55 million. However, the damages and costs estimated by the government agencies reflect only a fraction of the total costs of damages to physical infrastructure and assets as the damages suffered by households and commercial establishments are not accounted for in the absence of insurance coverage and unavailability of data. To overcome this limitation of impact assessment, this study carried out the survey of 1168 households and 792 commercial and small industrial establishments from six wards of Mumbai.

In case of households, During the July 2005 floods, the average depth of flooding was 5 feet and the houses remained flooded for average 3 days. 59% said that the effect of floods on their families was high. Most surveyed households (69.35%) were in the lower middle-income category of INR 5000-15000 followed by 16.52% earning less than INR 5000 per month and 10.62% earning INR 15000-30000. On an average, the income loss due to floods was INR 5000 (84% respondents) and amount spent on repair/ rebuilding of house was INR 15000 (86% respondents). On an average time, it took the households around 8 days to complete the repair/reconstruction of the house.

Table 3 shows the total costs of repair/replacement for the flood affected households. The costs estimated through the primary survey have been extrapolated for Mumbai by assuming that overall 20% of households located in eastern and western suburbs were affected by floods in July 2005[2]. It must be noted here that in the absence of insurance coverage, the huge costs calculated here to the

[2] 2001 census data show the total population of around 8.5 million in eastern and western suburbs of Mumbai. Assuming the average of 4 members per family, this translates to about 2.1 million households. We make a rough estimation that 20% of these households (about 420,000) were directly affected due to floods in July 2005 given the extent of flooding in suburbs and calculate the costs accordingly. It must be noted here that we are considering households who are located at the ground level and first storey of residential buildings. Hence 20% seems a reasonable estimate for directly affected households. This exercise provides at best only indicative estimates of the overall costs that households have had to bear in the absence of insurance coverage.

tune of INR 12,000 million (US$ 267 million) are the out-of-pocket expenses borne by the city residents on account of floods.

Table 3: Cost of repairs/replacement in households

Item	Average cost of repairs/replacement per household (in INR)	% of households reporting these costs in survey	Estimated number of households affected by floods	Estimated costs of damage in INR million
Income loss	5000	84	352800	1764
Reconstruction of house	15000	86	361200	5418
Stove	1500	57	239400	359.1
Electric Fans	1000	35	147000	147
TV	7000	42	176400	1234.8
VCR/VCD	2700	7	29400	79.38
Music System	3000	1	4200	12.6
Motorcycle	8000	13	54600	436.8
Refrigerator	7000	30	126000	882
Washing Machine	6000	8	33600	201.6
Furniture	5000	31	130200	651
Wardrobes	4000	32	134400	537.6
Utensils	3000	38	159600	478.8
Total Estimated costs				**12202.68 (US$ 267 million)**

The primary survey also covered commercial establishments like retail shops, IT centres, Jewellery stores, dairy, etc. and small industries such as manufacturing units and warehouses. Most of these are either located on the ground level in industrial parks or along the roadside and get affected by floods with heavy precipitation. During the July 2005 floods, the average depth of flooding reported by commercial establishments was 4 ft. The average time taken by them to get back to normal business was 3.5 working days. Once again, in the absence of insurance coverage (only 7% of the respondents claimed to have insurance coverage of any kind including life insurance), these establishments had to bear the burden of repairs and/or replacements for different physical assets damaged/destroyed during the July 2005 floods as seen in Table 4 below. The costs have been extrapolated for Mumbai by assuming that overall 40% of such establishments located in eastern and western suburbs were affected by floods in July 2005[3].

[3] MCGM records show around 400,000 registered retail shops and other commercial establishments in the city out of which 60% or 240,000 are located in the suburbs. We make a rough estimation that 40% of these establishments were affected due to floods in July 2005 given the extent of flooding in suburbs and calculate the costs accordingly. This exercise provides at best only indicative estimates of the overall costs that such establishments have had to bear in the absence of insurance coverage.

Table 4: Cost of repairs/replacement in commercial & industrial establishments in Mumbai

Item	Average cost of repairs/replacement per establishment (in INR)	% of establishments reporting these costs in survey	Estimated number of establishments affected	Estimated costs in INR million
Grounds and fences	40000	48	46080	1843.2
Walls	11000	26	24960	274.56
Windows	5000	4	3840	19.2
Doors and mouldings	6000	18	17280	103.68
Electrical wiring and switches	10000	28	26880	268.8
Heating	10000	1	960	9.6
Air conditioning	14000	1	960	13.44
Machine tools	15000	25	24000	360
Finished products	24000	28	26880	645.12
Raw materials	20000	13	12480	249.6
Inventory	24000	13	12480	299.52
Total Estimated costs				**4086.72 (US$ 90 million)**

Source: Calculated based on primary data

In addition to this, there are a number of indirect impacts like non-availability of essential supplies, price rise due to shortages and disruption of essential services that the respondents have reported. Some of the major problems faced by both households and commercial and industrial establishments are flood waters entering the premises, non-availability of local transportation, disruption of electricity and supply of clean drinking water. 70% households and 82% establishments reported that their premises were flooded with water. More than 80% households and establishments also reported non-availability of local transportation and disruption of electricity. 62% households said that there was non-availability of food and other supplies. Data on daily octroi collections and daily electricity supply also show a major dip in the aftermath of floods. In fact, in case of electricity, it took the private utility nearly two weeks to restore the power supply back to its normal levels.

The devastating floods of July 2005 became a real eye opener for the local administration and led to the formulation of the Disaster Management Plan for the city and other short to medium term measures to improve the coping capacity of the city to floods in future. Along with the local government, citizens – households and commercial/industrial establishments –also responded to the threat of recurrent floods and undertook a variety of measures in the aftermath of July 2005 floods.

The following are some of the important response measures:

- In the immediate aftermath of the July 2005 floods, a Fact Finding Committee was appointed to look into the causes and to recommend activities to reduce the future risks of flooding in Mumbai. The committee came up with several recommendations, such as, upgradation of storm water drainage system, disaster management, river development and so on to improve the existing environment and upgrade and improve the governance and management to achieve sustainable development of Mumbai.
- Accordingly, the Brihanmumbai Stormwater Disposal System (BRIMSTOWAD) is now being implementing at the cost of INR 1200 crore (approx. US$ 266 million). This project is doubling the capacity of the existing drains from 25 mm rainfall per hour to 50 mm per hour of rainfall.
- A fully-equipped Disaster Management Cell (DMC) was made operational at MCGM headquarters in Mumbai after 2005. This cell has been given the responsibility of coordinating with different stakeholders and agencies for the rescue and relief operations in the event of floods during monsoon. 31 rain gauges have been installed and they feed rainfall data of 15-minute interval to the disaster control room. Alert is issued to the control rooms in each ward whenever the hourly rainfall exceeds 40 mm.
- Greater Mumbai Disaster Management Action Plan (DMAP) came into existence in 2007. Under this plan, the risks and vulnerabilities associated with floods, earthquakes, landslides, cyclones, etc., have been identified. The plan envisages specific roles for different stakeholders including government agencies and community organizations.
- As part of private responses, households and commercial and industrial establishments have undertaken steps like increasing height of the surrounding plot, reconstruction with stilt parking, repairing and elevating electrical meters, repairs to elevate and protect inventory, etc.
- It must be noted that all private initiatives and responses in the absence of insurance coverage are direct out-of-pocket expenses for the individuals or establishments.

3.2 Findings of Bangkok study

Estimating the full extent of the 2006 flooding in Bangkok and its impact requires a detailed and wide-ranging assessment of its effects. Even among the four districts selected in the case study, the proportion of inundated area and the accompanying damage varied considerably. Reflecting the mixed character of these districts, as formerly agricultural regions now undergoing rapid suburbanization, the damage extended to national infrastructure such as roads and rail lines, community buildings, businesses, fisheries and farms, along with other less tangible dimensions, such as mental health, may not always be readily measurable.

Table 5 gives an overview of the reported damage in each of the four case study districts on October 5, just after the flooding. In particular, it gives an idea of the physical damage to communal infrastructure and the associated impacts this has on education, social life and mobility for residents. The damage to the rice growers was also substantial at 84 million baht, which shows the importance of agriculture in Bangkok, particularly in suburban and peripheral areas such as the study districts. Similarly, table 6 shows the impact of 2006 floods compared to the impacts of a 'normal' flood event of 2010 and the substantial damages in 2006.

Table 5: Damage to national infrastructure and associated costs in 2006

Infrastructure	Damage	Costs
Highways	286 routes on 757 roads: 31 roads with no access.	1,735 million baht ($58 million): 1,650 million baht to rebuild damaged roads and 85 million baht to restore accessibility to obstructed roads.
Rural roads	496 routes: 12 roads with no access. 467.6km of roads and 1,337m of bridge to be rebuilt. 102 pipe and 49 land erosion projects.	1,257.7 million baht (around $42 million)
Railways	6 projects, all in northern Thailand.	300 million baht (around $10 million)
Waterways and dykes	496 routes requiring protection from erosion/deterioration. 12 roads with no access.	226 million baht (around $7.5 million)

Table 6: Flood related impacts in 2006 compared to 'normal' floods in 2010

District	Total flooded area (rai)		Total flood-affected farmers		Total compensation (Baht, millions)	
	2006	*2010*	*2006*	*2010*	*2006*	*2010*
Khlong Samwa	14,254	494	772	47	7.259	1.269
Minburi	5,877	464	441	54	1.891	1.278
Lad Krabang	14,826	410	325 & 671 (inland fisheries)	32	4.377	0.987
Nong Chok	16,817	1,010	672	52	7.090	2.129

This provides a fuller picture of flood-related costs to individuals and the community. Table 7 below summarizes the average loss for each household, business and farm in the sample communities. While it includes repair costs to housing, vehicles and other equipment, it also extends to the intangible or indirect losses that result from illness, work absence or additional transport costs caused by flooding. Revenue shortfalls or unpaid leave create an added burden that conventional measurements of costs and losses often fail to capture. As Table 7 shows, these indirect costs are substantial for households, businesses and agriculture. In the case of businesses, the indirect costs of lost customers, work absence and the 'invisible' cost of flood prevention in fact exceed the direct costs of repairs and physical damage.

Table 7: Flood related costs calculated based on primary survey

HOUSEHOLD SECTOR					
Proxy variables	**Sub-proxies**				**Total**
Loss Incurred	*Food and utilities*	*Transportation*	*Repairs*	*Flood prevention*	
	15,000	600	25,000	5,000	44,400
Work absence	*Daily income*	*Day (s) absent*			
	300	3			900
Health	*Medication*				
	300				300
					45,600

BUSINESS SECTOR					
Proxy Variables	**Sub-Proxies**				**Total**
Loss Incurred	*Lost customers*	*Stock damage*	*Repairs*	*Flood prevention*	
	15,000	5,000	5,000	5,000	30,000
Work absence	*Expenses (workers)*	*Day(s) absent*			
	300	3			900
					30,900

AGRICULTURAL SECTOR			
Proxy Variables	**Sub-Proxies**		**Total**
Loss Incurred	*Field damage*	*Flood prevention*	
	30,000	12,000	42,000
Work Absence	*Daily income*	*Day(s) absent*	
	500	30	15,000
			57,000

The results highlight the importance of a localized analysis of the impacts of flooding, as both the intensity and the nature of its effects vary considerably from district to district. Of the four, Minburi was the worst affected in 2006 and 2010. The impact was particularly pronounced in September and October, as residents suffered loss of livelihood as a result of economic disruption and health risks.

Work absence is also an important indirect cost in the flooding. Nevertheless, work attendance remained relatively unaffected through the flooding, suggesting a comparatively high level of adaptation. However, within the agricultural sector work absence was a major problem as fields and land were inundated, in the worst cases potentially extending into weeks. Interestingly, the relatively low impact of work absence on poor and affluent households was in fact similar for the lowest income (<10,000 Baht/month) and the highest income (>50,000 baht/month) households.

From these results, it would seem that low income households demonstrated a relatively high level of adaptation to the flooding. There are probably a number of dimensions to this that need to be explored further: for example, the limited ability of low income households to shoulder the costs of work absence, especially when they lack the security of formally salaried employment.

With regards to flood preparedness, the results were poor at the household level in 2006: for instance, only 26% of households had stocked food and only 31% drinking water before the flood. However, this proportion rose substantially for the 2010 flood (to 37% and 41% respectively), suggesting that many households had learnt important lessons from the previous event. And when respondents were asked if in future they would be willing to stock up on supplies before flooding, for both goods around 75% of households answered positively. This suggests that local communities have the capacity to develop better preparation strategies and that there is still further potential to improve on these responses.

Health care costs, whether for minor pharmaceutical purchases or more serious referrals, are another important indirect cost that is often overlooked in damage assessments. These costs are often not insubstantial. In Nong Jork, where much of the area is farmland, parts of the district experienced protracted flooding, with some areas submerged in over a foot of water for more than a month. As a result, the generally low income population was faced with a variety of health issues, such as dengue fever and foot-and-mouth disease.

The costs of the flooding, through lost income and damaged infrastructure, were generally more severe for the community as a whole than individual households. If the impacts at a community level are more severe, as these results suggest, then this would reinforce the importance of collective adaptation and mitigation strategies at a community level.

Table 8: Intensity of flood impact by sector and income level

PROXY PARAMETERS	Household Sector (300HH)								Agricultural Sector(50)			Business Sector(30)	
	Community				Home								
	<10,000	10,000-30,000	30,000-50,000	>50,000	<10,000	10,000-30,000	30,000-50,000	>50,000	Farm	Livestock	Fishery	Consumer Goods	Services
Flood Level	57.14%	54.07%	52.22%	63.16%	32.14%	41.48%	47.78%	42.11%	45.45%	66.67%	60.00%	68.75%	57.14%
No. of Days Flooded	62.50%	47.41%	52.00%	52.63%	57.14%	38.52%	44.44%	42.11%	78.79%	75.00%	80.00%	56.25%	57.14%
Loss Incurred	44.64%	43.70%	45.56%	31.58%	30.36%	28.15%	28.89%	36.84%	42.42%	50.00%	40.00%	43.75%	50.00%
Work Absence	*	*	*	*	80.36%	87.41%	85.33%	84.31%	90.91%	91.67%	80.00%	56.25%	42.86%
Health	*	*	*	*	66.07%	59.26%	74.44%	68.42%	*	*	*	*	*
Production Price	*	*	*	*	*	*	*	*	75.76%	58.33%	100.00%	*	*
Stock	*	*	*	*	*	*	*	*	*	*	*	31.25%	*
Customer	*	*	*	*	*	*	*	*	*	*	*	43.75%	64.29%

	Flood Level	No.of flood days	Loss Incurred	Work Absence	Health
High	30 cm	> month	>10,000	> week	Admission
Medium	15 cm	1-4 week	5,000-10,000	3-5 days	District Officer
Low	5 cm	< week	<5,000	1-2 days	Store Purchases
No Impact	No impact	No impact	No impact	No impact	No impact

Within the agricultural sector, farmland was the worst affected by flooding in both 2006 and 2010, with levels in excess of a foot lasting over a month. Therefore, from one perspective, farmland is arguably the most vulnerable to flooding. Nevertheless, it is important to note that fisheries were the most affected by the increasing cost of production in 2006. As for small businesses, the impact is less straightforward and depends in particular on the product of the enterprise. For instance, while the service sector was weakened by flood-related disruption, demand for basic consumer goods actually rose among residents who were more reliant on local shops to provide them with food and other provisions. The government therefore must factor these different effects into its assessments and compensation strategies to reflect the varying costs to different agricultural sectors.

Large areas of Bangkok were inundated in 2006 floods and this led to further measures in the aftermath of the event to strengthen the existing network to protect the city from runoff. The strategic focus since 2006, such as the Royal Irrigation Department (RID) master plan, is largely infrastructural, with an emphasis on creating and enhancing drainage and pumping. In partnership with the Department of Drainage and Sewage, the RID developed a 450 km^2 protected area in the eastern suburbs beyond the King's Dike, supported by a system of monitors and flood walls along the main canals to restrict inflows of floodwater from nearby. Three pumping stations have been constructed at Hok Wah Sai Lang, Saen Saeb and Pravetburirom to provide the system with an additional CMS of drainage capacity. These have been accompanied by strengthening the city's retention and drainage capacity.

Further, flood protection for the Chao Phraya Basin encompasses a broad range of different actors with a variety of specializations and institutional mandates. This includes sector-specific agencies, such as the Electricity Generating Authority of Thailand (EGAT), the Royal Irrigation Department (RIG) and the Public Works Department (PWD), and administrative bodies with localized governance remits such as the BMA and the Local Administration Department (LAD).

The BMA's strategies focus primarily on three approaches:

- **Flooding prevention** – achieved through both structural measures (such as polders, pumps and sewerage) and non-structural approaches (such as planning regulations, public communications and improved information gathering). While the former is typically employed in dense, inner city districts, the latter is often favored in low density residential and agricultural areas. This potentially suggests that in suburban areas, such as the case study districts, full prevention may not be achievable, but the negative effects of inundation can be substantially reduced.
- **Post-flood disaster recovery** – focused on immediate mitigation through operating and maintaining pumping and drainage capacity, as well as developing a short term action plan. In 2006, this included the installation of additional pumps in high risk areas, the release of surplus water into irrigation areas and upstream water retention.
- **Medium-term post-flood disaster recovery scenario** – maintaining existing infrastructure and constructing additional capacity to sustain and enhance protective capacity, accompanied by measures to prevent and resolve flooding. Careful coordination, monitoring and evaluation is necessary to achieve this.

As for the involvement of private sector and community in responding to flood threats, the BMA has already undertaken some projects to promote partnerships along these lines, such as the 2007 BMA Declaration of Cooperation on Alleviating Global Warming Problems, with 36 private and public sector signatories. In addition, in 2008 it implemented a 'canal water quality improvement' campaign to raise awareness of the importance of canal environments, with the participation of local canal side communities. Independent institutes such as the Asian Disaster Preparedness Center have also launched community-based disaster preparation programs.

3.3 Findings of Manila study

The study carried out in Metro Manila selected two study areas, Marikina and Pasig City. Household and commercial surveys, key informant interviews, FGDs and secondary data sources have revealed the following impacts of 2009 floods on the households in the two cities:

- Majority (90 percent in Marikina City; 71 percent in Pasig City) asserted that they suffered highly from the Ondoy floods in 2009. On the average, the flood waters in their homes reached an average of 20 ft., while in some it reached the maximum height 30 ft. in 2009. But of the two cities, Marikina had suffered more with 75 percent of their dwelling structures fully or partially damaged while only 35 percent of Pasig had suffered the same.
- Most (81 percent) of their major repairs and reconstruction were concentrated on adding and repairing/repainting the floors, walls, and roofing of their homes while the rest (19 percent) either constructed a new home, fixed their plumbing, drainage system and toilets.
- On the average, it took them 30 days to complete the repair and reconstruction of their homes, with a small minority (10 percent) unable to do so because of not having the resources to do it or were prevented by the authorities to reconstruct their homes as these were located in danger zones.
- In Marikina, affected residents spent an average of (Pesos) P141,000 compared to P12,000 in Pasig City to repair their damaged homes and appliances. The disparity is due to the fact that extreme flooding in Marikina hit more upper/middle-income households while in Pasig City the extreme floods (in terms of height and length) devastated mostly low and middle-income households.
- In terms of losing household assets, almost half (45 percent) of the surveyed households reported having lost severely, while 30 percent lost mildly and 16 percent had negligible losses.
- On the average, 30 man-days were lost by the residents in 2009 because of the flood damage to their homes, basic services, and infrastructure (roads, bridges and water channels). Water supply was interrupted for 22 days and electricity could not be delivered for about a month (Marikina) and 14 days (Pasig).
- Children's schooling also suffered with about 70 percent of the households unable to send their children to school.
- In terms of income loss, the respondents averaged losing P21,000 per household (average salary of public school teacher is P10,000) with some reaching P500,000 income loss due to Ondoy floods.
- Most (almost 80 percent) of the respondents suffered from coughs/colds and fever due to the floods. About 40 percent complained of diarrhea and stomach ailments. On the average, they spent P6,517 for medical expenses, with some families spending a maximum of P70,000 during the Ondoy floods.

Below is a comparative summary of costs and losses (Table 9 and 10) incurred prior, during, and after the Ondoy floods based on the recollection of respondents during FGDs.

Table 9: Costs due to floods in Marikina and Pasig city during 2009 floods

Summary of Costs/Losses Due to Floods (monthly)

	Pre-Ondoy		Ondoy Period		Post-Ondoy	
	Men HH	Women HH	Men HH	Women HH	Men HH	Women HH
Absences from school	6	8	14	17	6	7
Number of workdays lost from sickness due to flood	5	7	9	10	5	8
Number of work days lost due to flood	6	8	20	22	6	9
Average income loss due to floods	P1,715	P3,250	P7,250	P6,450	P2,750	P3,400
Average amount of spent on medicine	P300	P400	P3,200	P3,000	P500	P450
Average losses (appliances, etc.)			P25,000	P20,000		
Average income	P6,250	P5,000	-	-	P6,500	P4,200

Table 10: Costs of basic needs in Marikina and Pasig city during 2009 floods

Summary of Costs of Basic Needs/Services (in pesos, monthly, US$ 1=P43)

	Pre-Ondoy		Ondoy Period		Post-Ondoy	
	Men HH	Women HH	Men HH	Women HH	Men HH	Women HH
Food	P6,000	P5,800	P2,500 + relief goods	P2,000 + relief goods	P6,500	P6,000
Water						
• Drinking	P50	P45	P240	P240	P60	P50
• Cooking/washing utensils	P80 (well) P500 (piped)	P80 (well) P550 (piped)	P80 (well, long lines) P1,500 (piped)	P80 (well, long lines) P1,500 (piped)	P80 (well) P740 (piped)	P80 (well) P700 (piped)
Energy/electricity	P2,000	P1,800	P5,000	P4,500	P2,000 (wet) P3,000 (dry)	P1,800 (wet) P2,500 (dry)
Sanitation/Laundry (mud, waist deep; cleaning – 2 weeks – one month)	P300	P310	P2,000	P2,000	P360	P320
House repair			P1,500 – P15,000	P1,000 – P8,000		

In case of commercial establishments, the survey targeted 100 establishments (50 in each city) but processed only 85 research protocols. With regards to damages to their buildings and properties, the respondents reported an average of P85,316, while damages to equipment, appliances and furniture amounted to a median average of P100,000. Their expenses for repair for buildings amounted to median average of P10,500. Meanwhile, their expenses on repairs of equipments/appliances amounted to a median average of P50,000. After the floods, other costs involved disinfecting, sanitation and rehabilitation. The respondents reported spending a median average of P5,000. Flood fighting/control costs on the other hand, yield a median average of P37,500. Costs of removing debris from the premises amounted to a median average of P8,000. Meanwhile, the respondents reported a median average loss of net income due to flood interruptions of P50,000. Total annual revenue lost to floods had a median average of P225,000. Majority (96 percent) of the establishments stopped work or closed operation because of damage to physical structures, equipment and/or their places remaining inaccessible due to the floods. The average time needed to recover was 1-2 months.

Most of the responses coming from households can be categorized into the following: 1) physical-structural adjustments, and 2) changes in lifestyles and habits. About one-third added a floor or raised the floor and strengthened the foundation of their homes. They also moved the storage of goods, valuables, and irreplaceable goods to a higher level so these won't get wet or damaged. They also become more diligent in cleaning their surrounding canals/drainage channels for garbage/debris.

Overwhelming 83 percent surveyed households claimed to have been assisted by the local/city government with food and clothing. In case of manufacturing sector, many relocated their activities to other parts of the city where flooding is less likely to occur. This was a strategy adopted by large commercial and industrial establishments in the city. For those who remained or did not relocate, they just strengthened their buildings or build upper floors where they conduct their business. Meanwhile in Pasig, most of the factories were compelled by the City Environment Office (CENRO) to follow safety standards.

As regards the immediate and medium-term responses of the city/local government are concerned, these can be summarized into: 1) evacuation, 2) restoration of basic services and 3) rebuilding of infrastructural support. Also, in Marikina City, communicating the risk of city flooding is now very much institutionalized in their early warning system, indicated by the siren signals according to the water level in the Marikina bridge. Meanwhile, Pasig City has also installed an early warning system communicated through the city's disaster risk reduction management (DRRM) council and to the barangay/community DRRM counterpart bodies.

Given the challenges and learnings from the disastrous events of 2009, several policies and programs were enacted by the Congress. Two overarching frameworks for adapting to climate change were crafted, the 2010 National Disaster Risk Reduction and Management and the 2011 National Framework Strategy on Climate Change. Each was drafted in compliance with the law by virtue of the "Philippine Disaster Risk Reduction and Management Act of 2010" and the "Climate Change Act of 2009". The first provides for the creation of the National Disaster Risk Reduction and Management Council; the second, for the Climate Change Action Plan approved for implementation by President Benigno Aquino III towards the end of November 2011.

Similarly, Disaster Risk Reduction and Management Act of 2010 was signed, amending the 30-year old Presidential Decree 1566. This law mandated that each city/municipality must have a disaster risk reduction and management plan. Meanwhile the Climate Change Action Plan made the first law more actionable by specifying the programs to be implemented by the Climate Change Commission and the other agencies of the Aquino government.

3.4 Enhancing adaptation through response measures

As seen in the previous sub-sections, both government and citizens have responded to the threat of floods by undertaking a variety of short to medium-term measures in the three cities. The important issue to be discussed here is whether and how far do these response measures add to the existing adaptation capacity and would they succeed in enhancing the adaptation capacity in the long-term. We discuss here the important issues related to adaptation capacity in the three cities.

As for **Mumbai**, there are a number of issues related to public and private response measures that need to be highlighted here:

- BRIMSTOWAD is a major policy initiative that is expected to improve the existing and age-old storm water drainage system in Mumbai and replace it with the one that will be much more effective in dealing with greater intensity rainfall. Once the project is implemented completely, it is expected to improve the flood situation in Mumbai as the new system is being designed for 50 mm rainfall per hour instead of 25 mm per hour design currently in place. Also, the project has been designed for the runoff coefficient of 1 instead of 0.5 due to the land use changes that have occurred in the city in past few decades. Thus BRIMSTOWAD is expected to increase the adaptation capacity of the city for flash floods caused by heavy intensity rainfall in future.
- However, if an extreme weather event like July 2005 were to occur again in the next few decades, even the design criteria used under BRIMSTOWAD will not be enough to cope with the ensuing floods in low-lying areas. Thus, we need to note this that the residual impacts of the weather events would still be faced by the city and cannot be done away with completely.
- In addition to revamping the storm water drainage network, MCGM has started clearing clogged drains every year before monsoon. Regular widening and desilting of drains is undertaken. However, there are multiple agencies involved in this, such as, MMRDA, Public Works Department, Railways, Mumbai Port Trust and Airport Authority of India. Unless there are coordinated and well synchronized efforts undertaken by these agencies, isolated efforts will not help in the long-run to cope with floods.
- As regards the disaster management plan formulated by the local authorities, the plan is quite comprehensive and defines the role of different stakeholders as seen in the earlier discussion. However, the plan is generic in nature and has less operational value as pointed out by the fact finding committee. Also various planning and implementing agencies in Mumbai often operate as islands making it difficult to have a well coordinated response in case of disasters or weather events.
- There are a number of steps taken up by the civic authority, MCGM in recent years based on the recommendations of the fact finding committee, to improve the disaster response and management. Accordingly, the rainfall data are now available with the automatic weather stations for 15-minute interval which can be used to issue early warning to ward control rooms. This will improve the response and coping capacity in the long-run. The 15-minute interval rainfall data over a number of years in future can also be used to analyze the intensity and pattern of rainfall in the city and early warning systems and response measures can be improvised accordingly.
- The early warning system currently being used by the control room looks effective on paper. Regular information regarding rainfall intensity and traffic diversion is given to the general public through the website maintained by the MCGM. Yet, the awareness levels regarding such systems are very poor. For example, our primary survey reveals that 91% households did not even know about the DMC and 99% were not aware of the website that gives out such information. 88% were not aware of the emergency contact number. Thus, awareness-building is the key to making early warning systems effective and add to the coping capacity in future.
- Measures related to infrastructure improvements would require a longer time frame given the socio-economic and political dynamics in the city. Also, the land use policies and planning will not be effective unless they are coupled with strategies to deal with slum settlements and

migrants into the city. The experience of the city dwellers in the aftermath of 2005 floods only shows that the city administration and other stakeholders would need more specific strategies and an integrated approach to build resilience of the city to climate risks.

- As for the planning process, development planning takes environment into consideration at the generic level. But climate risks and associated impacts of heavy precipitation, sea level rise and storms are uncertain and varied in nature. What is needed is more scientific knowledge base related to such risks, their impacts on the city and technical knowledge related to how we can mitigate and adapt to such risks. This would increase the possibility of mainstreaming climate risks and adaptation into the planning process.
- As regards the efficacy of private response measures in enhancing the adaptation capacity to deal with floods in the long term, it is too early to evaluate this given the information we received through the primary survey. It must be noted that these responses are strictly private in nature with individual initiative and without any public or government intervention in it. As such there are no benchmarks to evaluate how efficient these responses are.

In case of **Bangkok**, the following issues need to be highlighted here:

- Given different strategies adopted by the authorities for flood control in the aftermath of 2006, the unprecedented flooding in 2011 have clearly shown that much more needs to be done to enhance adaptation capacity of the city in the long-term. As the fieldwork for this study was concluding, the city was presented with one of the worst extreme flood events. According to the Federation of Thai Industries, the cost to the seven hardest hit industrial estates could reach $13 billion, involving 891 factories and 460,000 workers.
- While there is no room in this study to examine the extreme flood event of 2011, it is worth noting a number of elements that highlight the persistence of many key issues.
    - The official response to the flooding was sharply criticized for its lack of institutional coordination, the divisive relationships between different agencies and the strong degree of politicization that accompanied relief efforts.
    - While some institutional reforms have been made since 2006, the overall challenges of fragmented governance were still apparent.
    - In today's context, when Bangkok is a sprawling metropolis with much of its population and industry concentrated in the suburbs outside its core, the strong focus on securing the city centre does little to alleviate the suffering of hundreds of thousands of the city's residents.
    - The protection of inner Bangkok was regarded as coming at the expense of other neighborhoods that were forced to suffer deeper and more prolonged bouts of flooding as a result.
- To be effective, adaptation strategies must be supported by adequate and multidimensional data. Previous risk assessments have been hampered by information shortfalls, ranging from a lack of baseline climate data to the marginalization of non-technical considerations such as socioeconomic vulnerability, water security and health profiles. Data gathering should also include a localized focus, as in this study, on the specific circumstances of individual districts.
- The dysfunctional nature of the city's flood management must be addressed through national and municipal governance reform. This should resolve a broad range of ongoing challenges, including poor institutional coordination, deficient city planning, funding constraints, poverty-related vulnerability and building code development.
- The flood protection strategy will also necessarily require a site-specific perspective and potentially the decentralization of some authority to districts and communities.
- Meaningful stakeholder participation is essential, drawing on the widest possible range of actors. This should include not only the various responsible public sector bodies, but also local communities and the private sector.

- Flood protection measures must develop a long term planning vision. Too much effort is expended on reactive measures once flood events have already occurred, with limited preparation or anticipation of projected future trends. Furthermore, strategic directions are often only partially or inconsistently implemented, as with development restrictions in the eastern areas of Bangkok where the study districts are located.
- Flood protection strategies must consider not only the technical and economic implications of flooding, but also the social and human dimensions. Flooding has been widely regarded in the past as a water management issue, rather than a complex phenomenon that impacts livelihoods, urban development and other fields.
- Even in the aftermath of the 2011 flood, the BMA's flood prevention plan still appears to concentrate primarily on infrastructure development in both the short and long term. Yet the risks of flooding are not only environmental, but socioeconomic in nature.
- Flood prevention therefore requires an integrated approach that spans health, waste management and the dynamics of agglomeration economies.

For **Manila**, the following issues regarding adaptation need to be highlighted here:

- Floods and storms continue to cause severe economic damage to Philippines as evident from repeated flood events, the latest one in December 2011. Thus, the fundamental lesson that has to be inscribed into people's life-ways and institutions is the urgent need to develop a culture of disaster prevention, mitigation, adaptation and safety behavior.
- But Philippine society, especially government institutions, is not able to effectively fulfil the responsibility in implementing the required engineering, land zoning, infrastructure planning and sustainable relocation of people.
- Commercial and other private sector interests and informal settlers continue to build over, across, beside waterways or in mountain slopes/hills that obstruct, constrict and deflect water/river flows.
- As far as relocation as a strategy is concerned, majority of commercial establishments who refuse to follow safety standards imposed by the city have moved to cities that are not so strict in imposing restrictions. Overall, this poses problems when considered at the macro level, because local government units (LGUs), in order to attract business often relax the compliance standards.
- In case of households, making people move constitutes the most challenging task for LGUs as most residents do not want to leave their homes because of theft/loss of belongings. They would rather climb up to the ceilings/roofs of their houses than move.
- It is apparent from the focused group discussions that the design of the recovery and reconstruction program must be transparent, accountable and must deliver evidence-based results and outcomes. Also, the approach must be community-based, people-centred and equitable and should focus on reduction of future risks in recovery and reconstruction.
- The crafting of local risk reduction and management plans at the barangay (community), city, and provincial levels provide a very promising scenario. These local plans drawn locally and elevated to the city level make design strategies contextually-specific and more appropriate, responsive and effective for local needs.
- The findings of this study suggest the need for a bottom-up process where the particular environmental and social-political-economic vulnerabilities of the affected communities are integrated in the "Local Climate Action Plans" and the "Local Disaster Risk Reduction and Management Plans" which builds into an integrated "Municipal/City Climate Action Plans" and "Municipal/City Disaster Reduction and Management Plans".
- These vulnerabilities should also be calibrated well at the governance level, thus moving towards water-based urban design, vertical urbanism and green economy, technologies and architecture can be programmed or mainstreamed into urban development.

4.0 Conclusion

As stated earlier, this research project undertakes an analysis of the immediate to medium-term post-disaster recovery scenario in the aftermath of extreme weather events of flooding faced by vulnerable cities in three Asian developing countries, namely, Mumbai (India), Bangkok (Thailand) and Manila (Philippines). The project has developed three case studies for the selected cities. Each of the studies have measured the physical, economic and social impacts of selected extreme weather events of flooding, identified the public and private responses in the short to medium-term and explored their policy implications for long-term adaptation capacity, city resilience and investment and development plans.

Each study is based on the analysis of primary and secondary data pertaining to the selected events of flooding and their resultant physical, economic and social impacts. The impacts considered here include loss of life, injuries, damage to property and infrastructure, damage to economic stocks like physical capital, inventory and indirect impacts on flow variables like income, investment, employment and disruption of essential services. After measuring these impacts, the analysis has focused on the immediate to medium-term post recovery scenario, wherein, we have examined the responses of the civic administration as well as citizens themselves to cope with future floods. The findings have significant policy implications for integrating adaptation strategies with long-term investment and development plans for the cities at risk. This exercise is particularly relevant to these cities belonging to the developing world, where natural disasters have long-term implications for not only economic development but poverty alleviation as well.

The main objectives of the research project are:

1. Analysis of immediate to medium-term impacts and responses in the aftermath of extreme events of flooding faced by three coastal cities, Mumbai (India), Bangkok (Thailand) and Manila (Philippines)
2. Examine the effects of short to medium-term responses to extreme events on enhancing the long-term adaptation capacity of these cities
3. Explore the policy implications of the findings for long-term disaster management, city resilience and long-term development plans

In order to achieve the objectives, the following activities were carried out under the project:

1. Developing a common methodology in the inception workshop held in December 2010 to identify and measure the immediate to medium-term impacts of selected weather events resulting in flooding in the three cities.
2. Measuring physical, economic and social impacts of floods with particular focus on stock and flow variables using primary and secondary data
3. Examining the short to medium-term responses of local government institutions and the community at large including households and private sector
4. Exploring the linkages of the response measures to adaption capacity in the long-term and policy implications for development planning and city resilience
5. Initiating the process for integrating post event recovery strategy with investment and development plans through stakeholder workshops that would lead to long term reduction in vulnerability and enhancement of adaptive capacity in the three cities

The project findings in the three cities highlight their vulnerability to climate risks due to their geographic location, flood prone topography, large population with a major percentage living a life of poverty in informal settlements, changing land use pattern, rapid infrastructure development often by reclaiming land from sea (as in case of Mumbai) and inadequate civic amenities. The study has examined the physical, economic and social impacts of selected extreme weather events leading to flash floods in the three cities. An important finding is that the huge monetary costs of these impacts are the uninsured losses borne by households belonging to poor strata of society and the private sector mostly engaged in informal activities. The study also examines the responses of local government institutions as well as people to cope with flooding. There are a number of public and private adaptation strategies that have been identified in this report. A significant finding is that all private initiatives and responses are a direct out-of-pocket expense for the concerned individuals or establishments. There is virtually no insurance cover that helps them to deal with the adverse impacts of floods and bring about changes or improvements in the existing infrastructure. Some of the public and private responses have the potential to enhance the medium to long-term adaptation capacity of the city to cope with future floods. However, there is a need to address the larger issues of climate risks and adaptation in the long-term development planning for the cities

Overall, the project has achieved its stated objective of analyzing the short to medium-term impacts and responses in the aftermath of extreme weather events leading to floods in the three cities. The case studies developed here further examine if the response measures undertaken by both local administration and communities has the potential to enhance the adaptation capacity of the city in the long-term. There are critical policy implications of the findings of this study, in particular, the huge monetary burden of the impacts of floods which is borne by the community in the absence of insurance coverage and other compensation or aid. Responses also mean the cost related private adaptation. Such private costs, especially the costs borne by the poor and vulnerable sections in these cities and informal sectors often go unaccounted for in usual damage impact assessment studies.

This research project in a way highlights the cost of inaction if very little is done in future to enhance the coping capacity of the cities for future weather events and climate risks in general. The project puts forth a convincing argument that adaptation strategies need to become a part of mainstream planning while devising strategies of developing infrastructure, housing, transport network and other facilities and services in the city. Although adaptation is costly, the costs of inaction can prove to be costlier. Hence, there is a need for integrated and coordinated efforts from all agencies including local government, planners, public utilities and community at large to work towards greater adaptation to future climate risks for the city.

5.0 Future Directions

The findings of the project are quite relevant for the three cities which are in transition and on a development path. It is extremely important that these findings are shared with the larger audience of policy makers, academia and local community to initiate a meaningful dialogue on climate risks, general perceptions about the adaptive capacity and how adaptation can be mainstreamed into policy processes. Therefore, the project should culminate in journal articles as well as be presented in different forums to make it more relevant.

We envisage the following logical steps to take this research theme further:

- There is a need to study the policy processes further, especially the formulation of development and investment plans in the cities to understand how climate risks and adaptation can be incorporated into these plans.
- There seems to be a communication gap among scientific community, technocrats and designers, urban planners, disaster management specialists and public representatives as far as future climate risks faced by cities, their potential impacts, required defense mechanism and preventive actions. We need an integrated project where these stakeholders are brought together as a part of a capacity-building exercise and their perspectives are shared to decide the future course of action as far as mainstreaming adaptation is concerned.

6.0 References

1. ADB/JICA/World Bank (2010). Climate Risks and Adaptation in Asian Coastal Megacities, p.23. Retrieved at: http://siteresources.worldbank.org/EASTASIAPACIFICEXT/Resources/226300-1287600424406/coastal_megacities_fullreport.pdf
2. Bankoff, Greg. (2003) Constructing Vulnerability: The Historical, Natural and Social Generation of Flooding in Metro Manila *in* Disasters 27 (3): 95-109.
3. Birkmann, Jorn (2009). Assessing Vulnerability in the Context of Multiple-Stressors. United Nations University, Institute for Environment and Human Security
4. Blaikie et al. (1994) At Risk: Natural Hazards, *People's Vulnerability and Disasters*. London: Routledge.
5. Cited in Panya Consultants (2009). Climate Change Impact and Adaptation Study for Bangkok Metropolitan Region, p.x. Retrieved at: http://siteresources.worldbank.org/INTTHAILAND/Resources/333200-1177475763598/3714275-1234408023295/5826366-1248255995902/full-report.pdf
6. Cruz, R.V., H. Harasawa, M. Lal, S. Wu, Y. Anokhin, B. Punsalmaa, Y. Honda, M. Jafari, C. Li and N. Huu Ninh, 2007: Asia. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of theIntergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 469-506.
7. Dutta, D. (2011). An integrated tool for assessment of flood vulnerability of coastal cities to sea-level rise and potential socio-economic impacts: a case study in Bangkok, Thailand. Hydrological Sciences Journal, 56(5).
8. Hallegate, S. et al. (2010), " Flood Risks, Climate Change Impacts and Adaptation Benefits in Mumbai: An Initial Assessment of Socio-Economic Consequences of Present and Climate Change Induced Flood Risks and of Possible Adaptation Options", OECD Environment Working Papers, No. 27, OECD Publishing. doi: 10.1787/5km4hv6wb434-en
9. Hallegatte S., Coastal Cities, Climate Change Vulnerability and Adaptation, OECD Project led by Jan Corfee-Morgot, available at www.oecd.org/dataoecd/31/34/44104953.pdf
10. Hallegatte, S. et al. (2010), "Flood Risks, Climate Change Impacts and Adaptation Benefits in Mumbai: An Initial Assessment of Socio-Economic Consequences of Present and Climate Change Induced Flood Risks and of Possible Adaptation Options", OECD Environment Working Papers, No. 27, OECD Publishing. doi: 10.1787/5km4hv6wb434-en
11. IPCC (2001): Climate Change 2001: Impacts, Adaptation and Vulnerability: Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press.
12. Klein, R.J.T. and R.J. Nicholls. 1998. Coastal zones. In Handbook on Methods for Climate Change Impact Assessment and Adaptation Strategies, I. Burton, J.F. Feenstra, M.L. Parry, J.B. Smith, and R.S.J. Tol (eds.). Version 2. United Nations Environment Programme and Institute for Environmental Studies, Amsterdam, pp. 7-1 to 7-35.
13. Marome, W.A.(2011). *Improving the Characterization of Impact Variables to Extreme Flood Events: A Case Study of the Flood 2006 in Bangkok*. CARII: Building Adaptive Capacity for Managing Climate Change Risks in Coastal Cities. Retrieved at: http://start.org/download/car2/1-marome.pdf
14. MCGM (2006), Fact Finding Committee on Mumbai Floods , Final Report, Volume I, March 2006
15. MCGM (2010), Flood Preparedness Guidelines 2010, www.mumbaimonsoon.com
16. MMRDA, (2007) Basic statistics on MMR, Mumbai Metropolitan Region Development Authority, http://www.mmrdamumbai.org/basic_information.htm
17. MPCB, (2005), Report on Environment Status of Mumbai Region, Maharashtra Pollution Control Board, Government of Maharashtra

18. Nicholls, R.J., Hanson, S., Herweijer, C., Patmore, N., Hallegatte, S., CorfeeMorlot, J. Chateau, J. and Muir-Wood, R. (2008). Ranking Port Cities with High Exposure and Vulnerability to Climate Extremes. OECD Environment Working Papers No. 1.
19. Nitivattananon and Noonin (2008). Citied in Bangkok Metropolitan Administration, Green Leaf Foundation and United Nations Environment Programme (2009). *Bangkok Assessment Report on* Climate Change 2009. Bangkok: BMA, GLF and UNEP
20. OECD (2008), Ranking Port Cities with High Exposure and Vulnerability to Climate Extremes: Exposure Estimates, Environment Working Papers No. 1
21. Panya Consultants (2009). Climate Change Impact and Adaptation Study for Bangkok Metropolitan Region, p.x. Retrieved at: http://siteresources.worldbank.org/INTTHAILAND/Resources/333200-1177475763598/3714275-1234408023295/5826366-1248255995902/full-report.pdf
22. Porio, Emma. 2010. Vulnerability on Flooded Riverlines in Urban Philippines: The Case of Metro Manila. Paper presented in the Regional Conference on Environments of the Poor, Asian Development Bank, Oct. 25-27. Forthcoming in the "Environments of the Poor", Institute of Southeast Asian Studies, Singapore.
23. Porio, Emma. 2011. Vulnerability, Adaptation, and Resilience to Floods and Climate Change-Related Risks Among Marginal, Riverine Communities in Metro Manila. In Journal of Asian Social Science 39: 425-445. Brill Publishers (Netherlands).
24. Sherbinin A., Schiller A. and Pulsipher A., (2007), The Vulnerability of Global Cities to Climate Hazards, Environment and Urbanization, Vol. 19(1), Sage Publications on behalf of International Institute for Environment and Development
25. Tohiguchi, M. et al. (2002). *Transformation of the canal-side settlements in greater Bangkok.* Journal of Architecture, Planning and Environmental Engineering, 55(1). Retrieved at: http://sciencelinks.jp/j-east/article/200207/000020020702A0169635.php
26. Winters, Paul, et al (1998). Economic and Welfare Impacts of Climate Change on Developing Countries *in* Environmental and Resource Economics 12: 1-24.
27. World Bank (2004), Understanding the Economic and Financial Impacts of Natural Disasters, Disaster Risk Management Series No. 4, The World Bank, Washington DC
28. World Bank (2009). *Climate Change Impact and Adaptation Study for Bangkok Metropolitan Region*, p.xi. Retrieved at: http://siteresources.worldbank.org/INTTHAILAND/Resources/333200-1177475763598/3714275-1234408023295/5826366-1248255995902/executive-summary.pdf
29. World Bank (2009). Philippine Typhoons Ondoy and Pepeng: A Joint Assessment. Sector Reports. Typescript. 77 pp.
30. Yusuf, A. and Francisco, H. (2009). Climate Change Vulnerability Mapping for Southeast Asia. Economy and Environment Program for Southeast Asia.

7.0 Appendices

7.1 Case study of Mumbai

Enhancing Adaptation to Climate Change by Integrating Climate Risk into Long-Term Development Plans and Disaster Management: The Case of Mumbai, India

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1. Introduction

Mumbai (formerly known as Bombay) is one of the largest mega cities in the world in terms of population and is currently ranked 4th after Tokyo, Mexico City and New York1. The city is the financial capital of India with a large commercial and trading base. It plays host to a number of industries, multinational companies and important financial institutions. With per capita income thrice that of the national average, Mumbai makes huge contribution to the total tax revenues of the country. The city is an important international sea port and strategic for the country from defence perspective. Unfortunately, Mumbai is also acutely vulnerable to climate risks due to its location on the sea coast, flood prone topography and the landmass composed largely of reclaimed land. Also, the most vulnerable section among the residents is the slum dwellers and squatter communities in the city that comprise more than 60% of the total residents as per the preliminary estimates of the 2011 census. Therefore, it is critical for the city to assess the vulnerabilities and devise adaptation strategies to cope with future climate risks.

In recent years, Mumbai has been experiencing many weather events, including the extreme weather event in July 2005 that led to unprecedented floods, massive damages, loss of life and property and affected the economic and social activities adversely. Such loss of physical, economic and financial capital, while important in itself, leads to a loss of economic and social services over a longer-term. Extreme weather events tend to have long-term consequences for economic development and poverty alleviation in the city and can potentially alter the development trajectory permanently. Accompanied by physical, economic and social vulnerabilities in cities like Mumbai is their low adaptive capacity due to constraints on physical, financial and human resources.

It is now widely accepted that impacts of future climate change will often be observed through changes in the magnitude and frequency of existing climate-related hazards in the form of extreme weather events. Therefore, disaster risk reduction and disaster management is an important context for integrating or mainstreaming adaptation into decision-making for the cities at risk. With this in view, the present study has been undertaken to assess the vulnerability of the coastal city of Mumbai to climate change in general and heavy precipitation events in particular. The study seeks to understand the impact that such precipitation events and resultant flash floods tend to have on the households and commercial establishments in the city. It further seeks to evaluate the community and institutional responses to floods and current adaptation efforts. The ultimate aim of the study is to understand the implications of short-term responses and adaptation efforts for long-term development planning of the city.

1.1 Coastal megacity of Mumbai

Mumbai is located on the western seacoast of India on the Arabian Sea at 18053’ N to 19016’ N latitude and 720 E to 72059’ E longitude. Mumbai is an island outside the mainland of Konkan in Maharashtra State and is separated from the mainland by a narrow creek known as Thane Creek and a Harbour Bay. The city is surrounded on three sides by the sea: Arabian Sea to the West, Harbour Bay in the West and Thane Creek in the East. The height of the city is just 10-15 meters above the sea level in most parts. The city occupies an area of 468 square kilometres (sq. km.) and its width is 17 km. east to west and 42 km. north to south2. The entire region encompasses rich natural heritage, such as, hills, lakes, coastal water, forests, and mangroves, alongside built areas.

Greater Mumbai Region (GMR, referred to as Mumbai in the text) consists of 7 islands in the city area and 4 islands in the suburbs. The present day city is divided into two revenue districts, Mumbai City District, i.e, the island city in the South and Mumbai Suburban District comprising the Western and Eastern suburbs. As the original cluster of seven islands was joined to form the present city, a large part of the City and Suburban District is built on the land reclaimed from the sea. The coastline of Mumbai has been reclaimed for development purposes; e.g., areas like Cuff Parade and Mahim creek were wetlands, later reclaimed for residential and commercial uses. The new industrial, commercial and residential settlements have also developed along the reclaimed coastal areas which are low-lying and flood prone.

The Municipal Corporation of Greater Mumbai (MCGM) is the primary agency responsible for governance of the GMR or Mumbai city. The city is divided into different administrative zones known as 'wards' to facilitate the day-to-day functioning of the civic authority. The map of Mumbai city, including the location of different administrative wards is shown in Figure 1 below. MCGM has a long history in urban governance. It was the first municipal corporation established in India in the year 1882. Since then, the civic body has been responsible for the provision of civic amenities, education, public health, art and culture and heritage conservation in the city. MCGM holds the distinction of being one of the largest local governments in the Asian continent[3]. For administrative purposes, Mumbai Metropolitan region (MMR) has been designated to combine GMR and the surrounding areas of Thane, Navi Mumbai, Ulhasnagar, Mira Road, Vasai, Virar, Bhayandar, Bhiwandi, Karjat, Alibaug, etc. Mumbai Metropolitan Region Development Authority (MMRDA), set up in 1975, is responsible for planning and coordination of the development activities of this region. The total area of the MMR, excluding Mumbai city, is 3887 sq. km., with a population base of 5.90 million as per 2001 census[4]. These surrounding areas are significant for the economy and transportation services in Mumbai, as thousands of people travel everyday from these areas into the city for employment.

1.2 Description of the study

The present study analyzes the immediate to medium-term post-disaster recovery scenario in the aftermath of flooding caused by heavy intensity precipitation in Mumbai in July 2005. The study identifies the developmental impacts of this extreme weather event and explores their policy implications for long-term disaster management, city resilience and adaptation strategies. The study identifies the adaptation efforts undertaken by the local government and communities in the aftermath of July 2005 floods and assesses the potential for these efforts to enhance the adaptation capacity of the city in the long run.

The study uses both primary data collected from communities and primary and secondary data collected from government institutions pertaining to July 2005 floods, their resultant physical, economic and social impacts and response strategies taken up since then. The impacts include stock variables like loss of life, injuries, damage to property and infrastructure, damage to physical capital and inventory and health impacts as well as flow variables like loss of income, investment, employment and disruption of essential services like water and electricity. Similarly, response strategies are identified at both the institutional and community level. The study then focuses on the policy implications of the response efforts for disaster management, city resilience and adaptive capacity in the long-term. The study aims to bring out the long term policy implications for integrating adaptation strategies into long-term investment and development plans for the city.

The methodology used in the study is outlined here:

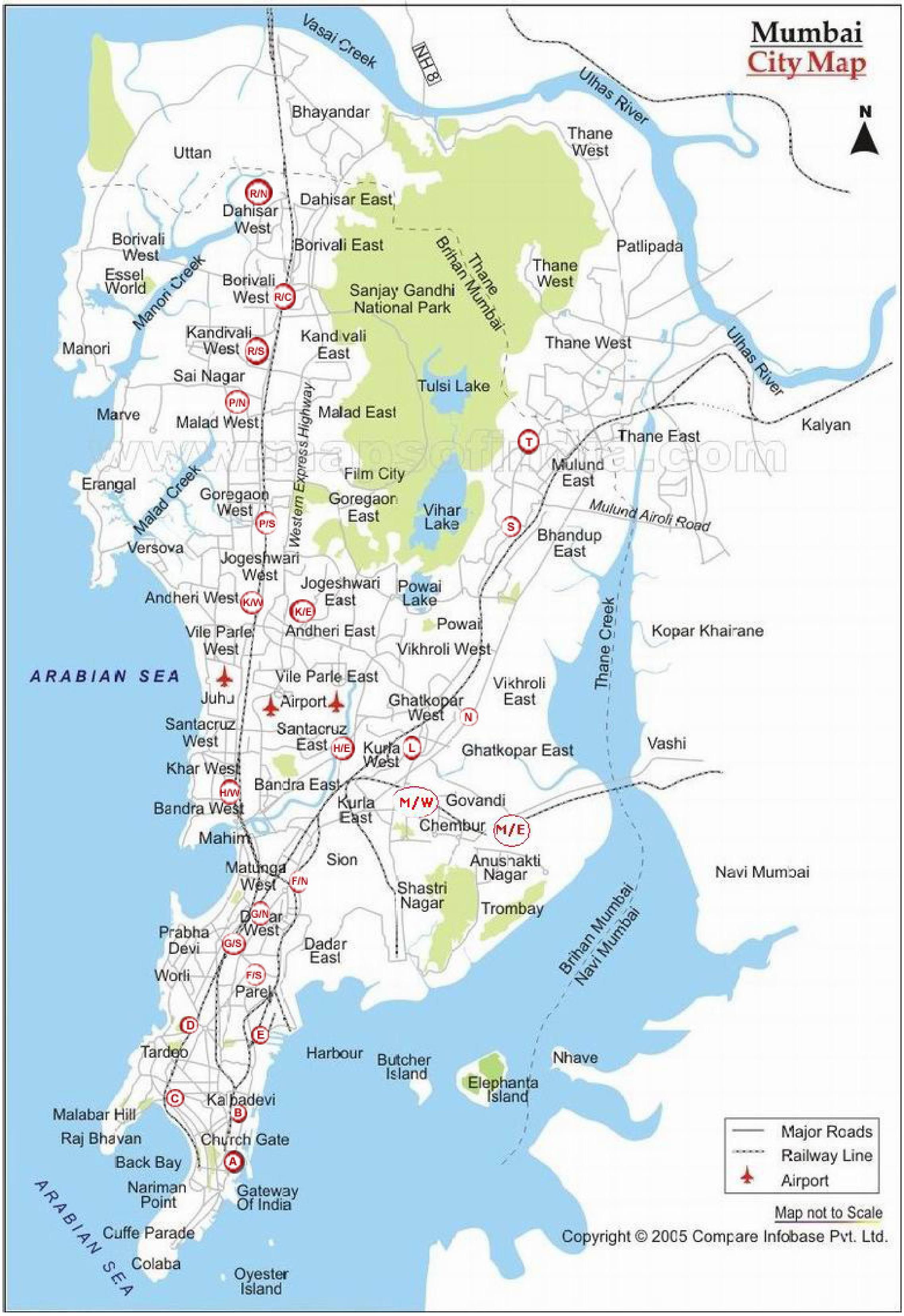
- **<u>Primary data</u>** collected from households and commercial and small industrial establishments in Mumbai by administering a detailed questionnaire Six flood prone wards in Mumbai – F North, F South, H East, K East, L and P North –selected for the survey and questionnaires administered to 1168 households and 791 commercial and small industrial establishments spread over the six wards. The sample selected from the six wards is given in Table A1 in the annexure. Further, the six ward maps with details like flooding spots, landslide prone areas, location of slums, etc. are given in the annexure.

- Survey questionnaires pertain to impacts of July 2005 floods, community and administration response, costs of damage and repairs/replacements, response measures undertaken in the aftermath of July 2005 and experience of subsequent flood events
- Special section on awareness of climate change added to the questionnaire to understand the climate risk perception among people
- Information collection through **Unstructured interviews** of selected local government officials working at the ward level, with Disaster Management Cell (DMC) and key planners. Details of the interviews are given in Table A2 in the annexure.
- personal interviews carried out based on open ended questions to understand their views on flooding events in Mumbai, climate risk perception, current adaptation events, level of preparedness and enhancing long-term coping capacity through short and medium-term measures undertaken by the local government
- **Secondary data** collected from the DMC and other sources within MCGM as well as a private sector electricity utility to understand the magnitude of impact on city infrastructure and provision of services, relief and recovery efforts, disaster management priorities and practices and overall development planning process

1.3 Outline of the report

The outline of the case study presented here is as follows. Section 2 takes an overview of reviews the physical, economic and social vulnerabilities in Mumbai city from the perspective of heavy precipitation and risk of flooding. This section presents the historical data on the rainfall pattern and resultant flash floods and takes an overview of weather/climate risks for Mumbai city. Section 3 describes the catastrophic event of July 2005 which witnessed unprecedented rainfall and flooding in Mumbai. The focus of the section is on the physical and economic impacts during the July 2005 floods. The information gathered through the primary survey of households and commercial and industrial establishments as well as secondary data from government sources is used here to understand the impacts on stocks and flow variables. The responses to floods including efforts taken up by local government institutions and communities are reviewed in Section 4. This section once again uses primary and secondary data to identify the response measures. Section 5 seeks to understand the efficacy of response measures in increasing the coping capacity of the city for future floods in the long-term and looks at the possibility of mainstreaming adaptation to climate risks into the development planning of the city. Section 6, the concluding section, summarizes the overall findings of the case study.

Figure 1: Map of Greater Mumbai Region



Source: http://www.mcgm.gov.in

2. Vulnerability and climate risks

The geographical location of the city and its physical, economic and social characteristics make the city more vulnerable to the threats posed by climate risks, such as, sea level rises, storms and floods. This section looks at each of these vulnerabilities in detail. The rainfall pattern as recorded by the weather stations since 1970s and the risk of flooding in the city is also described here. A number of studies have tried to project the climate risks for Mumbai, a review of which is brief undertaken towards the end of this section.

2.1 Physical and socioeconomic vulnerability

Mumbai, being on the seacoast, experiences a tropical savanna climate5,6 with a heavy southwest monsoon rainfall of more than 2100 millimetres a year in the monsoon season between June and September. The City District receives the average total annual rainfall of 2146.6mm, whereas, it is 2363.0 mm in the suburbs. The flash floods that led to the complete disruption of normal life in Mumbai in July 2005 were the result of an unprecedented rainfall of 944.2 mm on July 26th in the Suburban District7. Further, most parts of the present day city are built on the reclaimed land. The city is about 10-15 metres above sea level in many places8. The airport area is only 7.5 metres above sea level. Similarly major commercial and residential areas like Bandra-Kurla Complex, Wadala and Worli are low-lying areas. Thus, heavy precipitation often causes flash floods. There are 40 chronic flooding locations identified in the Greater Mumbai Disaster management Action Plan (DMAP) that are spread over the island city and eastern and western suburbs. These flooding spots are a worry for the civic administration as heavy precipitation often causes flooding in the local settlements and disrupts traffic and normal city life.

Being a coastal city, Mumbai is also prone to cyclones and gusty winds. There are a number of wards along the coast (Arabian Sea and Thane Creek) that are vulnerable to cyclonic impacts. For instance, in wards A – D, G-North, G-South, S and T, the (DMAP) has identified settlements that are acutely vulnerable to cyclones. There settlements were originally fishing communities, but are now home to many slums along the coast. Given the poor quality of construction material used by these homes, they are extremely vulnerable to cyclones and winds[9].

As per 2001 census, Mumbai has over 276,000 dwellings (residential, industrial and commercial) of which 60% are non-engineered constructions, which correspond with the large presence of slum settlements[10]. Such constructions are more vulnerable to extreme weather events. Many slum settlements, generally located on the hill slopes, bottom of hills or near abandoned quarries, face the risk of landslides usually occurring during heavy rains with gusty winds. DMAP identifies 117 such settlements which are extremely vulnerable to landslides, loss of life and damage to property in case of heavy precipitation.

Perhaps the most important factor enhancing the vulnerability of the city to climate risks is the ever growing population of Mumbai. The city population has grown steadily in the last 5 decades. There is a consistent growth from about 3 million in 1951 to 8 million in 1981 to 12 million in 2001 as per the Census figures, with the population density of about 30,000 per sq. km. [11]. As the financial capital of the country, Mumbai attracts a large workforce, which adds to the pressure on basic infrastructure, civic amenities and housing. It also leads to congestion, heavy vehicular traffic, growth in illegal slum dwellings, unhygienic living conditions and the problem of solid waste disposal.

Mumbai, with a large population to cater to, requires basic infrastructure in the form of a large transport network of railways and roadways. Thousands of people avail of this huge network every day. However, this massive network is not sufficient for a large population moving in a single direction during peak business hours. Most commercial activity is concentrated in the island city in the south. The movement between south and north for business purposes in the peak hours places a huge burden on the transport network. The road network has become very congested over the years with increasing number of vehicles and more people traveling to and from the city. For instance, people residing in surrounding areas of Mumbai, known as the MMR, use the railways and roads network to come to the city everyday for employment or business. In addition to this, Mumbai has an international airport located in the middle of the city, catering to more than 4 million international travelers and 4.2 million domestic travelers[12]. The massive transportation network is extremely vulnerable to weather events, as was apparent during the July 2005 floods and would suffer from massive damages and costs from flash floods, storm surges and sea level rises.

The preliminary estimates of Census 2011 suggest that 60% population in Mumbai lives in slums. Due to increasing costs of land and material, it has become virtually impossible for the poor and low-income households to acquire residential property in the city. As a result, the base of slum-dwellers has increased tremendously. Slums have mushroomed in almost all the wards of Mumbai, along the coast, on the hill slopes, along the highways, railways and in low-lying areas. Many settlements lack basic infrastructure like water, sanitation and legal electricity connections. They are non-existent on city's development plans. None of the 2335 settlements are recognized on the developmental plan of Mumbai and the land under slums has development plan reservations, even though some settlements have existed before development plans were formulated[13]. Further, regular displacements prevent slum-dwellers from settling in safe and secure localities and they move towards landslide prone areas, low-lying regions, and unsafe dumping sites.

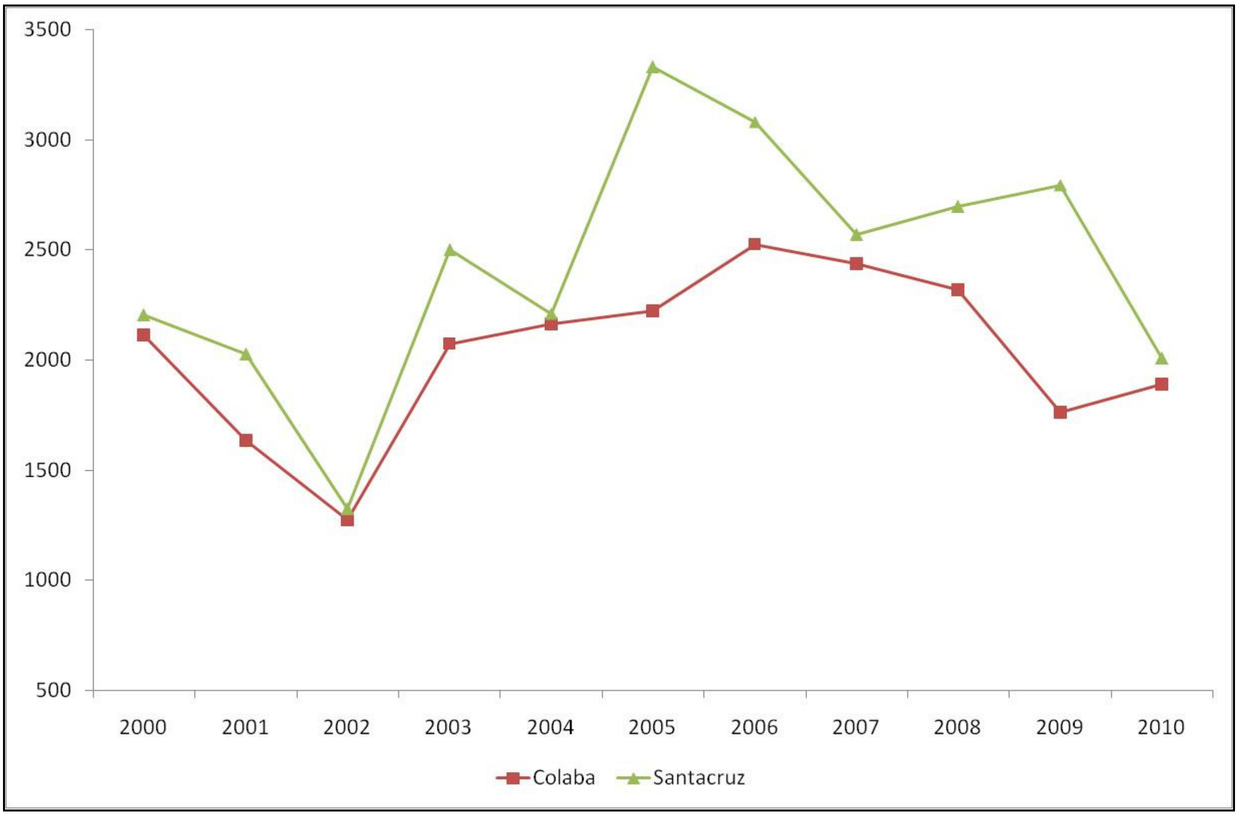
Given the increasing population and majority living a life of poverty and destitution, health vulnerabilities are imminent. As the Mumbai Human Development Report 2009 indicates, the overall life expectancy in Mumbai is much lower at 52.6 years for males and 58.1 years for females[14]. Tuberculosis (known as a poor man's disease), HIV/AIDS, Malaria and Jaundice are some of the major killers in the city. Infant mortality is 36.66 per 1000 live births and malnourishment is rampant among slum children. The city boasts of enviable health infrastructure compared to other Indian cities, yet the public health facilities are grossly insufficient to cater to such a huge population and in the event of a disease outbreak, the civic machinery does not have adequate infrastructure to deal with the health emergency. 75-80% population depends on relatively expensive private healthcare facilities for treatment and coverage of health insurance negligible[15].

As regards economic vulnerability, Mumbai has a pre-eminent position in the country as the commercial and trading base. The per capita income of city residents is twice that of Maharashtra State and thrice that of the national average[16,17]. Mumbai is also an important source of tax revenue for the country. In recent years, the share of tertiary sector in Mumbai's income has increased, whereas, the share of secondary sector has remained almost stagnant. Most industries in Mumbai are located in eastern and northeastern corridor with a few in the western region. The industrial units are in mixed areas as no buffer zone is provided for them. In fact, Mumbai was the first City Corporation to adopt the concept of a development plan under which industrial zones were allowed to be used for residential and commercial purposes[18]. Therefore, there is no clear distinction between residential, commercial and industrial zones for the city. The land use pattern in the city has also undergone major changes in recent years with the conversion of industrial areas into residential and commercial complexes. The climate vulnerability of Mumbai, therefore, means a threat to the life and property within the city, impact on the entire development trajectory and the economic loss for the entire nation.

2.2 Rainfall pattern and risk of flooding

As mentioned earlier, Mumbai receives an average of 2129 mm of rainfall per year during the monsoon season between June and September. The India Meteorological Department (IMD) records the cumulative rainfall for 24 hours at two weather stations, Colaba (located in island city) and Santacruz (Western suburb) and reports it through its weather bulletin every day[19]. The annual recorded rainfall at both weather stations between 2000 and 2008 is shown in Figure 2. As seen in the figure, in most years, especially after 2005, annual rainfall has exceeded the average. Since 2006, MCGM has installed 34 automatic rain gauges spread across all the wards, out of which 28 currently transmit rainfall data to the Disaster Control Room (DCR) with 15-minute interval[20]. However, the current database of 15-minute interval rainfall is not adequate enough as regards the time horizon to understand the precipitation pattern across different areas within the city.

Figure 2: Annual recorded rainfall in 2000-2010 in Mumbai



Source: India Meteorological Department, www.imd.gov.in

As per the IMD criteria, forecast of ***'heavy'*** rainfall is issued if the precipitation is more than 65 mm in a day and warning of ***'very heavy'*** rainfall is issued if it is more than 135 mm during the day[21]. The number of days of heavy and very rainfall between 2001 and 2008 is shown in Table 1 below. As the table indicates, heavy to very heavy rainfall is not uncommon during the monsoon season in the city. The days when the daily rainfall is above 65 mm are critical from the point of view of flooding in the city. In fact, very high rainfall of greater than 200 mm per day is also not uncommon during the onset phase of monsoon. The historical data going back to 1886 for Colaba and 1957 for Santacruz reveals that in any year, the probability of 24-hour rainfall exceeding 200 mm is 50% for Santacruz and 33% for Colaba[22].

Table 1: Intensity of rainfall in Mumbai (Number of days in a year)

Year	No rainfall	Below 65mm	65-135mm	135-200mm	Above 200mm
2001	23	94	6	2	-
2002	40	77	4	1	-
2003	18	92	9	3	1
2004	30	82	11	-	-
2005	32	79	7	4	3
2006	17	93	7	4	2
2007	19	92	8	1	2
2008	31	78	9	4	3

Source: MCGM, Disaster Management Cell

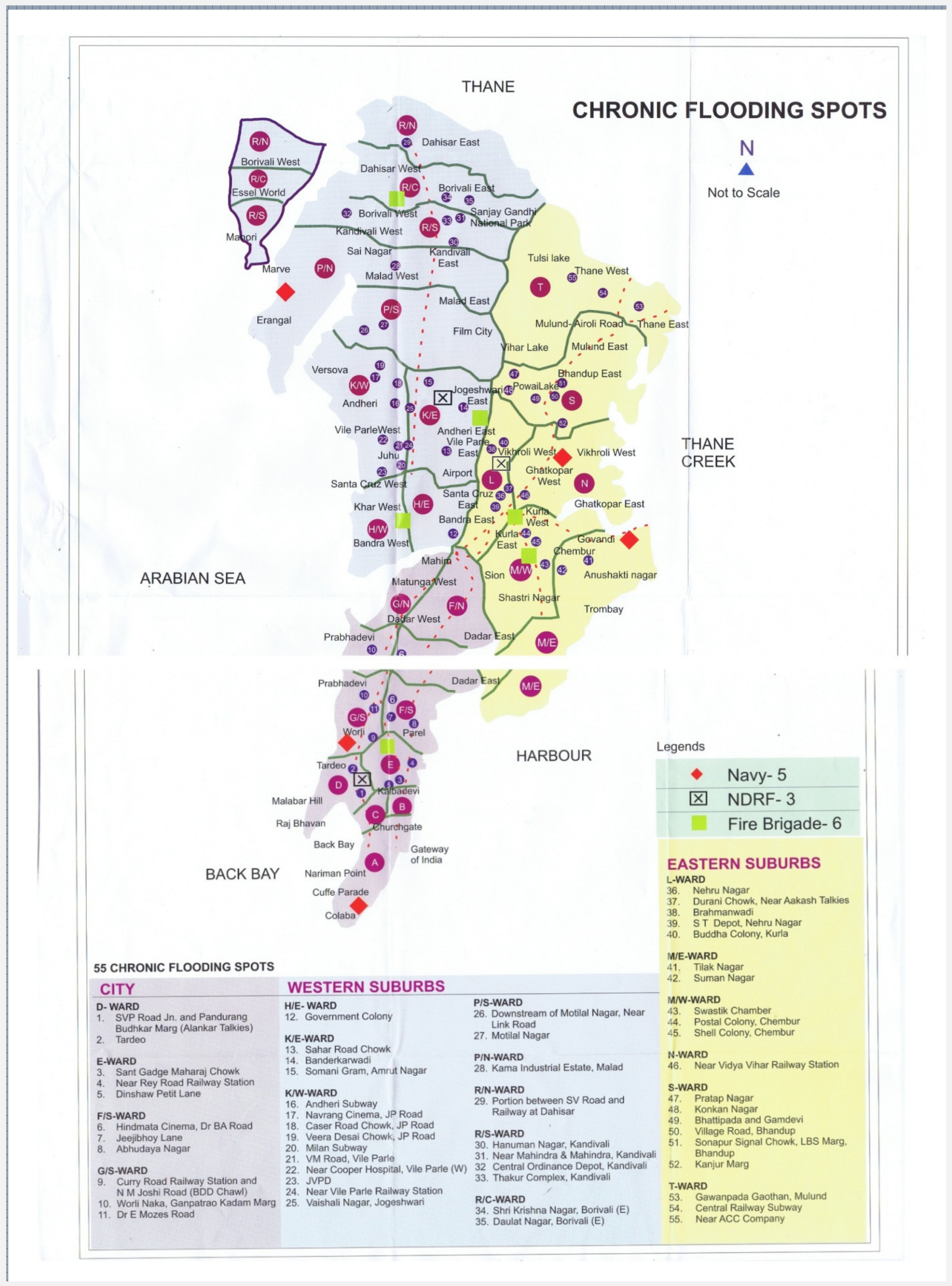
As discussed in the previous section, many low-lying and reclaimed parts of Mumbai are prone to flooding. The chronic flooding spots in the city have been identified by the civic administration depending on the past experience. They are shown in Figure 3 below. There are 55 chronic flooding spots spread over the island city and the suburbs. The flooding spots correspond to the low-lying areas, reclaimed areas and areas in the river flood plains. For instance, the flooding spots in the island city are low lying areas and also on reclaimed land with no natural drainage outlet. The central area is barely two to three meters above sea level and surrounded by hills. It is, thus, prone to flooding in monsoon. In the western and suburbs, major flooding spots are in the river flood plains. There are four main streams or rivers in Mumbai suburbs – Mithi, Dahisar, Poisar and Oshiwara. When the rainfall exceeds the retention capacity of their basins, floods occur in Mumbai suburbs. Mithi river has the largest catchment area and is the natural drainage system in the suburbs. Flooding caused by overflowing of this river can create major floods in Mumbai as seen during the extreme precipitation event of July 26, 2005.

The instances of flooding over the last decade are shown in Table 2 below. Flooding is believed to be dependent on the following factors[23,24]:

- Intensity and duration of the rainfall per hour,
- Timing of high hide
- Topography of the area, in particular, the height compared to the mean sea level
- Percentage of runoff and carrying capacity of storm water drainage (SWD) system

In recent years, DCR at MCGM has been recording rainfall from 28 rain gauges in different wards for a 15-minute interval. However, the time horizon of this database is as yet not sufficient and reliable enough to investigate the causal relationship between flooding and intensity and duration of rainfall and time of the high tide.

Figure 3: Chronic flooding spots in Mumbai



Source: MCGM (2010), Flood Preparedness Guidelines 2010, www.mumbaimonsoon.com

Table 2: Recorded instances of flooding in Mumbai

Year	Island city	Eastern suburbs	Western suburbs
2000	55	49	106
2001	85	46	93
2002	86	50	106
2003	86	41	123
2004	56	56	88
2005	90	91	190
2006	107	137	339
2007	66	25	70
2008	60	24	53

Source: MCGM, Disaster Management Cell

Compared to the other cities in the country, Mumbai has a well-designed but age old storm water drainage (SWD) system in place. This system was designed for the rainfall intensity of 25 mm per hour and a coefficient of runoff of 0.50. With rapid urban development and encroachment on natural water ways, the carrying capacity of the system has substantially reduced and the runoff has increased considerably. Therefore, the city has been getting flooded frequently. A number of studies and committee reports from Natu Committee Report in 1975 to IIT Bombay study to abate flooding at Milan Subway and Grand Road/Nana Chowk (two chronic flooding spots) in 2005, have tried to suggest remedial measures for flood abatement in the city[25]. The BRIMSTOWAD Report of 1993 has been an important study to identify potential improvement of SWD system in the city. The recommendations of this report are currently being implemented at least partially in the aftermath of the catastrophic event of July 26, 2005. The implementation of this report and implications for the SWD system in the city are discussed in detail in Section 4 of the study.

2.3 Future climate risk projections

The coastal location of Mumbai puts it at greater risk of sea-level rise, flooding, high winds, cyclones and coastal erosion. The city has regularly been facing weather events of heavy precipitation leading to floods and landslides during the monsoon season. On many occasions, heavy rains over the city have been the result of tropical storms or cyclones that hit the city or pass nearby. Studies carried out over the past decade indicate that Mumbai is likely to be highly vulnerable to climate risks with majority of its population living on the flood prone and reclaimed land. Estimates obtained in 2001 from the Goddard Institute for Space Studies[26] suggest that in the Canadian Climate Centre's business-as-usual emissions (A2) scenario and sustainable path (B2) scenario, the average annual temperatures in the city would increase by 1.75^{0}C and 1.25^{0}C respectively. Mumbai is also predicted to have an average annual decrease in precipitation of 2% for the A2 scenario and an increase of 2% in the B2 scenario. Perhaps, the most damaging scenario for the city is the predicted sea-level rise of 50cm by 2050[27]. Flooding along coastal and low-lying areas would increase dramatically endangering the slums located there. Vulnerability assessment undertaken by Schiller et al. (2007)[28] further suggests that a 'bundle' of stresses, such as, Mumbai's flat topography, geology, wetlands and flood prone areas, projected sea-level rise, building conditions including not meeting building codes, squatter settlements, flood-ravaged buildings, poor sanitation and waste treatment and low incomes reducing the ability for disaster preparedness will create an enhanced vulnerability for the city.

An OECD study[29] has analyzed the recurrence of an extreme weather event like July 2005 for Mumbai. Its findings suggest that in the current scenario, the return period for an event of this magnitude is greater than 200 years. However, with imminent climate change, today's extreme events could become more frequent. For instance, a 1 in 10 event could occur every other year. Using the Storm Water Management Model of USEPA, the study further explores the future flood footprints for Mumbai. By 2080, the study finds extended flood footprints in the city with deeper flooding in more vulnerable areas. The total costs of such an event by 2080 would dramatically go up to US$ 2300 million from the present-day costs of US$ 650 million.

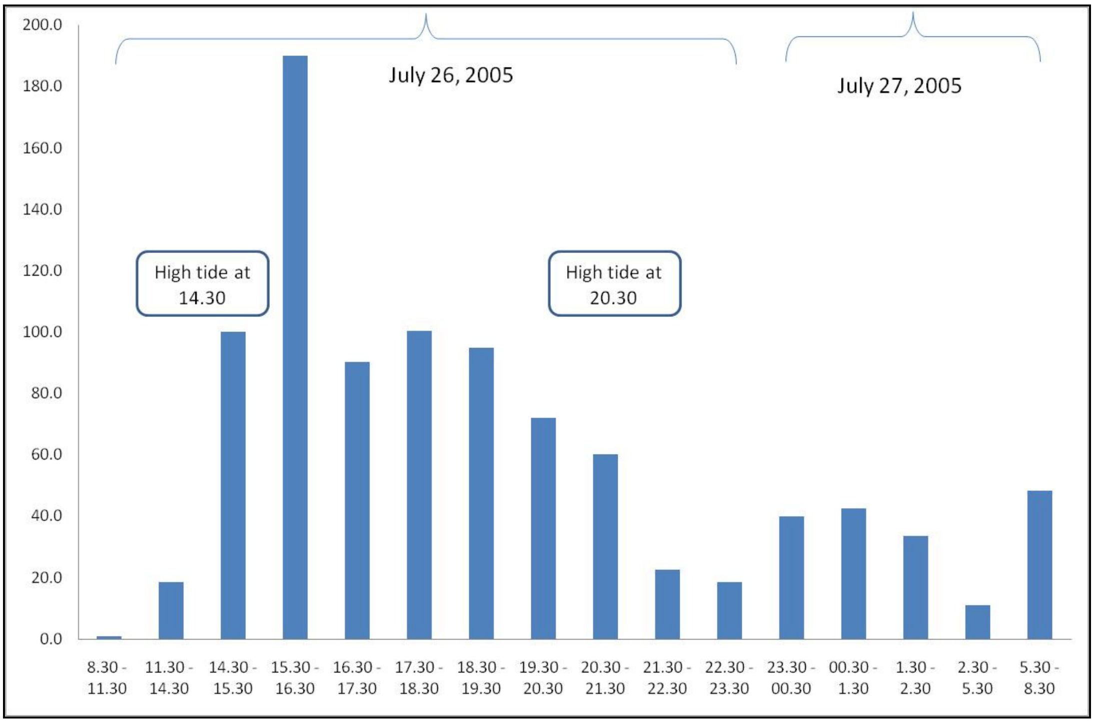
Yet another OECD study[30] has done a global screening of 136 coastal cities to identify their exposure to storm surges and high winds. The study has also investigated how climate change is likely to impact these cities through coastal flooding by 2070s. For the present day conditions (reference year 2005), Mumbai is ranked the first among top ten coastal cities in terms of exposed population. The total exposed population to weather events resulting from current climate conditions in Mumbai is estimated at 2.787 million. Under the future climate conditions, the population exposed to weather events like storm surges and flooding will go up to 11.418 million. Similarly, the value of exposed assets is currently US$ 46.20 billion, which would dramatically increase to US$ 1598.05 billion by 2080. Further, the city is ranked 2nd in terms of population exposure to future climate conditions by 2080, second only to another vulnerable coastal city in India, Kolkata (formerly Calcutta). Mumbai is also among the top 20 cities with greatest exposure to extreme sea-level and with greatest exposure to wind damage from tropical cyclones. The city is also expected to have a high exposure to coastal flood risk in the 2070s. The study further emphasizes that exposure will not necessarily translate into impact if effective adaptation and risk management strategies are in place. However, for a city like Mumbai with far lower standards of adaptation and risk management or flood defences, the impacts of extreme weather events are likely to be large in future.

A recently concluded OECD study (2010)[31] has demonstrated an approach to assess the future risks from extreme weather events and quantify the benefits of different adaptation options on a city-scale. The study focuses on applying this approach to flood risk in Mumbai. The findings of the study suggest that by 2080, in a SRES A2 'upper bound' climate scenario, the likelihood of a 2005-like event will more than double. The total direct and indirect losses from such an event would also triple to around US$ 1890 million. The study specially looks at the marginalized population comprising a large number of households in the city (engaged in the informal sector) who would suffer from the total losses of US$ 250 million. The analysis further shows how the adaptation efforts could significantly bring down the costs of extreme flooding events in future.

3. Extreme floods of July 2005: Impact assessment

On July 26, 2005, Mumbai suburban district and the entire MMR region were struck with a heavy storm. India Meteorological Department (IMD) weather station located at Santacruz (suburb in the west), recorded 944mm rainfall (45% of the annual average rainfall in Mumbai) between 8.30 am on July 26 and till 8.30 am on July 27[32], with the highest precipitation for a few hours between 2.30 pm and 7.30 pm as can be seen in Figure 4 below. The IMD forecast had predicted heavy to very heavy rainfall for the day which meant 65–125mm in 24 hours. The actual rainfall was so huge in magnitude that the administration had no guidance or prior experience to react to such a situation[33]. This unprecedented rainfall coinciding with the high tide brought the city to a standstill. The heavy flooding on this day was on account of the very heavy downpour 380 mm for 3 hours between 14.30 and 17.30 as seen in Figure 3. This intensity was 5 times more than the intensity of rain for which the old SWD system had been designed (25 mm per hour) and also 2.5 times more than the system being designed under BRIMSTOWAD (50 mm per hour)[34].

Figure 4: Rainfall in mm on July 26-27, 2011



Source: MCGM (2006), Fact finding committee on Mumbai floods, Final Report

The following would give an idea of the magnitude of the deluge and the impact on the city[35,36]:

- Excluding hilly areas of forest and lakes, 22% of the city land was submerged in rainwater on July 26-27, 2005.
- Around 2 million people were stranded in transit or took shelter in different transportation modes. Another 2.5 million people were under water for hours. Around half of them were the poor living in the slums of Dharavi, Sion, Kurla, etc.
- Civic amenities such as electricity, water supply and transportation and communication networks were completely shut down.
- 150,000 people were stranded at the two main train stations, CST and Churchgate and thousands more had to wade through the dirty and contaminated water for 24-48 hours to reach their destination. The air traffic had to be suspended for 2 days due to submergence of the airport.
- It took 1-4 weeks for the train and bus services to start normal functioning between Mumbai and surrounding MMR region. Road and train services to other areas within and outside the state were also disrupted for 3-10 days.
- The worst-hit were the low-lying areas and the poor living in slums or squatter settlements along the pavements and near railway tracks.
- Floods claimed more than 700 lives in the city. More than 14,000 houses were completely damaged and more than 357,000 houses were partially damaged.
- The total cost of damages has since been estimated at Indian Rupees (INR) 306 crores (US$ 68 million @ 1US$ = Rs.45).
- The most extensive loss was suffered by trade and commerce as a large number of shops, commercial establishments and warehouses suffered heavy losses due to flooding. The Indian Merchants Chamber has estimated these losses to the tune of INR 5000 crores (US$ 1100 million).
- In the immediate aftermath, Mumbai also saw 3000 hospital admissions due to gastroenteritis, malaria, hepatitis, dengue and so on.

3.1 Direct and indirect impacts

From the impacts perspective, an extreme weather event (often termed as a natural disaster), implies a combination of **losses** in physical, financial and human capital and **reduction** in economic activities of investment, consumption, production and employment[37]. This combination of losses in stocks and reduction in flows due to extreme events may be so severe that they may actually alter the medium to long-term trajectory or development path of a region[38].

However, most impact assessment studies tend to measure the economic losses in terms of the most easily measured direct losses, i.e. the financial costs of visible physical damage to existing infrastructure and property. Indirect or secondary impacts such as the effect on provision of goods and services, provision of public utilities like water and electricity, transportation and mobility and so on are typically not measured due to practical difficulties[39] arising out of data availability and absence of measurable variables. This can be overcome by the use of proxy variables to some extent, although these variables may not be able to measure the exact indirect impacts.

From the perspective of cities in the developing world, there is further caution that needs to be exercised when we interpret the measured impacts of extreme weather events. Such impact assessments tend to focus on insured losses and mortality as these can be measured easily and directly. However, a major part of the local economy is in the informal sector, where the prevalence of insurance for physical assets is minimal. Hence, the losses of the informal sector are not captured when impact assessments are done. The ground reality for such cities is that insured losses and mortality are just a fraction of the total losses that communities suffer. Most of the losses are out-of-pocket expenses that do not get accounted for when direct impacts are measured.

To overcome some of these aspects of impact assessments, the present study does not rely only on the insured physical and financial losses measured by the authorities in the aftermath of the July 2005 event in Mumbai. An extensive primary survey has been carried out in six wards of Mumbai which have many chronic flooding spots. These wards are the most affected when flash floods occur in Mumbai during monsoon. This section describes and measures the impacts of the extreme weather event of July 2005 in Mumbai based on the government reports on damage assessment as well as the primary survey. The focus of this section is on the impacts on both stocks and flows, i.e., direct impacts on physical infrastructure and economic losses and indirect impacts on services and provisions.

3.1.1 Direct impacts: stock variables

MCGM undertook damage assessment exercise in the immediate aftermath of July 2005 floods and submitted the report to seek financial assistance from the central government under the CRF (Central Relief Fund). Table 3 and 4 below outline the overall impacts assessed by the MCGM and the cost of damages to municipal infrastructure including municipal buildings, water supply systems, roads and storm water drains for which the relief was sought to the tune of INR 2475 Million or US$ 55 million[7] under the CRF[40]. In addition to this, the health impacts of the severe floods, while accounting for the incubation period for most diseases up to two weeks after the floods have been estimated as shown in Table 5[41].

[7] For conversion of INR to US Dollars, the exchange rate used throughout this study is 1 US$ = INR 45.

Table 3: Overall impacts of July 2005 floods as assessed by MCGM

Item	Impact
Estimated loss of life	As per Government records 445 people lost their lives
Names of roads blocked/congested	Most arterial roads and highways in the suburbs severely affected due to waterlogging and traffic jams resulting from vehicle breakdown in deep waters
Estimated number of establishments/vehicles damaged	– Residential establishments - partly damaged: 50,000 – Residential establishments - fully damaged: 2,000 – Commercial establishments: 40,000 – Vehicles: 30,000
Effect on train services	Heavy rains led to railway tracks being submerged and consequent stoppage of services on central (main and harbour lines) and western railways
Effect on air services	Heavy rains led to airport being flooded. Additionally there was extremely poor visibility as a result of which flight services in and out of Mumbai stopped on the night of the 26th July 2005
Effect on power supply	Electricity supply stopped in most parts of Mumbai's Western Suburbs in the night of 26th July 2005
Water supply	Pumping stations at Deonar, Chunabhatti and Shiv Tekdi submerged in flood water affecting pumps, motors and control panels.
Sewerage	Severe damage caused to 11 pumping stations and surrounding structures. These included STP's at Versova, New Versova, Goregaon, Saki naka, Malad, Kherwadi and Khar.
Storm Water Drains	Water entrances, flood gates, manholes, and nallahs at several places were damaged
Roads	Approximately 6 bridges, 154 major roads, 229 minor roads and 10 cement concrete roads have been damaged.

Source: MCGM report on relief measures and damage assessment

Table 4: Cost of damages to Municipal infrastructure during July 2005 floods

Item	Amount in INR million
Health	
MCGM Medical Colleges	4.73
Peripheral Hospitals	11.46
Muni Properties & Buildings	8.28
Water Supply System	251.81
Utilities	
Abttoir	35.45
Education	1.30
Garden	1.86
Roads	1911.36
Waste Management	
Sewerage Operations	13.67
Solid Waste	90.44
Strom Water Drains	144.90
Total Cost	**2475.27 (US$ 55 million)**

Source: MCGM report on relief measures and damage assessment

Table 5: Health impacts as on August 12, 2005 in Mumbai

Name of the disease	Admission in last 24 hrs.	Total admissions since 29th July	Number of deaths
Gastroenteritis	154	1318	1
Hepatitis	27	194	--
Enteric fever, Typhoid	5	53	--
Malaria	62	406	2
Dengue	5	49	--
Leptospirosis	56	197	10
Fever (Unknown cause)	597	1,044	45
Total	**906**	**3,261**	**57**

Source: Govt of Maharashtra (2005), Maharashtra Flood Damage 2005

However, the damages and costs estimated by the government agencies reflect only a fraction of the total costs of damages to physical infrastructure and assets as the damages suffered by households and commercial establishments are not accounted for in the absence of insurance coverage and unavailability of data. To overcome this limitation of impact assessment, this study carried out survey of households and commercial and small industrial establishments in six wards which were severely affected by floods in July 2005 and continue to get affected by flash floods each monsoon season. The ward-wise breakup of the sample size in the primary survey is given in Table A1 in Annexure.

3.1.1.1 Households

The primary survey covered randomly selected households in six flood affected wards of Mumbai. The households selected by the survey are located on the ground level or first storey of a building as these are likely to be most affected by floods. During the July 2005 floods, the average depth of flooding was 5 ft and the houses remained flooded for average 3 days. 59% also said that the effect of floods on their families was high, while 24% reported that there was medium impact of floods on them. Most surveyed households (69.35%) were in the lower middle-income category of INR 5000-15000 followed by 16.52% earning less than INR 5000 per month and 10.62% earning INR 15000-30000. On an average, the income loss due to floods in 2005 was INR 5000 (84% respondents) and amount spent on repair/ rebuilding of house was INR 15000 (86% respondents). On an average time, it took the households around 8 days to complete the repair/reconstruction of the house.

Table 6 shows the total costs of repair/replacement for the flood affected households. The costs estimated through the primary survey have been extrapolated for Mumbai by assuming that overall 20% of households located in eastern and western suburbs were affected by floods in July 2005[8]. It must be noted here that only 6.8% (80 out of the surveyed households) have any form of insurance cover. Furthermore, only 3.59% (41 out of the surveyed households) have claimed insurance for damages due to flooding. Thus, the huge costs calculated here to the tune of INR 12,000 million (US$ 267 million) are the out-of-pocket expenses borne by the city residents on account of floods.

[8] 2001 census data show the total population of around 8.5 million in eastern and western suburbs of Mumbai. Assuming the average of 4 members per family, this translates to about 2.1 million households. We make a rough estimation that 20% of these households (about 420,000) were directly affected due to floods in July 2005 given the extent of flooding in suburbs and calculate the costs accordingly. It must be noted here that we are considering households who are located at the ground level and first storey of residential buildings. Hence 20% seems a reasonable estimate for directly affected households. This exercise provides at best only indicative estimates of the overall costs that households have had to bear in the absence of insurance coverage.

Table 6: Cost of repairs/replacement in households

Item	Average cost of repairs/replacement per household (in INR)	% of households reporting these costs in survey	Estimated number of households affected by floods	Estimated costs of damage in INR million
Income loss	5000	84	352800	1764
Reconstruction of house	15000	86	361200	5418
Stove	1500	57	239400	359.1
Electric Fans	1000	35	147000	147
TV	7000	42	176400	1234.8
VCR/VCD	2700	7	29400	79.38
Music System	3000	1	4200	12.6
Motorcycle	8000	13	54600	436.8
Refrigerator	7000	30	126000	882
Washing Machine	6000	8	33600	201.6
Furniture	5000	31	130200	651
Wardrobes	4000	32	134400	537.6
Utensils	3000	38	159600	478.8
Total Estimated costs				**12202.68 (US$ 267 million)**

Source: Calculated based on primary data

In case of households, impacts that need special consideration are the health impacts in the aftermath of July 2005 floods. The most prevalent diseases during monsoon in the city as reported by households are Malaria (86.5%) followed by fever (82%) and other diseases like typhoid, jaundice and diarrhoea as seen in Table 7 below.

Table 7: Diseases prevalent during monsoon

Prevalent diseases during monsoon	% of respondent households (n=1168)
Malaria	86
Dengue	54
Typhoid	61
Jaundice	61
Fever	82
Diarrhoea	42
Stomach Infection	38

There was a reported increase in the incidence of diseases after the July 2005 floods as seen in Table 8. 87% responded that there was an increase in the incidence of malaria followed by typhoid (50%), jaundice (47%), dengue (41%) and diarrhoea (37%).

Table 8: Increased incidence of diseases after July 2005 floods

Increase in incidence of diseases after floods	% of respondent households (n=1168)
Malaria	87
Dengue	41
Typhoid	50
Jaundice	47
Diarrhoea	37

3.1.1.2 Commercial and small industrial establishments

The primary survey covered commercial establishments like retail shops, IT centres, Jewellery stores, dairy, etc. and small industries such as manufacturing units and warehouses. Most of these are either located on the ground level in industrial parks or along the roadside and get affected by floods with heavy precipitation. During the July 2005 floods, the average depth of flooding reported by commercial establishments was 4 ft. However, 30% reported the average depth of 5-8 ft. The average time taken by them to get back to normal business was 3.5 working days. However, 15% reported spending between 1 to 2 weeks before the business operations could resume once again. In the absence of insurance coverage (only 7% of the respondents claimed to have insurance coverage of any kind including life insurance), these establishments had to bear the burden of repairs and/or replacements for different physical assets damaged/destroyed during the July 2005 floods. In addition, they also had to spend on account of clean-up, loss of income, operating costs and other emergency expenses when flood waters entered their establishments.

Table 9 and 10 show the total costs of repair/replacement and other flood related expenses. The costs estimated through the primary survey have been extrapolated for Mumbai by assuming that overall 40% of such establishments located in eastern and western suburbs were affected by floods in July 2005[9].This allows us to arrive at rough and indicative estimates for the costs of damage faced by the largely informal private sector in Mumbai that includes small retail shops based on the ground level and small industrial establishments.

Table 9: Cost of repairs/replacement in commercial & industrial establishments

Item	Average cost of repairs/replacement per establishment (in INR)	% of establishments reporting these costs in survey	Estimated number of establishments affected	Estimated costs in INR million
Grounds and fences	40000	48	46080	1843.2
Walls	11000	26	24960	274.56
Windows	5000	4	3840	19.2
Doors and mouldings	6000	18	17280	103.68

[9] MCGM records show around 400,000 registered retail shops and other commercial establishments in the city out of which 60% or 240,000 are located in the suburbs. We make a rough estimation that 40% of these establishments were affected due to floods in July 2005 given the extent of flooding in suburbs and calculate the costs accordingly. This exercise provides at best only indicative estimates of the overall costs that such establishments have had to bear in the absence of insurance coverage.

Electrical wiring and switches	10000	28	26880	268.8
Heating	10000	1	960	9.6
Air conditioning	14000	1	960	13.44
Machine tools	15000	25	24000	360
Finished products	24000	28	26880	645.12
Raw materials	20000	13	12480	249.6
Inventory	24000	13	12480	299.52
Total Estimated costs				**4086.72 (US$ 90 million)**

Source: Calculated based on primary data

Table 10: Costs incurred on account of floods (in INR)

Item	Average cost per establishment (in INR)	% of establishments reporting these costs in survey	Estimated number of establishments affected	Estimated costs in INR million
Disinfecting premises	18000	58	55680	1002.24
Clearing debris and damaged items	13000	22	21120	274.56
Loss of income due to business interruption	16000	36	34560	552.96
Increased alternative operating costs	10000	23	22080	220.8
Emergency expenses during floods	26000	8	7680	199.68
Loss due to suspended production	22000	20	19200	422.4
Total estimated costs				**2672.64 (US$ 59 million)**

Source: Calculated based on primary data

3.1.2 Indirect impacts: Flow variables

Besides the damages to physical assets and economic losses on account of that, there are a number of indirect impacts that households and commercial and industrial establishments suffered from during the floods. The survey questionnaire tried to capture some of these impacts by asking them about the other problems they faced on account of non-availability of essential supplies, price rise due to shortages and disruption of essential services. The problems faced during the 2005 floods by the respondents are described in Table 11 below.

Table 11: Major problems faced during July 2005 floods

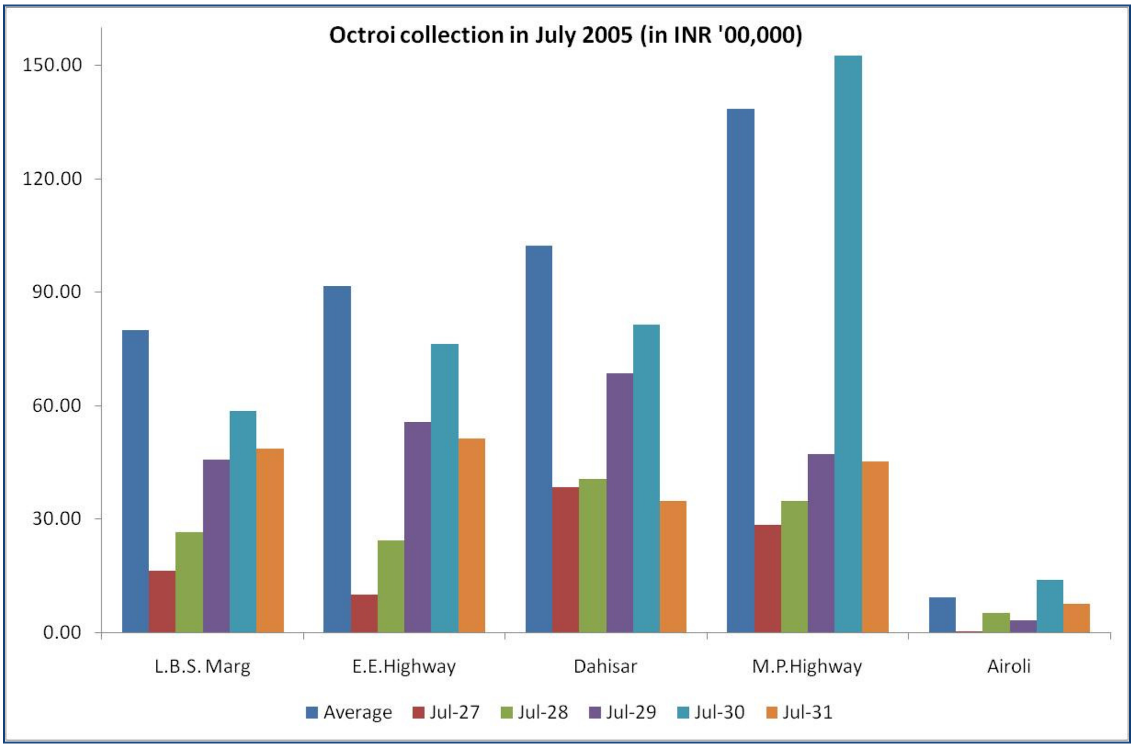
Problem	% among surveyed households (n=1168)	% among surveyed commercials & small industries (n=792)
House/office flooded with water	70	82
Non-availability of local transportation	87	82
Price rise of essential commodities	67	65
Non-availability of food and other household supplies	62	-
Non-availability of raw materials	-	56
Disruption in communication services	61	66
Disruption of electricity	83	88
Non-availability of clean drinking water	75	79
House flooded with sewerage/garbage	80	-
Non-availability of fuel	51	46.5

Some of the major problems faced by both households and commercial and industrial establishments are flood waters entering the premises, non-availability of local transportation, disruption of electricity and supply of clean drinking water. 77% of households reported that on an average, during the floods water was available for about 15 hours. 43% further reported that on average water supply was discontinued for 3 days while electricity supply was discontinued for 5 days.

As discussed earlier, although indirect impacts of weather events are critical in terms of disrupting the normal life of the affected residents, they often cannot be assessed properly due to difficulties of measurement and unavailability of sufficient data. The nature of these impacts is such that there is often a qualitative or subjective element attached to them which also makes the measurement difficult. In the present study, we have tried to capture the impact of provision of essential commodities and services like electricity supply during the extreme event of July 2005. As directly measuring the shortages of essential commodities in the city during floods is difficult, we have used octroi collections done by MCGM at 5 entry points into the city as proxy for provision and availability of essential supplies of goods including fuel for the residents. Figure 5 shows the average collections at the five entry points for the month of July 2005 and a visible dip in the collections from July 27 to July 31 when the city was coping with floods. The strong dip in octroi collections at all the entry points are an indication of supplies of essential commodities getting affected for a number of days after the heavy precipitation occurred on July 26. Also, the dip in octroi collections is also a net economic loss to the civic authority, which needs to be considered when assessing the monetary losses on account of floods.

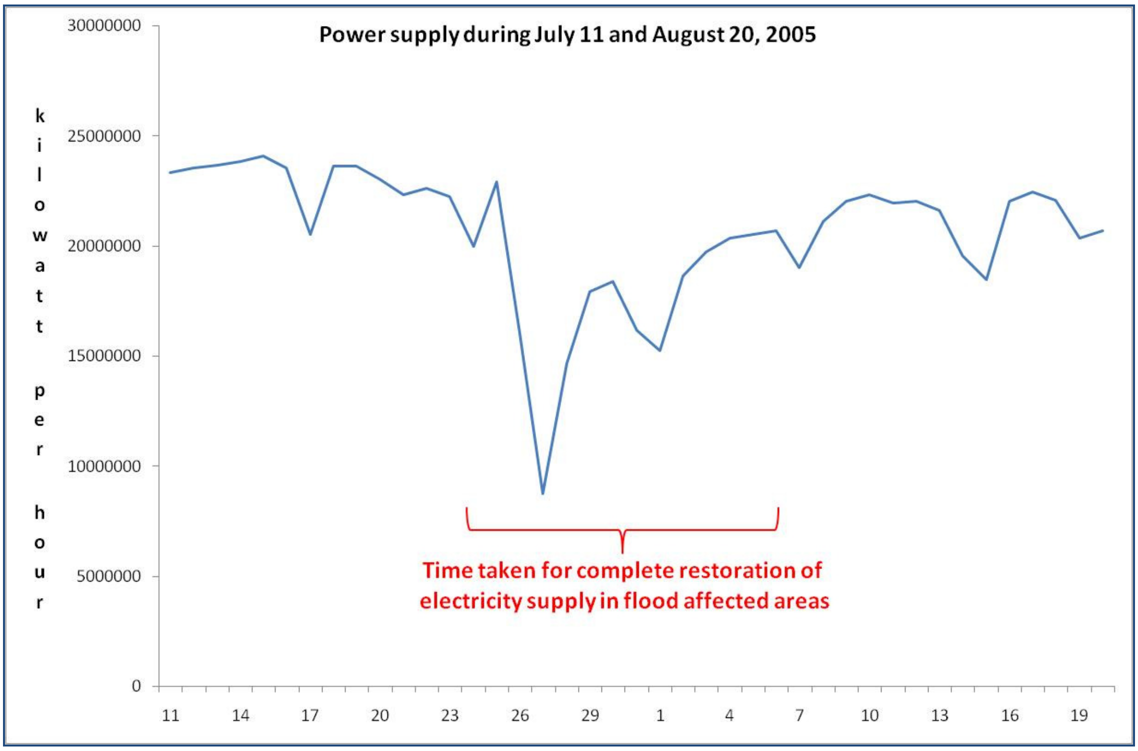
Another important service affected by floods was electricity supply in the suburbs. Figure 6 shows the daily distribution of power supplied to the households in the western suburbs by the private utility, Reliance Energy. The time period of July 11-August 20, 2005 is plotted here to show a substantial dip in the daily power drawn by households and commercial and industrial consumers. As the figure shows, it took the private utility nearly two weeks to restore supply back to normal. The disruption of electricity supply affects the normal life for households and also causes direct economic losses to the commercial and industrial consumers who are dependent on power supply to conduct their business. Although we have tried to capture the economic losses to these consumers, it is difficult to separate the losses on account of disruption in power supply. Another important point to be noted here is that reduction in the daily drawal of electricity is a net loss to the utility as well and it needs to be accounted for when calculating the monetary losses due to floods.

Figure 5: Octroi collections at entry points during July 27-31, 2005



Source: Octroi Department, MCGM

Figure 6: Daily power supply between July 11 and August 20, 2005



Source: Reliance Energy Daily Drawal Data

4. Response measures

The deluge of July 26, 2005 caught the civic administration as well as residents unawares and in the absence of an early warning system and near-total collapse of communication and transportation network, the administration faced the tough task of responding to the situation and implementing the rescue and relief measures.

The civic administration, without prior experience or guidance in managing a disaster of this kind, responded to the situation by undertaking the following rescue and relief measures[42]:

- Organized safe evacuation of people through boats & buses & providing shelters in public buildings, schools & transit shelters
- Community kitchens started & free food grains provided.
- Traffic police & Fire brigade cleared 26,000 stranded vehicles by 2.30 pm on 27th July
- Power & water supply restored and train services resumed on 28th July
- 24,000 animal carcasses disposed & more than 200,000 metric tonnes of garbage removed
- The rescue teams of MCGM & the Fire Brigade undertook 282 major & minor rescue operations which included rescuing school children & around 3,700 stranded people from 140 marooned buses
- Post flood sanitation measures like extensive spraying of disinfectants (in open spaces & waste collection areas) & insecticides undertaken
- Restoring supply of drinking water to affected areas using additional tanks, repair of damaged pumps & repair of pipelines
- Comprehensive healthcare services, health camps, outreach program & 130 specially constituted medical teams helped treat over 300,000 patients. Additional doctors, admission capacity & significant drug reserves made available to the affected people

Role of NGOs and individuals in providing relief during the devastating floods needs a special mention here. MCGM coordinated relief work at many places with the help of social service organizations (such as Nirmala Niketan College of Social Work and Tata Institute of Social Science). Over 20 NGOs including Akanksha, Yuvak Pratishthan, Apnalaya and industry houses (e.g, Tata Group through Dorabjee Tata Trust) also volunteered their help[38]. Coordination mechanism was set up through the DMC to coordinate the continuing relief operations by individuals, industry houses and NGOs. Food packets and drinking water was arranged for the stranded people with the help of NGOs and Social Organizations. Individuals or common people also played a major role in relief & rescue measures. Community kitchens were started and free food grains were provided by the Government of Maharashtra (GoM) and MCGM as well as voluntary NGOs and individuals. Common people threw open their doors to welcome anyone affected by floods. Stranded people who had nowhere to go were welcomed & were allowed to stay till the floods ceased. People came out wholeheartedly to help in co-ordination & relief operations.

The devastating floods of July 2005 became a real eye opener for the local administration and led to the formulation of the Disaster Management Plan for the city and other short to medium term measures to improve the coping capacity of the city to floods in future. Along with the local government, citizens – households and commercial/industrial establishments –also responded to the threat of recurrent floods and undertook a variety of measures in the aftermath of July 2005 floods. This section takes an overview of the response measures implemented by the civic authorities and citizens including households and the private sector. The important question to be addressed here is how effective are these response measures in enhancing the adaptation capacity of the city in the long-run. A discussion on this question is done towards the end of this section.

4.1 Local government institutions

In the immediate aftermath of the July 2005 floods, a Fact Finding Committee was appointed to look into the causes and to recommend activities to reduce the future risks of flooding in Mumbai. The committee was asked to analyze the short-term and long-term factors responsible for the floods that created havoc on July 26-27, understand the present status and limitations of the storm water drainage network, development of river basins in the city and factors that impede their natural flow and finally suggest guidelines for preparing long-term development plans that would overcome future flood situations. The committee came up with several recommendations, such as, upgradation of storm water drainage system, disaster management, river development and so on to improve the existing environment and upgrade and improve the governance and management to achieve sustainable development of Mumbai. Specifically the committee is of the view that a measured, well thought out plan and interventions should address the issues of frequently encountered floods in Mumbai region, land use planning, encroachments, population density, sustainability of present-day exploitation of water and natural resources.

The two most important recommendations of the committee pertain to the improvement of the disaster management system (DMS) in the city and risk zoning. The specific suggestions regarding both are highlighted in Box 1 below.

The fact finding committee further suggested some activities as given below:

- Restore the existing degraded rivers and river-banks to initiate recovery of the urban ecosystem
- Provide river flushing system to initiate rejuvenation of river channels
- Rejuvenate degraded urban ecosystems including lakes / ponds, rivers, creeks, and costal zones
- Restore the Mangrove-Ecosystem and rejuvenate the coastal zones
- Rejuvenation and environmental upgradation of hills, slopes, and lakes / ponds in Mumbai Region
- Improve municipal solid waste management systems
- Upgrade the sewage treatment plants and sewerages
- Construct detention basins and infiltration zones for flood control and provide spaces for people to escape to in case of disasters and calamities
- Remove encroachments and strictly adhere to the Development Plan (DP)
- Demarcate potential flood-zones on DP sheets. Develop a policy for management of development in those areas and amend DC rules suitably
- Strengthen monitoring, assessment and auditing of environmental and ecological status-related activities in Mumbai Region
- Empower the "Disaster Management Authority" to monitor, assess and audit environmental and ecological status after any disaster
- Set up the "environmental cess" for providing targeted O & M budget to sustain environmental services

Box 1: Suggestions of the fact finding committee

Important suggestions of the Fact Finding Committee on Mumbai Floods
Improving disaster management system (DMS): • Revamping the disaster management plan as the plan document looks more generic rather than an operational one • Vulnerability analysis should be carried out for the city • Disaster analysis should be based on probabilistic approach and relevant data should be available with all the agencies providing essential public services to the city where the data are compiled and analyzed systematically during the disaster free periods • It is the intensity of the rainfall rather than average rainfall that needs consideration for floods in the city • Disaster Management Plan (DMP) needs analytical approach to consider the 5 rivers and other water courses in the city and surrounding areas to manage storm water flows • Issues like low levels of Mumbai's coastal areas, evacuation plan for the city, shelter places, etc. need special consideration in the DMS • DMP needs scientific back-up, proper risk assessment and vulnerability analysis to become more effective • Roles and responsibilities of different officers should be specified in the standard operating procedures (SOPs) for different categories of disasters **Risk zoning:** • Reclaimed lands have the tendency of settling which needs to be considered for long-term projections of submergence while doing vulnerability analysis • More than 50% population lives in slum colonies which are highly vulnerable to floods and other risks. Hence, risk zoning is required to plan for preventive measures like infrastructure provisions and post disaster rescue and relief **Early warning mechanism:** • Daily rainfall record has little relevance for precipitation analysis as intense precipitation does not occur uniformly over longer time period • There is a need to develop a well coordinated rainfall analysis and forewarning system as IMD's forecasting for day's occurrence is not effective • MCGM should develop its own system of recording 15-minute interval rainfall data and issuing alert signal if rainfall exceeds 40 mm in an hour **(Source: MCGM (2006), Fact Finding Committee on Mumbai Floods , Final Report, Volume I, March 2006)**

The committee also recommended conducting the following studies for Mumbai:

A) Comprehensive study of Mithi River ecosystem, environmental impact of Worli-Bandra sea link project & investigating the hydrology of the bay area with 3-D model for long-term prediction
B) Comprehensive study of environmental impacts of MUIP/ MUTP's reclamation and building projects in Mumbai.
C) Ecosystem health indicators
D) Study to estimate the "carrying-capacity" of Mumbai's urban ecosystem vis-à-vis the issue of transportation, housing, sanitation, and drinking water

Some of the recommendations of the fact finding committee, especially those pertaining to the improvement in the DMS have seen been partially implemented as can be seen from the ensuing discussion.

4.1.1 BRIMSTOWAD Project

The Brihanmumbai Stormwater Disposal System (BRIMSTOWAD) is a project planned to overhaul Mumbai's storm water drainage system. The estimated budget for implementing the project was INR 1200crore (approx. US$ 266 million) as of August 2005. Mumbai has a drainage network, which in many places, is more than 100 years old, consisting of 2,000 km of open drains, 440 km of closed drains, 186 outfalls and more than 30,000 water entrances. The capacity of most of the drains as per the original design is around 25 mm of rain per hour during low tide, which is exceeded routinely during the monsoon season in Mumbai, which witnesses more than 1400 mm during June and July. The drain system works with the aid of gravity, with no pumping stations to speed up the drainage. Most of the storm water drains are also choked due to the dumping of garbage by citizens. Portions of Mumbai like Bombay Central and Tardeo remain below sea level. Reclamation of ponds and obstructions in drains due to cables and gas pipe exacerbate the problem.

The final report for the upgradation of the storm water network was submitted in the year 1993. The project was not acted upon due to lack of funds till the catastrophic floods in 2005. The work started only after the floods of July 2005 and subsequent recommendations of the fact finding committee. Following are the recommendations suggested by BRIMSTOWAD project report and subsequent studies. There is a consensus in all studies regarding the action plans, including:

- To provide storm water pumping stations
- To increase capacity of drains wherever necessary
- To improve flood gates at various places
- To repair dilapidated drains and augment the capacity wherever necessary
- To remove obstruction of water pipelines and cables
- To widen, deepen and extend the nallahs/drains and rehabilitate as per govt. policy
- To desilt and maintain SWD during rainy season by various equipments.

Some important points of the BRIMSTOWAD are worth considering:

- ✓ The project was conceived after major floods in Mumbai in 1985. Watson Hawksley was appointed as consultants to design the drainage system from Sandhurst Road to Milan subway in 1989.
- ✓ A proposal was submitted in 1993 for a project which involved replacement of drains, setting up of pumping stations at Worli, Haji Ali and Cleaveland Bandar,construction of a five-metre wide road alongside major drains for desilting, removal of obstructions from the drains and rehabilitation of slum-dwellers .
- ✓ The initial estimated cost of the project was around INR 600 crores. Around INR 143 crores was spent on the project till 1998. By 2005, the project cost had gone up to INR 1200 crores.
- ✓ Consultants used the software named “Wallrus” which has been developed by Hydraulics Research Station of Wallingford, Oxon, U.K. which simulates mathematical model of a catchment for a particular storm (rainfall) hydrograph and verifies results against the tide curve.
- ✓ As of now out of 20 works of Phase-I, 11 have been completed and 9 are in progress. Out of 38 works of Phase-II, 27 are in progress and 11 tenders are under preparation.

- ✓ BRIMSTOWAD report could not be fully implemented because of financial constraints. However much better gains could have been achieved with whatever amount has been spent, if proper priorities were followed systematically.

4.1.2 Disaster Management Action Plan

In December 2005, in the aftermath of the unprecedented Mumbai floods, Government of India enacted the Disaster Management Act, following which National Disaster Management Authority and State Disaster Management Authorities were set up in India. The Act also sought to constitute Disaster Response Fund and Disaster Mitigation Fund at national, state and district levels. It was post July 2005 floods that a fully equipped Disaster Management Cell (DMC) was made operational at the BMC headquarters. Many recommendations of the fact finding committee as outlined in Box 1 above were brought into practice since then to improve the response to disasters. Accordingly, Greater Mumbai Disaster Management Action Plan (DMAP) came into existence in 2007. Under this plan, the risks and vulnerabilities associated with floods, earthquakes, landslides, cyclones, etc., have been identified. The plan envisages specific roles for different stakeholders as outlined in Table 12 below. Also, the plan envisages specific relief and mitigation measures for Mumbai[43]:

- ➢ ***Infrastructure improvements:*** The mitigation strategy under the plan seeks to improve the transport, services and housing infrastructure. These include improvements in road and rail networks, sanitation and sewer disposal system, storm water drainage systems, slum improvements, housing repairs and retrofitting programmes.
- ➢ ***Contingency plan:*** This strategy includes plans to provide extra transportation if the major transport systems fail, transit camp arrangements, improvements in wireless communication and public information systems and NGO volunteers' assistance.
- ➢ ***Land use policies and planning:*** The Draft Regional Plan for MMR Region 1996-2011 provides a basic framework for the land use policies for the city. This plan includes strategies like protection of landfill sites, control on land reclamation, shifting of hazardous units from residential areas and decongestion.

Table 12: Role of different stakeholders to tackle flood risks

Stakeholder	Current / Expected roles
National, state and district disaster management authorities	❖ Prepare policies, plans and guidelines for disaster management ❖ National Disaster Management Authority to declare nation-wide policies ❖ Constituting National Institute of Disaster Management that imparts training and research and develops nationwide database on policies and prevention mechanisms ❖ Constituting National Disaster Response Force ❖ State Disaster Management Authority to prepare the state-level plans ❖ District Authority as district planning, coordinating and implementing body for all disaster management functions ❖ District Authority functions include mitigation and

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	preparedness, response, relief and rehabilitation
Local authority (MCGM – specific to Mumbai)	❖ Impart training to employees to cope with disasters ❖ Maintenance of resources for managing any extreme events ❖ Ensuring that all construction activity conforms to prescribed standards and specifications (building codes, earthquake and fire proof construction, coastal zone regulations, FSI regulations, etc.) ❖ Relief, rehabilitation and reconstruction activity in affected areas
MCGM and MMRDA	❖ Infrastructure improvement in terms of transport, services and housing ❖ Projects like MUTP and MURP to work towards these objectives ❖ Constructing flyovers, additional roads and road over bridges to reduce the traffic density and congestion in identified spots of high traffic density ❖ Road improvement programme to improve the conditions of roads particularly before monsoon ❖ Slum Rehabilitation Scheme to improve the quality of housing for slum dwellers and scatter communities
MCGM – storm water drainage department	❖ Regular de-silting (cleaning) of nallahs (narrow waterways) to reduce the tendency of flooding or choking during heavy precipitation ❖ Augmenting the capacity of the present storm water drains ❖ All flood gates manned to operate them during high and low tides ❖ Chronic flooding spots management by deploying special sqauds
MCGM – early warning system	❖ Automatic weather stations with rain gauge monitoring system to be installed across city to monitor rain intensity to facilitate early warning ❖ Anti-flood control rooms in all wards with equipped staff, wireless equipments, etc. ❖ A list of days when there is a hide tide of 4.7 mtrs and above to be prepared and distributed to railways, police and the district collector ❖ Nodal officer of MCGM to brief print, audio and visual media to provide timely and clear information and put a stop to rumours ❖ Electronic information display monitors controlled to be

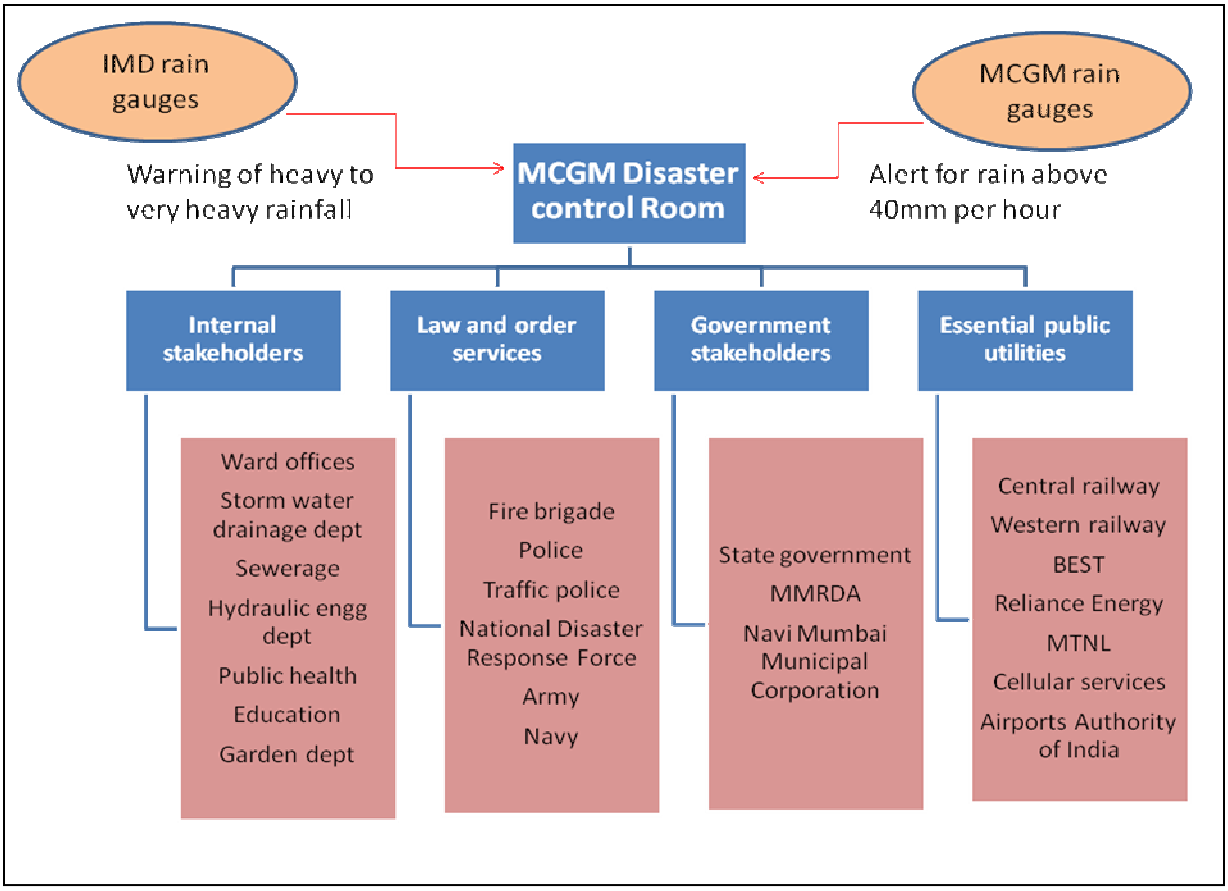
	installed at different places in city ❖ Booklet of all important contact numbers to be distributed widely
Police and fire brigade departments	❖ Police departments to work with municipal authorities to respond quickly and effectively to extreme events ❖ Identify and get equipped with specific equipments and facilities required to respond to extreme events ❖ Commissioned six command centres of fire brigade capable of acting independently ❖ Three highly trained search and rescue teams to be deployed and each team equipped with enhanced equipments
MCGM – public health department	❖ Preventive measures to stop the spread of water, food borne and vector borne diseases ❖ Information to be disseminated to the general public about prevention and cure of such diseases ❖ Keep stock of essential medicines, vaccines and pest control chemicals and equipments ❖ Provide immediate and urgent health services through primary health centres and hospitals run by the civic authority
MCGM – contingency plan	❖ Each ward to identify five schools as temporary transit camp during disasters ❖ BEST (transport authority in Mumbai) to put in service extra buses in case of transport failure ❖ Disaster management Cell to be equipped with all state-of-art communication equipments and networks to control the rescue and relief operations
NGOs	❖ Role in setting up an effective communication and public information system ❖ Role in rescue, relief and rehabilitation activities by providing volunteers ❖ To create awareness among people and educate them about extreme events and level of preparedness
Communities	❖ Based on past experience, perhaps the most crucial role performed by communities and individual people in helping with rescue and relief work

Source: Govt. of Maharashtra, (2007), Greater Mumbai Disaster Management Action Plan

4.1.3 Disaster Management Cell, MCGM

It was post July 2005 floods that a well equipped Disaster Management Cell (DMC) became functional at MCGM headquarters. This cell has been given the responsibility of coordinating with different stakeholders and agencies for the rescue and relief operations in the event of floods during monsoon. As per the recommendations of the fact finding committee, 31 rain gauges have been installed and they feed in rainfall data of 15-minute interval to the disaster control room. The rain gauges are set up at the fire station of each ward to. Alert is issued to the control rooms in each ward whenever the hourly rainfall exceeds 40 mm. In addition to this, the IMD also provides regular forecasts and issues warnings of heavy to very heavy rainfall when necessary. The response hierarchy in case of rainfall exceeding 40 mm per hour or a warning coming from the IMD is shown in Figure 7 below.

Figure 7: Hierarchy of response to flood alert



Source: Based on information in MCGM (2010), Flood preparedness guidelines 2010, www.mumbaimonsoon.com

The Disaster control room works 24x7 and has hotlines connected to each ward, major hospitals, news channels and other agencies and is well equipped with a standard operating protocol (SOP) with a set of priorities to tackle emergency situations. Each ward is given SOPs to follow which are updated regularly. Each ward has its own inventory of telephone numbers and contacts such as blood bank, medical staff, NGOs and so on, to be contacted for help. Rescue measures and capacity building have been polished since 2005 and there are few NGOs identified which can be called for help in case of emergency. NGOs are deployed only for extending the manpower depending on the intensity of the situation. DMC plans to include GIS surveillance in future to quicken the response time. The whole idea of improvisation in the system is *to "minimise the response time"*. Also, certain structures are identified, e.g., municipal schools, which can act as shelters in case of any untoward incident. Boats and trained swimmers have been kepi in contacts in case of emergency. In addition to this, the general public can access ward specific updated information on the website maintained by the DMC *www.mumbaimonsoon.com*. This website provides information to the citizens about real time rainfall data, tidal data and traffic diversions, etc.

4.2 Households

In addition to the response measures undertaken by the local civic authority, citizens have responded to the threat of flooding by undertaking different measures in the aftermath of July 2005. We have captured some of these measures through the primary survey. The households have undertaken repairs on their own to prevent flood waters from entering their premises as shown in Table 13.

Table 13: Major repairs undertaken by surveyed households since 2005

Item	% of households (n=1168)
Increasing height of surrounding ground	42
Reconstruction of house with stilt parking	11
Repairing & elevating electrical meters	27
Repairs inside house to elevate furniture	31
Repairs inside house to elevate electronic gadgets	33
Repairing/ modifying toilets	11

In addition to these repairs, the households have reported the following measures undertaken every year to prepare for monsoon in general and floods in particular. The percentages of respondents are given in the brackets.

- Repairing roof/ terrace (60%)
- Cleaning surrounding ground/ compound (41.5%)
- Start using boiled water for drinking (65%)

It must be noted here that only 6.8% surveyed households (80 out of the total respondents) have any form of insurance cover. Further, only 3.5% claimed insurance after 2005 floods. Again a negligible percentage received financial assistance from the authorities for house damage, vehicle damage, food and clothing and disability. This indicates the extent of private costs borne by citizens on account of floods.

4.3 Private sector

The primary survey of commercial and industrial establishments throws light on how these establishments have responded to the threat of floods in the aftermath of the July 2005 event and have undertaken measures to cope with floods in subsequent years. We asked these respondents about the agencies they contact during floods when the water enters their establishments. An overwhelming 75.5% said that they did not contact anyone and only 15% reported contacting the local ward office of MCGM. 7% contacted the police and 4% contacted the local fire brigade. These establishments have undertaken repairs on their own after their experience of the July 2005 floods to prevent flood waters from entering their premises and/or reducing the damage indoors as shown in Table 14 below.

Table 14: Major repairs undertaken by surveyed establishments since 2005

Item	% of commercial & industrial establishments (n=792)
Increase the height of the surrounding plot	72.9
Reconstruction with stilt parking	12.5
Repairing and/or elevating electrical meters	50.1
Repairs inside the office premises	42.6
Repairs outside the office premises	17.2
Repairs done to elevate and protect inventory	7.3

The most important aspect to be highlighted here is the fact that only 7.3% (58 out of the total respondents) have any form of insurance cover to assure them financial assistance against the damage done to the building, inventory and other assets during floods. Further, only 3% received financial assistance from the MCGM and state government after the July 2005 floods on account of office and asset damage. Hence, all the repairs undertaken by these respondents to reduce the impact of floods in subsequent years have been out-of-pocket expenses borne entirely by these establishments.

In addition to these repairs, these establishments have reported the following measures undertaken every year to prepare for monsoon in general and floods in particular. The percentages of respondents are given in the brackets.

- Repairing the roof (64.4%)
- Cleaning and clearing the surrounding area/ground (57.7%)
- Overhauling of vehicles (10.5%)
- Overhauling of machinery (24.9%)

5. Enhancing adaptation through response measures

As seen in the previous section, both government and citizens have responded to the threat of flash floods during monsoon by undertaking a variety of short to medium-term measures. The important issue to be discussed here is whether and how far do these response measures add to the existing adaptation capacity and would they succeed in enhancing the adaptive capacity in the long-term. Adaptation measures are usually classified as either public or private. Planned adaptation is public adaptation usually undertaken through a deliberate public policy decision, e.g., BRIMSTOWAD being implemented in Mumbai in the aftermath of July 2005 floods. Autonomous or spontaneous adaptation is private adaptation undertaken by households or communities on their own without intervention from the authorities. We have discussed a number of such steps taken up by households and commercial and industrial establishments in Mumbai. This section looks at how the public and private adaptation measures add to the adaptation capacity for which the

> *In respect of the issues associated with climate change, there exists a gap between the scientific knowledge, technical expertise, disaster relief set ups and understanding prevalent in the minds of the public representatives and the public at large which needs to be bridged in order to effectively address the issues and to generate proper consensus on the required defence mechanism, preventive actions or ameliorative measures to be contemplated.*
>
> *---Fact Finding Committee on Mumbai Floods, March 2006*

data gathered from citizens through primary surveys, government reports and personal interviews carried out with government officials are being used.

As for the public adaptation measures undertaken in Mumbai, there are a number of issues that need to be highlighted here:

- BRIMSTOWAD is a major policy initiative that is expected to improve the existing and age-old storm water drainage system in Mumbai and replace it with the one that will be much more effective in dealing with greater intensity rainfall. Once the project is implemented completely, it is expected to improve the flood situation in Mumbai as the new system is being designed for 50 mm rainfall per hour instead of 25 mm per hour design currently in place. Also, the project has been designed for the runoff coefficient of 1 instead of 0.5 due to the land use changes that have occurred in the city in past few decades. Thus BRIMSTOWAD is expected to increase the adaptation capacity of the city for flash floods caused by heavy intensity rainfall in future.
- However, if an extreme weather event like July 2005 were to occur again in the next few decades, even the design criteria used under BRIMSTOWAD will not be enough to cope with the ensuing floods in low-lying areas. Thus, we need to note this that the residual impacts of the weather events would still be faced by the city and cannot be done away with completely. But the magnitude of such impacts is likely to reduce given the new design of the storm water drainage network.
- In addition to revamping the storm water drainage network, MCGM has started clearing clogged drains every year before monsoon. Regular widening and desilting of drains is undertaken. However, there are multiple agencies involved in this, such as, MMRDA, Public Works Department, Railways, Mumbai Port Trust and Airport Authority of India. Unless there are coordinated and well synchronized efforts undertaken by these agencies, isolated efforts will not help in the long-run to cope with floods.
- As regards the disaster management plan formulated by the local authorities, the plan is quite comprehensive and defines the role of different stakeholders as seen in the earlier discussion. However, the plan is generic in nature and has less operational value as pointed out by the fact finding committee. Also various planning and implementing agencies in Mumbai often operate as islands making it difficult to have a well coordinated response in case of disasters or weather events.
- The DMAP looks comprehensive on paper, yet does not provide any specific timeframe for achieving the mitigation measures. Again, no specific attention is given to adaptation strategies which may be more important in the short to medium-term to deal with the climate risks of flooding, storms and cyclones.
- There are a number of steps taken up by the civic authority, MCGM in recent years based on the recommendations of the fact finding committee, to improve the disaster response and management. Accordingly, the rainfall data are now available with the automatic weather stations for 15-minute interval which can be used to issue early warning to ward control rooms. This will improve the response and coping capacity in the long-run. The 15-minute interval rainfall data over a number of years in future can also be used to analyze the intensity and pattern of rainfall in the city and early warning systems and response measures can be improvised accordingly.
- The early warning system currently being used by the control room looks effective on paper. Regular information regarding rainfall intensity and traffic diversion is given to the general public through the website maintained by the MCGM. Yet, the awareness levels regarding such systems are very poor. For example, our primary survey reveals that 91% households did not even know about the DMC and 99% were not aware of the website that gives out such information. 88% were not aware of the emergency contact number. Thus, awareness-building is the key to making early warning systems effective and add to the coping capacity in future.

- The disaster control at the central level is found to be well managed, but there are shortcomings at the ward level like the shortage of trained staff and often the junior engineers have to manage the control rooms at wards on rotational shifts. Also, the ward officers have stated that the approach is essentially top-down and they have very little say and flexibility in implementing response measures. Many affected wards that we interviewed have also complained of BRIMSTOWAD getting delayed and work slowing down as memories of July 2005 fade fast. Further, there are delays in sanctioning projects at ward level and knowledgeable officers are frequently transferred before such projects are underway.
- Measures related to infrastructure improvements would require a longer time frame given the socio-economic and political dynamics in the city. Also, the land use policies and planning will not be effective unless they are coupled with strategies to deal with slum settlements and migrants into the city. The experience of the city dwellers in the aftermath of 2005 floods only shows that the city administration and other stakeholders would need more specific strategies and an integrated approach to build resilience of the city to climate risks.
- As for the planning process, development planning takes environment into consideration at the generic level. But climate risks and associated impacts of heavy precipitation, sea level rise and storms are uncertain and varied in nature. Therefore, the planners feel that it is not feasible to include climate risks into the planning process per se. What is needed is more scientific knowledge base related to such risks, their impacts on the city and technical knowledge related to how we can mitigate and adapt to such risks. This would increase the possibility of mainstreaming climate risks and adaptation into the planning process.

Given the public response measures like revamping the storm water drainage network and improving the disaster response strategies plus the regular cleaning and desilting of drains, it is pertinent to examine what has been the experience of the citizens as regards intensity and depth of flooding post 2005 event. In subsequent years, the intensity of flooding has not reduced as reported by 65% respondents. However, the depth of flooding on average since the 2005 event has been around 2 ft. But some areas have reported 3-4 ft. water levels inside their homes and establishments. 42% households also reported that their house has experienced flooding for about 4 days in recent years. Further, 85% respondents are of the opinion that the local government authorities are not doing enough to prevent flooding in the city. 87% feel that it is the primary responsibility of MCGM to prevent floods in the city, but 60% also feel that the state government should also actively take this responsibility. It is further interesting to note that 85% of the respondents are aware of climate change and most consider the problem as either very serious or serious. Majority of them (84% of respondents) also feel that the authorities should have better infrastructure in place to deal with climate risks and more than 42% are of the opinion that quick response is the key to dealing with the adverse impacts of climate change.

As regards the efficacy of private response measures in enhancing the adaptation capacity to deal with floods in the long term, it is too early to evaluate this given the information we received through the primary survey. This is the only study carried out so far in Mumbai that has tried to capture private responses. It must be noted that these responses are strictly private in nature with individual initiative and without any public or government intervention in it. As such there are no benchmarks to evaluate how efficient these responses are. Many responses like repairing the premises are essentially short-term in nature, whereas responses like raising the plot level, raising other infrastructure like electric meters to protect them from flooding would be expected to have medium-term impact on the adaptation capacity. What must be highlighted over here is that all private initiatives and responses are a direct out-of-pocket expense for the concerned individuals or establishments. There is virtually no insurance cover that would help them to deal with the adverse impacts of floods and bring about changes or improvements in the existing infrastructure.

6. Conclusion

To summarize, the study carried out for Mumbai assesses the impacts and responses to the July 2005 catastrophic flood event in Mumbai. Unlike the impact assessments which focus on insured losses to property and infrastructure, this study has tried to capture physical and economic losses suffered by households and commercial and small industrial establishments that are essentially uninsured in nature. We have also tried to identify the short to medium-term responses coming from the local government as well as citizens themselves. The study also looks at how and if at all these responses add to the adaptation capacity of the city in the long run and what are the policy implications of the findings for the long-term development and investment planning. Some of the highlights of the study are given below:

- The extent of vulnerability of the city to climate risks, in particular, heavy precipitation and flooding is assessed here. We find that the city is vulnerable to climate risks due to its proximity to sea, flood prone topography, large scale reclamation done for further development, huge population with more than half staying in informal settlements or slums and inadequacy of basic civic services for water, sanitation, solid waste and public health.
- The review of scientific literature further highlights how the city is at great risk from sea-level rise, heavy precipitation and flooding, high winds, cyclones and coastal erosion. Further, with imminent climate change in future, an event like July 2005 could become more frequent, the flood footprints might deepen in more vulnerable areas and the costs of such events would also go up dramatically.
- The catastrophic event of July 2005 with unprecedented heavy rainfall of 944 mm in a single day disrupted the life in the city completely with millions affected due to near shut-down of electricity, water supply, transportation and communication services.
- There was massive damage to municipal and private infrastructure with costs of damages estimated at US$ 68 million. The private sector establishments suffered massive losses as it took 1-2 weeks for the city to back to normal. There are some estimates which show that the losses might have been as high as US$ 1100 million.
- When damage or impact assessments for such events are undertaken, the focus is largely on insured and direct physical and economic losses which are easily measurable. However, out study shows how insured losses are only a fraction of the total loss that citizens suffer from in the event of extreme weather events
- As seen from the extrapolated costs, there are huge costs that city residents have to bear. For example, our estimates indicate that the households might have spent around US$ 267 million on account of repairs or replacements of damaged assets. There is increased incidence of health impacts such as malaria, dengue and typhoid as well in the aftermath of the floods. But we have not been able to estimate the costs of health impacts due to inadequacy of data.
- For the commercial and small industrial establishments, we have estimated US$ 90 million spent on account of repairs or replacements and US$ 59 million on account of flood water entering the premises, subsequent clean up, loss of income and emergency expenditure.
- It must be noted however that these are only rough and indicative estimates for the costs of damage faced by the households and largely informal private sector in Mumbai. The actual costs may be much higher as our assumptions are quite moderate. For cities in the developing world, these findings are quite relevant as there is a large presence of informal sector whose losses do not get accounted for, although they form a substantial part of the overall costs.
- Further, for a city like Mumbai with more than 50% population living a destitute life in slums with unsafe and unhygienic conditions, weather events mean substantial costs on account of physical, economic, social and health impacts. In our primary survey, for majority of the households, the average family incomes are in the lower middle-income category of INR 5000-15000 per month (US$ 100-300). For such households, the physical and economic losses as indicated in Section 3 earlier are substantial.

- The most important issue here is that for almost all the households and private sector establishments, the costs of damages are out-of-pocket expenses due to the absence of insurance cover or aid or financial assistance coming from the government.
- Besides the direct losses, there are a variety of indirect impacts which are difficult to measure but are equally important. This study has tried to capture some of the impacts like non-availability of food and other essential supplies, disruption of electricity services by using proxies like daily octroi collections at entry points to the city and daily electricity supplied by a private utility.
- The study has further looked at responses from the local government institutions, households and private sector. Some of the public and private responses have the potential to enhance the medium to long-term adaptation capacity of the city to cope with future floods. However, there is a need to address the larger issues of climate risks in the development planning for the city.
- As of now, planning looks at these issues in a generic manner. Given the uncertainty associated with climate risks in future and given the lack of scientific and technical knowledge base regarding these issues at the local level, planning process is not equipped to integrate adaptation to climate risks into mainstream planning and substantial efforts in this direction are required in future.

The findings of this study in a way highlight the costs of inaction if very little is done in future to enhance the coping capacity of the city for future weather events and climate risks in general. Mumbai is currently in the process of drafting the new development plan that is expected to be implemented in the near future. The findings of this study put forth a convincing argument that adaptation strategies needs to become a part of mainstream planning while devising strategies of developing infrastructure, housing, transport network and other facilities and services in the city. Although adaptation is costly, the costs of inaction can prove to be costlier. Hence, there is a need for integrated and coordinated efforts from all agencies including local government, planners, public utilities and community at large to work towards greater adaptation to future climate risks for the city.

References

1. UN-HABITAT, Urbanization Facts and Figures, World Urban Forum III, An International United Nations Human Settlements Programme, Event on Urban Sustainability, Canada, 2006
2. MCGM, (2007), Statistics on Mumbai, Municipal Corporation of Greater Mumbai, available at http://www.mcgm.gov.in
3. *Ibid.*
4. MMRDA, (2007) Basic statistics on MMR, Mumbai Metropolitan Region Development Authority, http://www.mmrdamumbai.org/basic_information.htm
5. MCGM, (2003), Environment Status Report 2002-03, MCGM
6. MPCB, (2005), Report on Environment Status of Mumbai Region, Maharashtra Pollution Control Board, Government of Maharashtra
7. Govt. of Maharashtra, (2007), Greater Mumbai Disaster Management Action Plan, Maharashtra Emergency Earthquake Management Programme, Govt. of Maharashtra
8. *Ibid.*
9. *Ibid.*
10. *Ibid.*
11. MMRDA, (2007) Basic statistics on MMR, Mumbai Metropolitan Region Development Authority, http://www.mmrdamumbai.org/basic_information.htm
12. Govt. of Maharashtra, (2007), Greater Mumbai Disaster Management Action Plan, Maharashtra Emergency Earthquake Management Programme, Govt. of Maharashtra
13. Bhide, A. (2009). Shifting Terrains of Communities and Community Organization: Reflections on Organizing for Housing Rights in Mumbai, Community Development Journal, Vol. 44, No. 3 pp. 367-381
14. MCGM, (2009), Mumbai Human Development Report 2009
15. *Ibid.*
16. Govt. of Maharashtra, (2006), Economic Survey 2006-07, available at http://www.maharashtra.gov.in
17. RBI, (2007), Handbook of Statistics on Indian Economy, available at http://www.rbi.org.in
18. World Bank, (2005), For a Breath of Fresh Air: Ten Years of Progress and Challenges in Urban Air Quality Management in India, 1993-2002, Environment and Social Development Unit, South Asia Region, The World Bank (India Country Office), New Delhi, India
19. IMD, www.imd.co.in
20. MCGM (2010), Flood Preparedness Guidelines 2010, www.mumbaimonsoon.com
21. MCGM (2006), Fact Finding Committee on Mumbai Floods , Final Report, Volume I, March 2006
22. *Ibid.*
23. *Ibid.*
24. MCGM (2010), Flood Preparedness Guidelines 2010, www.mumbaimonsoon.com
25. MCGM (2006), Fact Finding Committee on Mumbai Floods , Final Report, Volume I, March 2006
26. Sherbinin A., Schiller A. and Pulsipher A., (2007), The Vulnerability of Global Cities to Climate Hazards, Environment and Urbanization, Vol. 19(1), Sage Publications on behalf of International Institute for Environment and Development
27. *Ibid.*
28. *Ibid.*
29. Hallegatte S., Coastal Cities, Climate Change Vulnerability and Adaptation, OECD Project led by Jan Corfee-Morgot, available at www.oecd.org/dataoecd/31/34/44104953.pdf
30. OECD (2008), Ranking Port Cities with High Exposure and Vulnerability to Climate Extremes: Exposure Estimates, Environment Working Papers No. 1
31. Hallegatte, S. et al. (2010), "Flood Risks, Climate Change Impacts and Adaptation Benefits in Mumbai: An Initial Assessment of Socio-Economic Consequences of Present and Climate Change

Induced Flood Risks and of Possible Adaptation Options", OECD Environment Working Papers, No. 27, OECD Publishing. doi: 10.1787/5km4hv6wb434-en
32. MCGM (2006), Fact Finding Committee on Mumbai Floods , Final Report, Volume I, March 2006
33. *Ibid.*
34. *Ibid.*
35. *Ibid.*
36. Govt. of Maharashtra (2005), Maharashtra Floods 2005, Relief and Rehabilitation Department, Govt. of Maharashtra
37. World Bank (2004), Understanding the Economic and Financial Impacts of Natural Disasters, Disaster Risk Management Series No. 4, The World Bank, Washington DC
38. *Ibid.*
39. *Ibid.*
40. MCGM (2005), Report on Relief Measures and Damage Assessment due to Heavy Rains on 26th July 2005
41. Govt of Maharashtra (2005), Maharashtra Flood Damage 2005
42. MCGM (2006), Fact Finding Committee on Mumbai Floods , Final Report, Volume I, March 2006
43. Govt. of Maharashtra, (2007), Greater Mumbai Disaster Management Action Plan, Maharashtra Emergency Earthquake Management Programme, Govt. of Maharashtra

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Annexure

Table A1: Ward-wise details of the sample selected for primary survey

F North	5,24,393	177	102
F South	3,96,122	103	149
H East	5,80,835	176	98
K East	8,10,002	241	139
L Ward	7,78,278	231	204
P North	7,98,775	240	100

Table A2: Details of personal interviews

Mr. Minesh Pimple	Asst. Municipal Commissioner	MCGM
Mr. Palwe	Asst. Shift In- charge	MCGM
Mr. Mahesh Narvekar	Chief Officer, DMP & CCSRS	MCGM
Mr. A.A. Pawaskar	Asst. Engineer (Repairs & Maintenance)	MCGM
Mr. H.A. Kale	Asst. Municipal Commissioner	MCGM
Uma Adusumilli	Chief Urban Planner	MMRDA
Mr Kamble	Asst Engineer	MCGM
S.Y.Kurhade	Asst Commissioner	MCGM

Figure A1: Ward map of F South

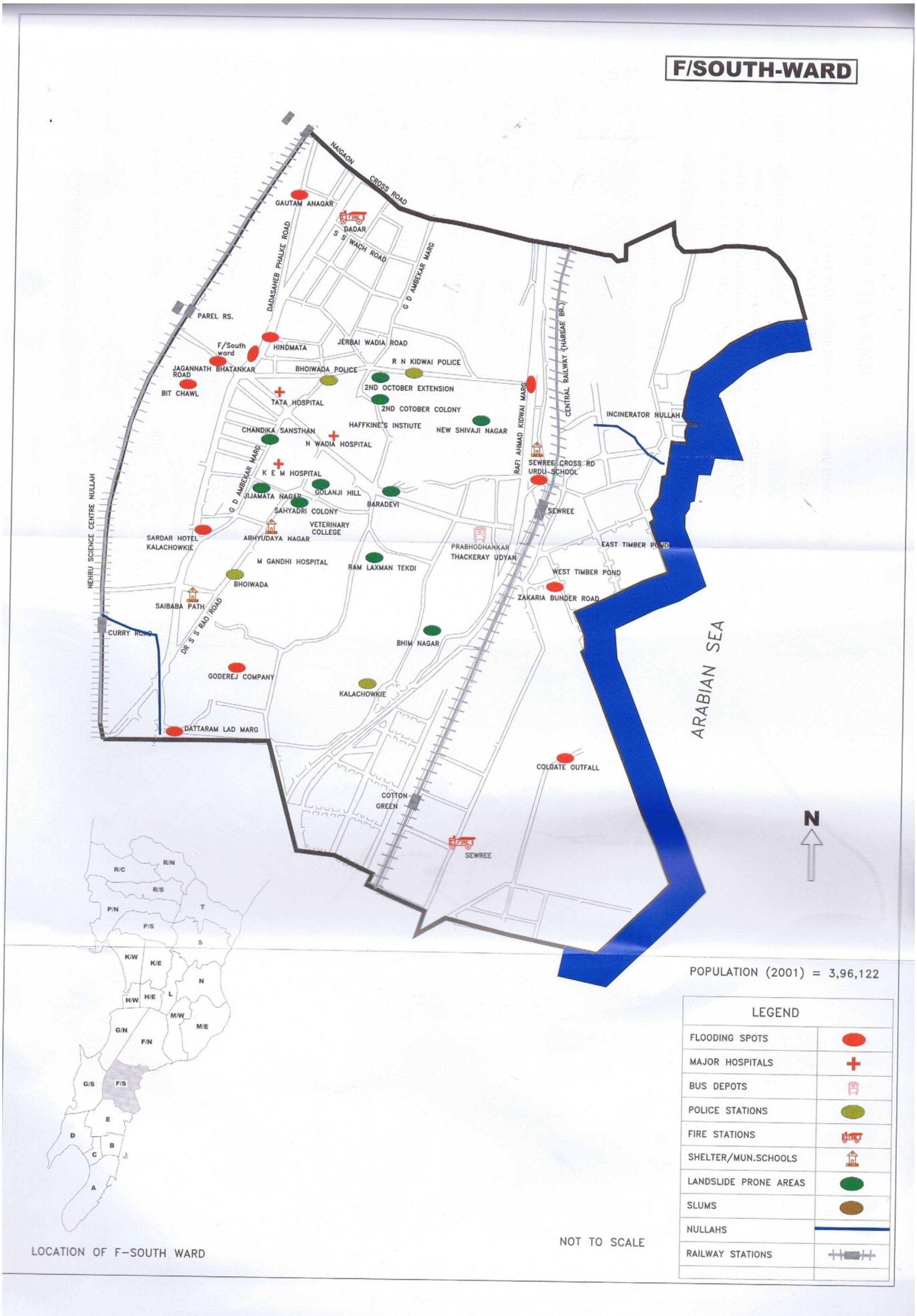


Figure A2: Ward map of F North

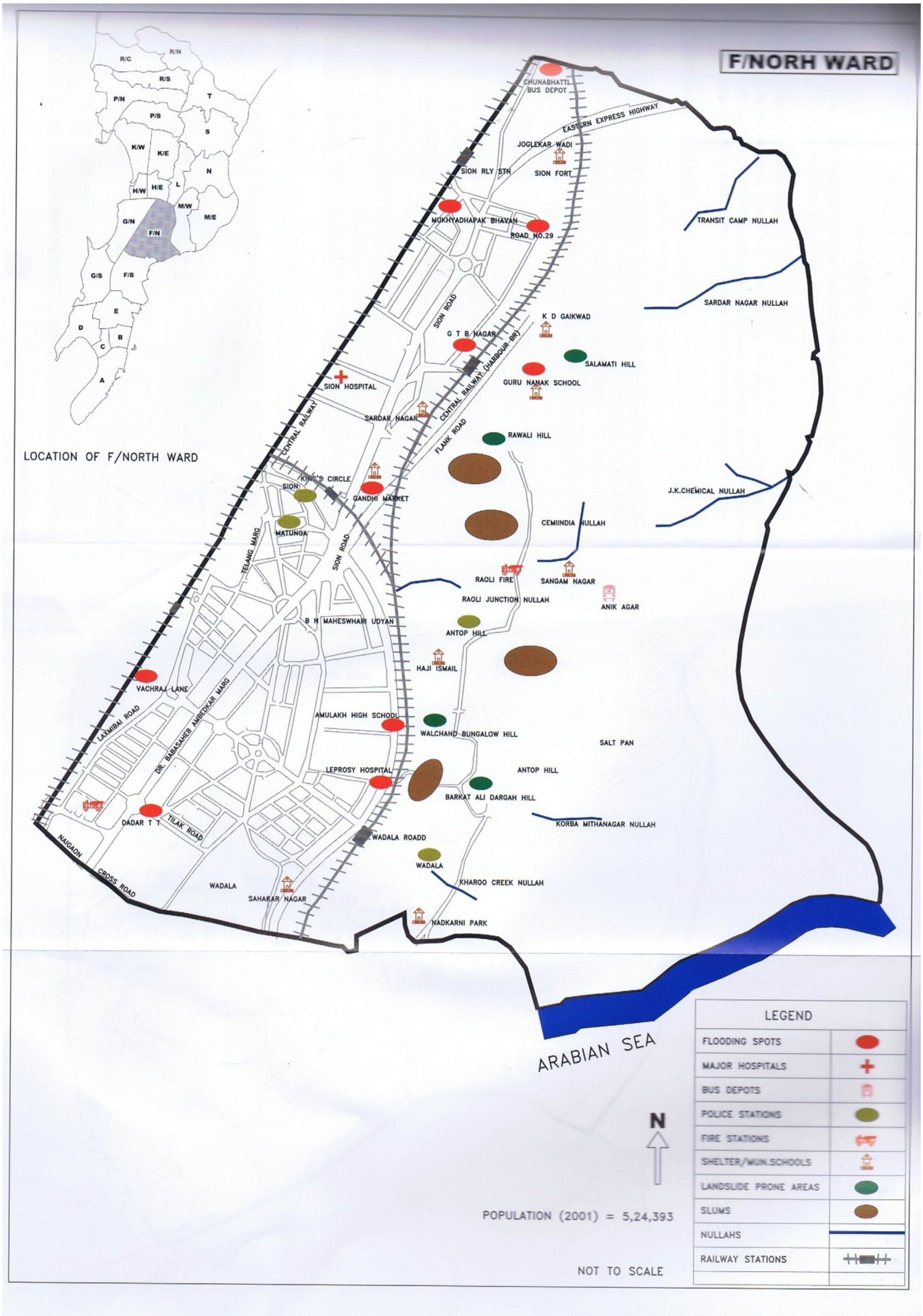


Figure A3: Ward map of H East

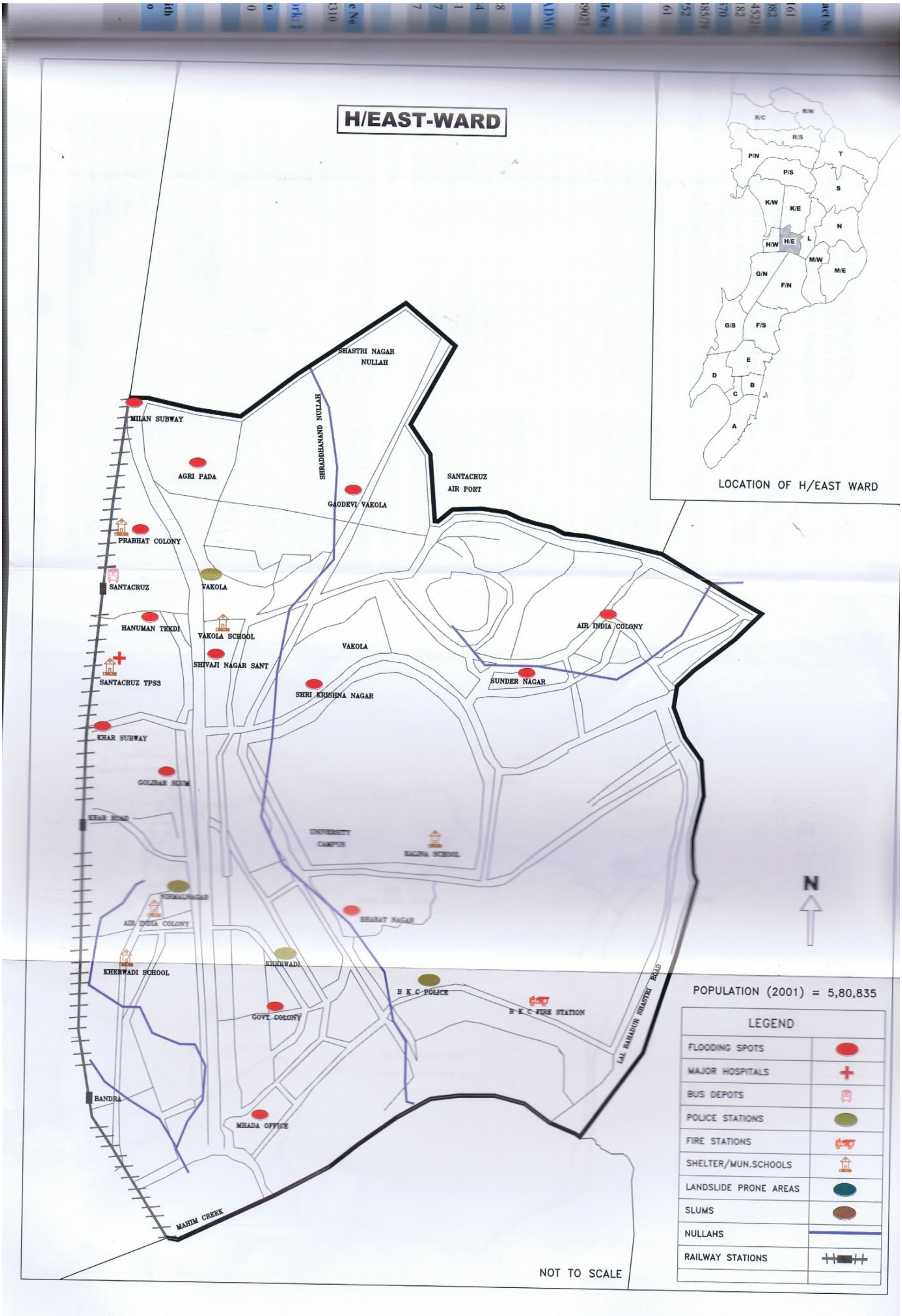


Figure A4: Ward map of K East

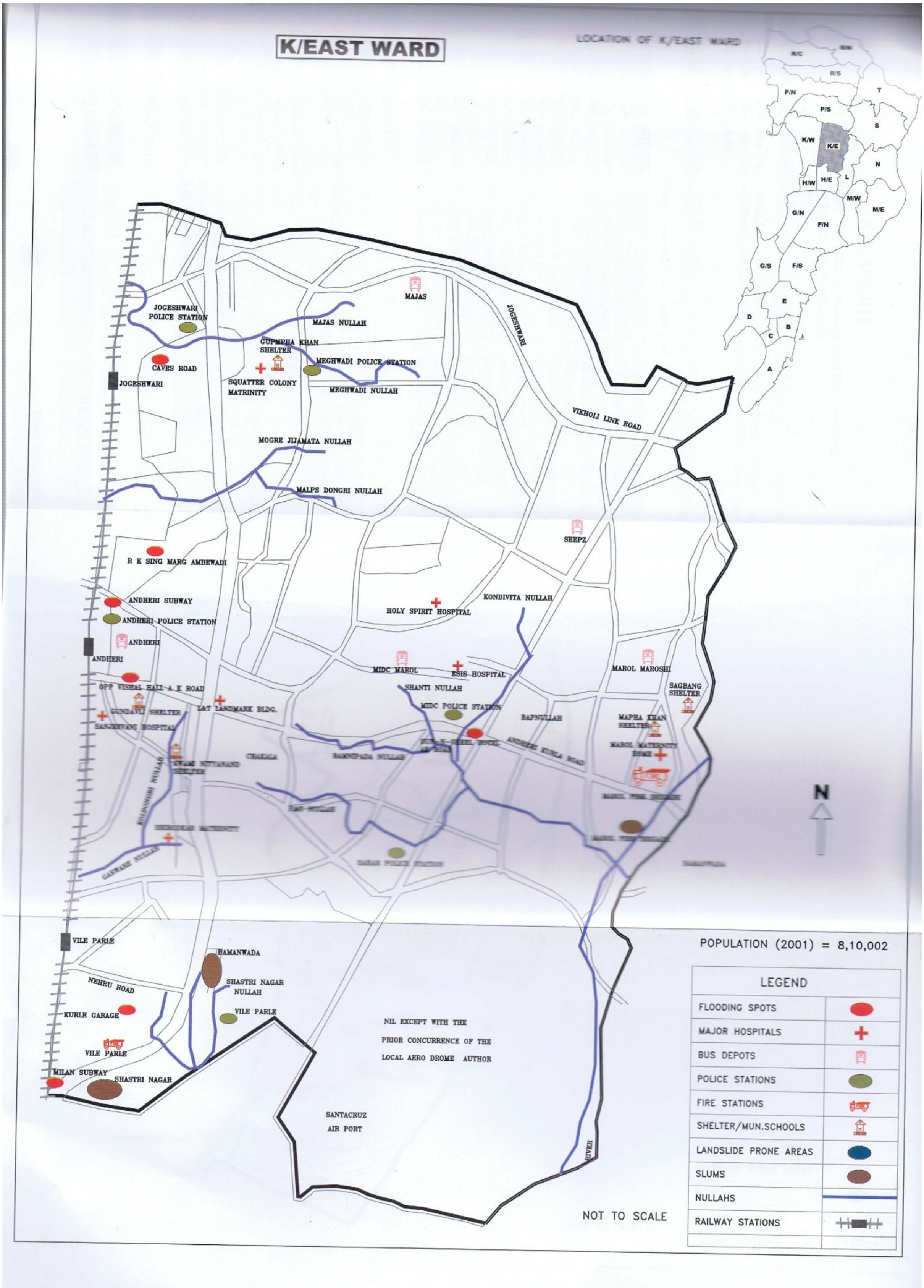


Figure A5: Ward map of L Ward

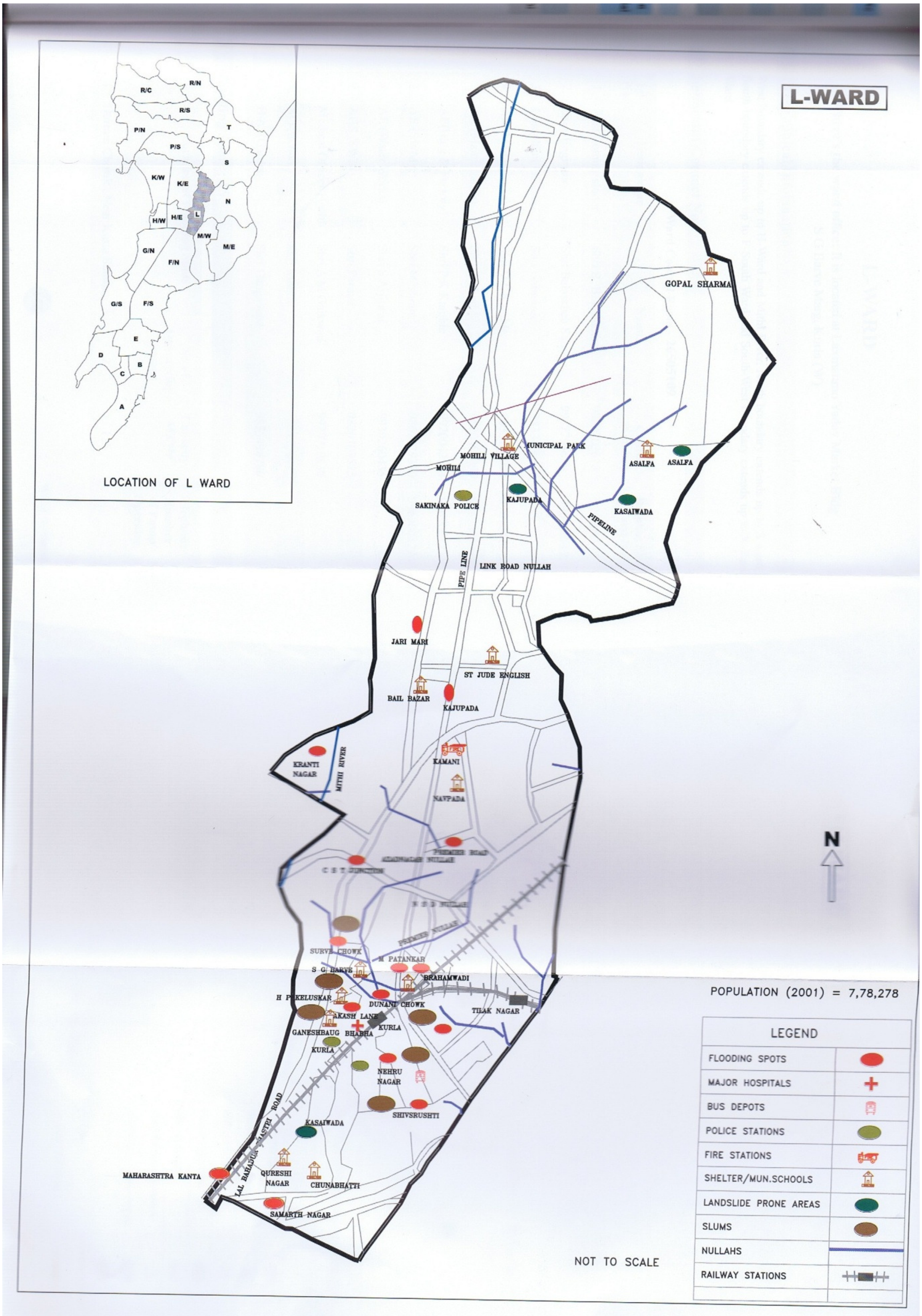
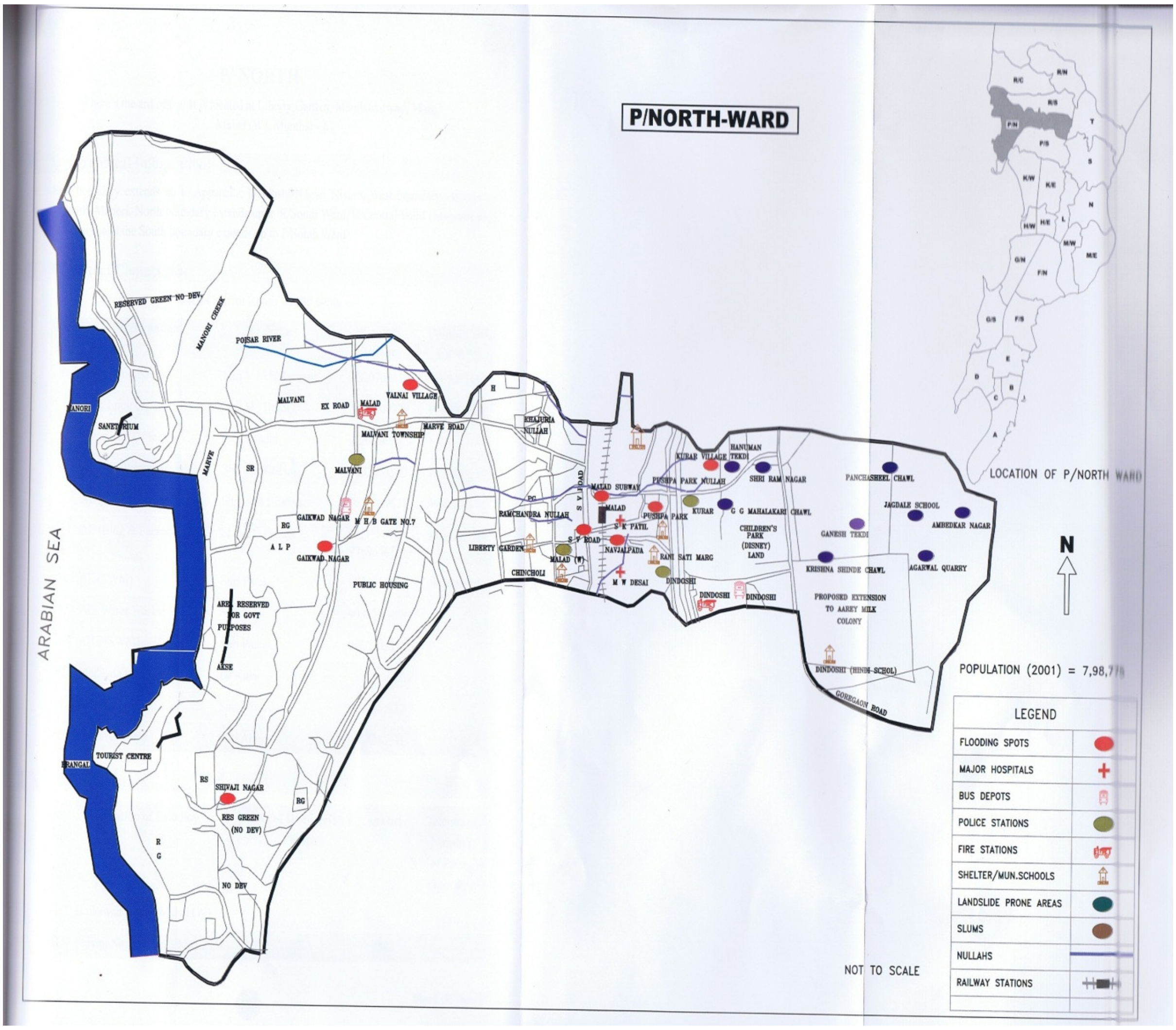


Figure A6: Ward map of P North



7.2 Case study of Bangkok

Enhancing Adaptation to Climate Change by Integrating Climate Risk into Long-Term Development Plans and Disaster Management

A Case Study of Bangkok

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Report Editor: *Peter Grant*

Introduction

Bangkok is not only Thailand's political, economic and administrative capital, but also a regional and global hub. In recent decades, it has transformed from a compact urban core into a sprawling megacity. Today, in addition to the original centre, the city also extends into its five neighboring provinces and forms a single agglomeration, the Bangkok Metropolitan Region: around 15% of the country's population resides here. However, alongside its economic and demographic vitality, Bangkok is highly vulnerable to climate change and other environmental issues. In particular, due to the 'three waters' of runoff, rain and sea rise, together with its low-lying topography of 1.0-2.0 meters, much of the capital is prone to inundation. Section 1, **Bangkok: An overview**, summarizes these issues and presents some of the key data.

Despite the city's extensive flood-protection system, comprising not only the historic network of canals but also the more recent development of the King's Dyke and additional drainage and pumping infrastructure, it is clear that Bangkok is still vulnerable to major flooding. Floods have been a regular occurrence in Bangkok throughout its recent history, with major events occurring in 1942, 1978, 1980, 1983, 1995, 1996, 2002 and 2006, the year of the case study in this report. During the field research in 2011, however, the city experienced its worst flooding in more than fifty years. Yet this vulnerability will only increase in the future, when it has been projected that the city will be unable to withhold more than a 1-in-10-year flood event, due to the expected effects of climate chance and land subsidence. Combined, these environmental factors are forecast to increase the costs and coverage of flooding substantially: in an A1F1 climate scenario, the costs of a 1-in-30-year flooding event are estimated to rise from $1.059 billion in 2008 to as much as $4.454 billion in 2050. The city's exposure, both in assets and population, will also be substantially increased by its forecast levels of growth in its built up area and its spatial extension. According to the OECD, by 2070 Bangkok will be the seventh most vulnerable coastal city in the world to flooding in terms of population, and the tenth most vulnerable in terms of assets.

Section 2, **Case study: The 2006 flood**, presents the background to Bangkok's flooding in 2006. The 2006 flood was precipitated, as with other major flood events, by several factors. Heavy continuous rain brought on by a tropical depression in the region led to intense localized rainfall in the city at the beginning of October. At the same time, large volumes of runoff were flowing in from the north: 85% of the annual rainfall as concentrated in September and October, while much of the upstream dam capacity was strained to its limits. Finally, at critical moments in late October and early November, the sea level rose to a peak of 2.22MSL: the maximum threshold before the Chao Phraya riverbank begins to flood is 2.5MSL. The city centre was protected, but the areas north of the city were allowed to flood, with flood flows also directed to the east of Bangkok. This report profiles the effects in four case study districts in the eastern suburbs of Bangkok: Minburi, Nong Jork, Lat Krabang and Klong Samwa. All of them are in Bangkok's traditionally agricultural hinterland and located at a very low land elevation of 0.8-1.5 MSL. Each of them has distinct physical, social and economic characteristics, yet all were impacted to varying degrees by the flooding and reflect Bangkok's rapid urbanization in their mix of agricultural, industrial and residential uses. Importantly, the areas also illustrate the experience of the many residents living outside the inner city's established polder system.

Section 3, **Impact assessment of the flood**, begins with an overview of the available secondary data on the impact of the flooding. Damage assessments should be holistic, reflecting not only the economic costs but also the environmental, social, psychological and health effects. Yet the official data is generally technical in nature, concentrating on infrastructure damage and compensation disbursements, and national in focus with little disaggregation at the district or community level. As a result, the local and non-physical impacts of the flooding are largely overlooked. Consequently, the research team on this study selected a total of 380 sample households, businesses and industrial estate to develop a more comprehensive picture of the flood. Using semi-structured surveys in sample communities within the districts, the team employed a series of sub-proxies, including physical damage, health costs, transport and work absence, to assess the direct and indirect flood-related costs to communities, businesses and individuals in the 2006 flood. This was with the aim of developing a more fine-grained understanding of the true costs of the flooding, particularly to socially vulnerable groups. The team also analyzed the flood protection measures of Bang Chan Industrial Estate, Minburi, and hosted a community workshop with stakeholders, researchers and a hydrological expert from the Ministry of Natural Resources and the Environment.

The results highlight the importance of a localized analysis of the impacts of flooding, as both the intensity and the nature of its effects vary considerably from district to district. Of the four, Minburi was the worst affected, particularly as residents suffered loss of livelihood as a result of the economic disruption and health threats. As with the other districts, the indirect costs of the flooding at times exceeded the direct physical damage, though this is not generally recognized in official assessments. The research findings highlighted the significance of work absence as a major indirect cost: while the impact on individual households was relatively moderate, the agricultural sector was severely affected. Medical care was another indirect expense for inundated communities with the spread of diseases such as dengue fever and foot-and-mouth disease.

Another important finding was that that the costs of the flooding, through lost income and damaged infrastructure, was generally more severe for the community as a whole than individual households. If the impacts at a community level are more severe, as these results suggest, then this would reinforce the importance of collective adaptation and mitigation strategies at a community level. Currently, preparedness in the event of extreme flooding is generally undertaken privately by individual households, with government encouragement focusing on self-reliance and personal initiative. But to minimize the very substantial community-wide costs of the flooding, there needs to be a platform for collective action.

The research also disaggregated its findings by income group and occupation to develop a clearer picture of the effects of the flooding on different groups. One significant finding was that the work absence levels of the poorest households were, as for more affluent households, relatively low. This suggests that, contrary to what might be expected, the poorest households demonstrated a relatively strong adaptive capacity. Economic insecurity may be a significant element in this, however, and further research is required to ascertain the nature of their adaptation strategies.

The results also highlight the varying impacts on different business and occupational sectors. Farming, according to the survey results, was the worst affected within the agricultural sector, with levels in excess of a foot lasting over a month. Fisheries, on the other hand, though less vulnerable to direct physical damage, was most exposed to the rising production costs as a result of the flooding. As for small businesses, the impact was less straightforward and depended in particular on the product of the enterprise. While the service sector was weakened by flood-related disruption, demand for basic consumer goods actually rose among residents who were more dependent on local shops to provide them with food and other provisions. Again, these nuances potentially have important implications for how post-disaster economic recovery strategies should be targeted.

Section 4, **Adaptation Responses**, outlines the recent adaption responses in Bangkok, particularly since 2006. These responses have been largely structural in nature and focused primarily on mitigation. Yet Bangkok's future will depend in great part on its capacity for long term adaptation to its flood risk: the city should be aiming for a state of 'safe failure' where in the event of major flooding exceeding the capacity of its protective infrastructure, the effects are minimized. This can only be achieved if efforts are infrastructure is supported by non-structural measures, such as better land use regulations. Another persistent issue is the fragmented and divisive nature of governance in Bangkok, particularly its flood management structures. In addition to the complex and often conflicting mandates of different ministries, tensions exist between national and municipal authorities, and even within the Bangkok Metropolitan Region (BMR) the different provinces have autonomous administration with limited coordination between them. Furthermore, there is also very limited participation, between the authorities the private sector and local communities, making collective adaptation a remote possibility.

Section 5, **Conclusion: Mainstreaming adaptation into long-term planning**, drawing on the findings of the research team, highlights some of the main policy directions the city's future strategic framework should follow. A long term adaptation strategy that is collective and participatory, guided by adequate data and a deeper recognition of the complex social dimensions of flooding, is crucial. Together with substantial national and municipal governance reform, this approach will help to address these challenges and preserve Bangkok's immense social and economic vitality.

1. Bangkok: an overview

1.1 City Demographics and Urbanization trends

Bangkok, the capital of Thailand since 1782, is not only the country's political centre but also its administrative and economic heart. Located on the lower plain of the Chao Phraya River Basin, the city is now a sprawling urban agglomeration and one of Asia's emerging megacities. The sheer pace of its spatial and demographic growth has meant that Bangkok itself has had to be continuously redefined. The city is now classified as the Bangkok Metropolitan Region (BMR), an area of around 1,569 km^2 that includes the five adjacent provinces of Samut Sakon, Nakhon Pathom, Nonthaburi, Pathum Thani and Samutprakarn.

Bangkok's status as the country's largest demographic concentration is unquestioned, with an estimated 15% of Thailand's population located in the greater Bangkok metropolitan area. This reflects a long historic trend, going back to the late nineteenth century, of disproportionate demographic growth in Bangkok. By 1937, for instance, the BMA's population was already 15 times that of Chiang Mai, its closest urban competitor and the country's largest urban settlement after Bangkok. By 1991, Bangkok was 41 times the size of Nakhon Ratchasima, at that point the country's second largest city, ahead of Chiang Mai. The exact number of Bangkok's rising demographic remains unclear, however, and estimates vary considerably. According to the National Statistics Office (NSO), Bangkok's population in 2009 was at 5.701 million – but UN DESA data puts it considerably higher, at 6.902 million. Other figures put the population at almost 10 million or even more, once unregistered migrants are factored in. In part, these discrepancies may reflect different perspectives on what constitutes Bangkok geographically: Bangkok City, the BMA or the BMR. Furthermore, for a number of reasons the official data may underestimate the true extent of the population: in 2000, for instance, while the number of registered residents was only 6.3 million, the actual population was thought to be closer to 8.9 million. The capital's demographic boom is projected to continue into the future. By 2050, according to one projection, the population will have reached 10.55 million in Bangkok City, and almost 16 million in the BMR as a whole.

This consolidation has been sustained by a long period of accelerated economic growth in the capital: much of Thailand's industrial and commercial capacity is concentrated within metropolitan Bangkok, as well as the bulk of its communications and transport infrastructure. In 2006, the year of this case study, the BMR generated 43% of Thailand's GDP. As a result, given its accelerating growth and status as Southeast Asia's main business hub, the capital continues to act as a population magnet, both nationally and globally, for migrants in search of employment opportunities. While Thais from other parts of the country, particularly areas where traditional livelihood opportunities such as agriculture have been contracting, have migrated to the capital in growing numbers, Bangkok also continues to attract large volumes of international migrants from adjacent countries and other regions.

This economic primacy, together with the expanding population that it attracts, are major dimensions in the city's increasing vulnerability and exposure to flooding. When a major flood event affects Bangkok, it not only threatens the political and administrative functioning of the capital, but also puts much of the country's factories and industrial parks at risk - and by extension, the homes and livelihoods of hundreds of thousands of the city's residents. The nature of Bangkok's development is also significant: the various symptoms and side effects of urbanization in Thailand are particularly pronounced in the capital. This is particularly evident in the rapid pace of Bangkok's urban growth. In recent years this growth has been particularly intense throughout the metropolitan region: the BMR saw a 74% increase in urban development between 1998 and 2003 alone.

However, it is not just the speed but also the nature of this change that poses serious challenges for Bangkok's future, particularly with regards to flooding. One of the city's most visible characteristics, driven by the growing population and other factors such as rising car ownership and weak planning regulations, is the accelerating spatial expansion towards its periphery – the 'suburbanization' of Bangkok. Economically, this is already clear from the spread of industrial development into what is termed the Extended Bangkok Metropolitan Region (EBMR), an extended region comprising the BMR and the Eastern Seaboard, a total of 19 provinces: in 2001, it accounted for 68% of the country's nominal GDP. But it is also reflected in the relocation of the city's residents in increasing numbers to the margins of the metropolis. In Nonthaburi Province, for example, the population grew by 47% during 2002-2007. Within the city centre, on the other hand, population density has declined. Though it increased throughout the 1970s and 1980s, this trend reversed sharply in the 1990s and by 1998 was only 155 persons/ha, compared to 222 persons/ha in 1970. While the population of inner Bangkok decreased from 3.25 million in 1978 to 2.86 million people in 2000, the population in the outer areas of Bangkok increased from about 670,000 to 1.12 million people during the same period. It is likely that the majority of its future growth will be in satellite developments in its metropolitan areas, rather than the city centre.

A second important element in Bangkok's development is its transition from water-based urban form, when the city fabric was designed sympathetically around natural climate and hydrology, to an impermeable "concrete pad". For instance, until recently Bangkok benefitted from a complex network of canals and water catchments to assist flood drainage. However, with dramatic redevelopment of the city, much of this system has disappeared beneath highways, factories and housing. This has substantially weakened its capacity to cope with heavy rain. Furthermore, the fabric of the capital has moved away from traditional "amphibious" structures that were designed in response to environmental threats, in particular its low-lying topography and flood-prone hydrology (described in section 1.2), to modern urban forms often less adaptive to local environment.

1.2 Climate and Coastal Vulnerability

1.2.1 Natural Environment and Hydrology

Bangkok spans a total of 1,569 km^2 in the lower part of the Chao Phraya River Basin. This is the largest basin in the country and at 159,000 km^2 amounts to around 35% of the country's entire land mass. Four main tributaries converge at Nakhon Sawan, a province north of Bangkok, and become the Chao Phraya River. This continues to flow south through the capital and out into the Gulf of Thailand. The river's flow capacity varies considerably from as much as 4,000 CMS in NakornSawan and Chainat, to 1,500 CMS in Ayutthaya and 3,000 CMS in Bangkok. The average annual discharge of the river is 770 m^3/s, but can reach significantly higher at certain times, particularly during a flood. In 1995, for instance, it reached a peak of 4,560 m^3/s.

Bangkok itself is located in a low-lying area of the basin, with an average ground elevation of only 1.0-2.0 meters above sea level. Some parts of the city are in fact at sea level as a result of land subsidence. Furthermore, the city is only 33km north of the coast. Its geography therefore makes it naturally susceptible to flooding, both from large volumes of runoff from the north of the country and tidal inflows from the sea. The volume of these floods can be immense: 31,000 million cubic meters for a flooding event with a 1-in-30-year probability. Given its location at the bottom of the alluvial plain, near the mouth of the Chao Phraya, in these conditions Bangkok runs the risk of becoming a 'bottleneck' as the water drains into the Gulf of Thailand, resulting in over 30 days of flooding in many parts of the city.

Bangkok's flood vulnerability is determined by three major water sources – rainfall, river runoff and tidal flows. Consequently, the capital is sometimes known as the "city of three waters". The worst cases are most likely to occur when these three sources combine to make the conditions necessary for a major flooding event.

- **Rainfall:** Estimates of Bangkok's annual rainfall are wide-ranging of rainfall every year, though this varies greatly from year to year: according to one set of figures, rainfall within the Chao Phraya River averages 1,099mm, but may range between a minimum of 354mm and a maximum of 2,471mm. Rainfall also varies greatly from month to month, from as little as 5mm in December to 305mm in September. Peak rainfall patterns typically occur twice yearly, in May-June and September-November. However, the great majority (88%) of this rainfall occurs during the wet season between May and October, particularly in the peak period of September and October, when tropical cyclones occur. Generally, the impact of the rainy season is cumulative and spread out over several months. However, at its most intense, when a heavy spell exceeds the city's drainage capacity, excess rainwater may result in intermittent, localized flooding in low-lying areas.

- **River Runoff:** During the rainy season, water runoff plays a vital role in irrigating the paddy fields and agricultural plains to the north of Bangkok. The surplus runoff then passes through the city's canal network and into the Chao Phraya River, from where it travels through Bangkok down to the Gulf of Thailand. However, though on average the Chao Phraya has a flow capacity of 2,500-3,000 CMS, larger volumes may result in flooding. For example, runoff in excess of 3,500 CMS will raise its water level to 2.1 metres above sea level – high enough to inundate the lowest lying areas of the riverside.

- **Tides:** At certain times, the Chao Phraya River is also strongly affected by the incoming tide from the Gulf of Thailand. The tide levels are cyclical and vary during the day, between -0.5m and 1.5m, though they may rise considerably higher: in 1995, for instance, levels reached 2.5m. However, tidal levels are also affected by seasonal variation, generally peaking in November and December, just after the rainy season has come to an end. The tidal rises are particularly evident in the lower stretch of the Chao Phraya river, between 23 km and 57 km from its mouth. Higher tides, combined with peak river flow from runoff and rainfall, may lead to flooding.

1.2.2 Bangkok's flood protection system

Bangkok's drainage system has been constructed around its extensive 2,606 km network of canals. These *khlong*, 1,655 of them in all, vary greatly in size with the largest spanning a width of 50 meters. Given Bangkok's susceptibility to flooding, the canals play an essential role in draining and conveying storm water through the city to the Chao Phraya River. While much of this infrastructure is a historic legacy from the days when Bangkok was a water-based city and dubbed 'the Venice of the East', the conduits and canals are supported by well-developed technologies including U-shaped boxes, round type drains, pumping stations, movable pumps and gates. However, as discussed in section 1.1, the effectiveness of this infrastructure has been weakened by the city's rapid development, submerging many of its canals and drainage channels beneath concrete.

As the city has intensified and expanded, thus becoming more exposed to the risk of flooding, further measures have been put in place to manage and mitigate the potential effects. However, much of the investment for this has been granted reactively, in the wake of a major disaster. Following the catastrophic floods of 1983, when the Rangsit irrigation areas suffered four months of flooding, the King's Dyke was constructed at the northern and eastern boundaries of Bangkok to prevent water in the eastern flood plain from inundating the city centre. Submersible equipment was also installed in several pumping stations on the Chao Phraya River. Later on, in the wake of the devastation of the 1995 floods, the BMA received government funding to construct 77km of barriers along the river, still ongoing when the 2006 flood hit Bangkok and finally completed in 2010. A Second Master Plan for the Chao Phraya Delta was also developed by a consortium of specialists and the Thai government, with support from the World Bank. This involved a major macro-level review of the causes and consequences of the flood, with a focus on both immediate and long term flood alleviation strategies.

Today, a substantial polder system encloses inner Bangkok, with 10 sub-polders supported by drainage tunnels and pumps to redirect the water into the river. The main roads and rail lines within the protected area serve as the polder's primary dykes. Polder systems have also been developed in the eastern and western areas of the city. In the west, this is supported by a series of dykes by the river and fortified by two *khlong*, the Mahasawas and Bangkok Noi canals, to protect the areas inside the dykes flooding. On the eastern side of the city, the King's Dyke is supported by around 20 retention ponds with a combined capacity of 6 million cubic meters. An additional retention pond in the south has an additional 6 million cubic meters in storage. 7 supersized drainage tunnels have also been constructed to accelerate drainage. These tunnels lie 15-22 meters underground and have a current operational capacity of 95.50 CMS, with another 60 CMS under development. Pumping stations speed the water through them and into the river[10]. During the wet season, a total of 15 sub-polders covering 168 km^2 are in operation to support the drainage of surplus water on either side of the river.

Within the city, then, Bangkok's flood management essentially works through three main methods. Firstly, it prevents the flow of water from outside, through the construction of dykes and embankments. Secondly, it evacuates the water from within the polder with pumps and drainage tunnels. Thirdly, it temporarily stores water in retention ponds or 'monkey cheeks'.[11] Yet Bangkok's

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[10] Department of Drainage and Sewage, BMA (2009). *Flood Protection in Bangkok*. Paper revised from Vitoonpanyakij, C. (2007). Flood protection in BMA 2006.

[11] Bangkok Metropolitan Administration, Green Leaf Foundation and United Nations Environment Programme (2009). *Bangkok Assessment Report on Climate Change 2009*. Bangkok: BMA, GLF and UNEP

relative exposure to flooding is also determined by 'manmade' factors, such as the operation of its dams[12]. In terms of the upstream management of the runoff, much of the monsoon rain is stored in around 3,000 dams and then strategically released for agricultural irrigation during the dry season. The two largest, the Bhumibol and Sirikit dams, together manage the runoff from 22% of the area of the Chao Phraya Basin[13]. The construction of these dams, in 1964 and 1971 respectively, has generally helped reduce flooding risk. Nevertheless, extreme weather events are still capable of exceeding their capacity, to devastating effect: for instance, in 1995, when storms in the upper watershed led to the release of 2,900 million cubic meters of runoff[14].

Despite these considerable investments, funding constraints have nevertheless prevented the city from fully realizing its flood protection strategy. For instance, one important element of the post-1995 Second Master Plan was the construction of a river diversion to eastern Bangkok along the Praong Chaiya-Nuchit canal. However, the high costs of land around Suvarnbhumi airport and associated expenses such as heavy pumping of floodwater at low elevations proved prohibitive, although the scheme was proposed again after the 2006 flooding[15]. Furthermore, as extreme flooding events demonstrate, the existing system is not sufficient to protect large areas of Bangkok from the potential threat of flooding. Though its protective infrastructure has been strengthened greatly in recent decades, Bangkok is still becoming increasingly vulnerable to flooding[16]. Nor is this infrastructure necessarily capable of withstanding major events: for instance, the King's Dyke is designed primarily as a solution to the city's regular low level flooding rather than low frequency, high impact flooding events such as 1-in-50 year events[17]. The projected risks relating to climate change and other environmental and developmental factors, and the implications these may have for the city's future, are examined in greater detail in section 1.3.

1.3 Past food events and future risks

1.3.1 Past events

The particular circumstances of every flood event in Bangkok is unique. Nevertheless, the city's chronic vulnerability is reflected in its long history of flooding, with major events in 1942, 1978, 1980, 1983, 1995, 1996, 2002 and 2006. The floods of 1983 and 1995 were especially intense, with both serving as landmarks that led to substantial investments in mitigation and protection strategies. The latter, estimated to have a 1-in-30-year frequency, flooded 65% of the BMA with depths of up to 2 meters, with some districts still inundated in December[18]. The flooding killed over 400 people and

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12 Sapphaisal, C. (2007). Planning and Flood Mitigation for the Chao Phraya River Basin. Retrieved at: http://www.rid.go.th/thaicid/_5_article/2550/chukiat.swf

13 UNESCO World Water Assessment Programme (2003), Chapter *16: Chao Phraya River Basin, Thailand*. In *UN World Water Development Report 1: Water for People, Water for Life*.

14 ADB/JICA/World Bank (2010). *Climate Risks and Adaptation in Asian Coastal Megacities*, p.25. Retrieved at: http://siteresources.worldbank.org/EASTASIAPACIFICEXT/Resources/226300-1287600424406/coastal_megacities_fullreport.pdf

15 Vongvisessomjai, S. (2007). Flood Mitigation Master Plan for Chao Phraya Delta. Paper presented at the 4th INWEPF Steering Meeting and Symposium. Retrieved at: http://web.rid.go.th/ffd/papers/Paper-Session%201/p1-04%20Flood%20Mitigation%20Master%20Plan.pdf

16 Bangkok Metropolitan Administration, Green Leaf Foundation and United Nations Environment Programme (2009). *Bangkok Assessment Report on Climate Change 2009*. Bangkok: BMA, GLF and UNEP

17 Whereas major urban centres in the Netherlands, for example, have typically designed to withstand a 1-in-10,000-years flood. IRIN, 'How to build a flood-resilient city'. November 28, 2011. Retrieved at: http://www.irinnews.org/printreport.aspx?reportid=94319

18 ADB/JICA/World Bank (2010). *Climate Risks and Adaptation in Asian Coastal Megacities*, p.25. Retrieved at: http://siteresources.worldbank.org/EASTASIAPACIFICEXT/Resources/226300-1287600424406/coastal_megacities_fullreport.pdf

impacted on almost 4 million others in the country[19]. More recently, in 2011, Bangkok experienced one of the worst flood events in its history. Hundreds of lives were also lost and as of December 1, 2011, according to World Bank calculations, the total cost economic damages and losses in the country amounted to $45.7 billion[20].

1.3.2 Future risks

Bangkok's vulnerability to flooding and other environmental challenges, such as heat waves, is projected to increase substantially in the coming decades. Some of the likely impacts, such as shifts in sea, temperature and precipitation levels, will result from climate change. There are other significant environmental issues beyond this, however, including the spatial pattern of future urban development and the accumulating effects of land subsidence.

In terms of climate change, Bangkok is already one of the most vulnerable areas in Southeast Asia[21] and has been identified by the IPCC as a future 'hotspot' due to the destabilizing effects projected on the city's hydrometeorology[22]. Much of Thailand's 2,615 km coastline is at risk, including Bangkok, with areas such as the district of Bang Khuntien especially vulnerable[23]. Global warming has already resulted in Thailand's rivers becoming increasingly unpredictable: flows are already becoming lower in the dry season and higher in the rainy season[24].

One of the most authoritative reviews of the projected effects of climate change within the BMR is the assessment undertaken on behalf of the IPCC by the University of Tokyo's Integrated Research System for Sustainability Science, who modeled potential impacts for Bangkok in 2050 in 'low' (B1) and 'high' (A1F1) emissions scenarios. In addition to temperature rises of between 1.2 (B1F1) and 1.9 (A1F1) degrees Celsius[25], climate change would have increase both sea levels and precipitation, with serious implications for Bangkok's future vulnerability.

Mean precipitation in the basin is projected to rise by 2 (B1F1) to 3 (A1) percent[26]. However, while the consequent increase in net flood volume will be more or less proportionate to this, the effect on peak river discharge in the Chao Phraya will be substantially greater due to the staggered flow patterns of the floodwater from the catchments upstream[27]. It will also have a significant impact on

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19 IRIN, 'How to build a flood-resilient city'. November 28, 2011. Retrieved at: http://www.irinnews.org/printreport.aspx?reportid=94319

20 World Bank. The World Bank supports Thailand's post-floods recovery efforts. December 13, 2011. Retrieved at: http://www.worldbank.or.th/WBSITE/EXTERNAL/COUNTRIES/EASTASIAPACIFICEXT/THAILANDEXTN/0,,contentMDK:23067443~menuPK:50003484~pagePK:2865066~piPK:2865079~theSitePK:333296,00.html

21 Yusuf, A. and Francisco, H. (2009). *Climate Change Vulnerability Mapping for Southeast Asia*. Economy and Environment Program for Southeast Asia.

22 ADB/JICA/World Bank (2010). *Climate Risks and Adaptation in Asian Coastal Megacities*, p.2. Retrieved at: http://siteresources.worldbank.org/EASTASIAPACIFICEXT/Resources/226300-1287600424406/coastal_megacities_fullreport.pdf

23 Bangkok Metropolitan Administration, Green Leaf Foundation and United Nations Environment Programme (2009). *Bangkok Assessment Report on Climate Change 2009*. Bangkok: BMA, GLF and UNEP

24 Bangkok Metropolitan Administration, Green Leaf Foundation and United Nations Environment Programme (2009). *Bangkok Assessment Report on Climate Change 2009*. Bangkok: BMA, GLF and UNEP

25 Cited in Panya Consultants (2009). Climate Change Impact and Adaptation Study for Bangkok Metropolitan Region, p.x. Retrieved at: http://siteresources.worldbank.org/INTTHAILAND/Resources/333200-1177475763598/3714275-1234408023295/5826366-1248255995902/full-report.pdf

26 ADB/JICA/World Bank (2010). *Climate Risks and Adaptation in Asian Coastal Megacities*, p.xii. Retrieved at: http://siteresources.worldbank.org/EASTASIAPACIFICEXT/Resources/226300-1287600424406/coastal_megacities_fullreport.pdf

27 World Bank (2009). *Climate Change Impact and Adaptation Study for Bangkok Metropolitan Region*, p.xi. Retrieved at: http://siteresources.worldbank.org/INTTHAILAND/Resources/333200-1177475763598/3714275-1234408023295/5826366-1248255995902/executive-summary.pdf

the size of the flood-prone area, rising in the context of a 1-in-30-year flooding event by 30% in the high (A1F1) emissions scenario[28]. Furthermore, a large part of Bangkok's increased future risk will result from the growing frequency of extreme weather events, such as high intensity flash precipitation and very wet years with strong La Nina conditions[29].

At the same time, while sea levels are rising at the relatively modest rate of 25mm annually at present[30], these gradual changes will accumulate in the coming decades. Sea levels in the Gulf of Thailand are projected to rise between 0.19 (B1) and 0.29 (A1F1) meters[31]. Given Bangkok's low-lying elevation, the impacts of higher sea levels could intensify the negative impact of flooding substantially. For instance, a simulation of the effects of future flooding in Bangkok according to the worst-case SLR scenarios used the baseline conditions of the 1995 flood as a comparator. It found that, in the event of a 0.32 SLR by 2050, the total flooded area would increase by 26% compared to 1995. With an SLR of 0.88 meters by 2100, the increase would be as much as 81%[32].

But the impacts of climate change to Bangkok in terms of flood vulnerability are likely to be exceeded by the costs of non-climate-related factors – in particular, the city's chronic land subsidence. Bangkok is naturally at risk due to the soft clay layer in its ground surface and low lying topography, but these problems has been greatly exacerbated by the excessive groundwater extraction[33]. However, stronger government regulation has slowed the rate of land subsidence and is expected to result in further reductions in the rate of subsidence, by 10% annually. According to official estimates, from a peak of 10cm a year in 1978, subsidence has since slowed to 1-2cm by 2007, averaging 0.97 cm a year between 2002 and 2007[34]. However, other estimates suggest a much faster rate of 5-10mm a year, with some outlying parts of the city in the southeast and southwest reaching as much as 30mm annually. What is certain is that land subsidence and sea level rises will have a combined impact. For example, if sea levels are assumed to rise by 12.3cm between 2009 and 2050, with land subsidence during this period totaling another 20cm, then the relative sea level rise will total 32.2cm[35]. Another study estimated that, due to the effects of subsidence and sea level rise, Bangkok could potentially find itself submerged in 50-100cm of floodwater by 2025[36].

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28 ADB/JICA/World Bank (2010). *Climate Risks and Adaptation in Asian Coastal Megacities*, p.xii. Retrieved at: http://siteresources.worldbank.org/EASTASIAPACIFICEXT/Resources/226300-1287600424406/coastal_megacities_fullreport.pdf

29 Bangkok Metropolitan Administration, Green Leaf Foundation and United Nations Environment Programme (2009). *Bangkok Assessment Report on Climate Change 2009*. Bangkok: BMA, GLF and UNEP

30 Bangkok Metropolitan Administration, Green Leaf Foundation and United Nations Environment Programme (2009). *Bangkok Assessment Report on Climate Change 2009*. Bangkok: BMA, GLF and UNEP

31 Cited in Panya Consultants (2009). Climate Change Impact and Adaptation Study for Bangkok Metropolitan Region, p.x. Retrieved at: http://siteresources.worldbank.org/INTTHAILAND/Resources/333200-1177475763598/3714275-1234408023295/5826366-1248255995902/full-report.pdf

32 Dutta, D. (2011). An integrated tool for assessment of flood vulnerability of coastal cities to sea-level rise and potential socio-economic impacts: a case study in Bangkok, Thailand. Hydrological Sciences Journal, 56(5).

33 Phien-Wej, N. et al. (2006), Land subsidence in Bangkok, Thailand. Engineering Geology, 82(4).

34 ADB/JICA/World Bank (2010). *Climate Risks and Adaptation in Asian Coastal Megacities*, p.26. Retrieved at: http://siteresources.worldbank.org/EASTASIAPACIFICEXT/Resources/226300-1287600424406/coastal_megacities_fullreport.pdf

35 Panya Consultants (2009). Climate Change Impact and Adaptation Study for Bangkok Metropolitan Region, p.2-3. Retrieved at: http://siteresources.worldbank.org/INTTHAILAND/Resources/333200-1177475763598/3714275-1234408023295/5826366-1248255995902/full-report.pdf

36 Phien-Wej et al. (2006), cited by Bangkok Metropolitan Administration, Green Leaf Foundation and United Nations Environment Programme (2009). *Bangkok Assessment Report on Climate Change 2009*. Bangkok: BMA, GLF and UNEP

Nevertheless, the consensus is that the future costs associated with land subsidence will be very substantial. A report commissioned by the World Bank, working with the first set of figures, extrapolated a cumulative subsidence rate of 5-30cm between 2002 and 2050. The economic cost of this subsidence, in the context of a 1-in-30 year flood in an A1F1 climate scenario, nearly doubles between 2008 and 2050. Almost 70% of the total increase in the costs of a 1-in-30 flooding event in Bangkok in 2050 is due to increased land subsidence[37]. In addition to the increased flooding, land subsidence also reduces the effectiveness of the city's dyke system and its underground sanitation[38].

Finally, as Bangkok's rapid urbanization is expected to continue, with a larger population and a more developed city fabric, the city's exposure is therefore forecast to be substantially higher even without climate change, land subsidence or other major environmental issues. Over 70% of flood-related costs in the future will relate to building damage[39] and flood-affected buildings are to increase, according to one projection, by a factor of 1.5 times between 2025 and 2100[40]. The city's continued development will therefore increase its vulnerability, even before climate change and other environmental impacts are factored in. For instance, a study by the OECD estimated that at present 0.907 million persons and $38.72 billion in assets were potentially exposed in the event of a 1-in-100-years extreme flooding event. By 2070, in the same environmental conditions but with the city's predicted future population and development, the exposure would rise to 2.392 million persons and $520.23 billion in assets[41]. In addition, the growing expanse of built-up area in and around the city, if not carefully planned, may conflict with the increasingly unstable weather patterns brought about by climate change. In particular, the rising frequency and intensity of 'flash' precipitation events will require effective storm sewage maintenance and substantive measures to improve the water-absorbing capacity of the city's urban landscape[42].

Projections for Bangkok's future flooding exposure therefore factor in the likely effects of different climate change scenarios alongside non-climate-related environmental changes, in particular land subsidence. They also have to model the transformation of the city itself, in terms of populations and infrastructure, and the difference this will have on the overall cost of a major flood event. A detailed forecast of the capital's vulnerability and exposure in 2050 for a World Bank report[43], using various possible climate scenarios, illustrates the very substantial effects that global warming, land subsidence and continued urbanization will have. Firstly, it is estimated that while the current flooding area of a 1-in-30 year flooding event is 550 km^2, by 2050 this will have risen to 719 km^2 in a B1 and 734 km^2 in an A1F1 scenario respectively. While a 625 km^2 flood is currently expected to occur every 50 years, by 2050 will be 1/15 years in an A1F1 scenario._Similarly, the total exposure of Bangkok's population to more than 30 days of flooding in a 1-in-30 year flood event will rise from 546,748 persons at present (2008) to as much as 805,055 persons in a B1 and 954,389 persons in an

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37 ADB/JICA/World Bank (2010). *Climate Risks and Adaptation in Asian Coastal Megacities*, p.xv. Retrieved at: http://siteresources.worldbank.org/EASTASIAPACIFICEXT/Resources/226300-1287600424406/coastal_megacities_fullreport.pdf

38 Bangkok Metropolitan Administration, Green Leaf Foundation and United Nations Environment Programme (2009). *Bangkok Assessment Report on Climate Change 2009*. Bangkok: BMA, GLF and UNEP

39 ADB/JICA/World Bank (2010). *Climate Risks and Adaptation in Asian Coastal Megacities*, p.xv. Retrieved at: http://siteresources.worldbank.org/EASTASIAPACIFICEXT/Resources/226300-1287600424406/coastal_megacities_fullreport.pdf

40 Dutta, D. (2011). An integrated tool for assessment of flood vulnerability of coastal cities to sea-level rise and potential socio-economic impacts: a case study in Bangkok, Thailand. Hydrological Sciences Journal, 56(5).

41 Nicholls, R.J., Hanson, S., Herweijer, C., Patmore, N., Hallegatte, S., CorfeeMorlot, J. Chateau, J. and Muir-Wood, R. (2008). Ranking Port Cities with High Exposure and Vulnerability to Climate Extremes. OECD Environment Working Papers No. 1.

42 Bangkok Metropolitan Administration, Green Leaf Foundation and United Nations Environment Programme (2009). *Bangkok Assessment Report on Climate Change 2009*. Bangkok: BMA, GLF and UNEP

43 The calculations used here were for Bangkok and Samut Prakarn provinces, the two most urbanized provinces in the BMR.

A1F1 scenario in 2050 - a 47% and 75% increase respectively. Importantly, the costs are not only the direct costs of damaged housing and infrastructure, but the indirect costs of work absence, loss of revenue and so on[44] . The costs of a 1-in-30-year flooding event also rise from the current (2008) $1.059 billion to as much as $4.454 billion in an A1F1 scenario by 2050, with the impacts land subsidence, sea level rise and storm surge included in the calculations. A large portion of this increase is directly attributable to land subsidence: the cost in 2050 with only land subsidence factored in, in current climactic conditions, is $2.982 billion – 67% of the total increase between 2008 and 2050[45].

The combined effect of these various factors is that not only will Bangkok be increasingly flood-prone in the future, due to climate change and other environmental issues, but it will also have more to lose as the city continues to develop and expand. A global assessment of port cities, conducted by the OECD, estimated that by 2070 Bangkok would be the seventh most vulnerable city in the world to coastal flooding in terms of population, and the tenth most vulnerable in terms of assets. In 2005, a 1-in-100 years flooding event would involve a potential exposure of around 0.907 million persons and $38.72 billion in assets. By 2070, factoring in climate change, anthropogenic land subsidence and the substantial changes to its population and urban fabric, the total exposure would come to 5.138 million persons and an extraordinary $1,117.54 billion in assets[46].

2. Case study: the 2006 flood

2.1 Case study areas

This study examines the impact of the 2006 floods, with a focus on four districts in the eastern region of Bangkok: Minburi, Nong Jork, Lat Krabang and Klong Samwa. As rapidly developing suburban settlements in a traditionally agricultural region, they provide a vivid illustration of the city's most challenging symptoms, particularly with regards to flood vulnerability. Furthermore, during the 2006 flood, these districts were among the worst hit. The rapid urbanization of these districts, and their experience of the 2006 floods, highlight the very serious consequences Bangkok may face in the future if these current trends continue unchecked.

The low-lying topography that characterizes much of the city is especially evident in eastern Bangkok. In the case study districts, the average land elevation is just 0.8-1.5 MSL, compared to 1.0-2.0 for Bangkok as a whole. The terrain slopes down from east to west and north to south, as illustrated in Figure 1. Consequently, Nong Jork, the district with the highest elevation (2.0MSL), is northwest to Lat Krabang, the lowest (0.5MSL) and the most southwesterly of the four districts.

[44] Panya Consultants (2009). Climate Change Impact and Adaptation Study for Bangkok Metropolitan Region, p.4-1. Retrieved at: http://siteresources.worldbank.org/INTTHAILAND/Resources/333200-1177475763598/3714275-1234408023295/5826366-1248255995902/full-report.pdf
As defined in the World Bank estimates, 'direct' damage is "measurable and often relates to the replacement value of destroyed immovable assets and stocks". This type of damage occurs during or shortly after the natural disaster. 'Indirect' damage on the other hand is not physical but nevertheless has associated costs for individuals and communities. This includes lost revenue and unpaid work absence. The latter is particularly associated with informal employment and non-salaried workers, and so imposes an added dimension of social vulnerability to the costs.
[45] ADB/JICA/World Bank (2010). *Climate Risks and Adaptation in Asian Coastal Megacities*, pp.28-29, 30, 52-54. Retrieved at: http://siteresources.worldbank.org/EASTASIAPACIFICEXT/Resources/226300-1287600424406/coastal_megacities_fullreport.pdf

[46] Nicholls, R.J., Hanson, S., Herweijer, C., Patmore, N., Hallegatte, S., CorfeeMorlot, J. Chateau, J. and Muir-Wood, R. (2008). Ranking Port Cities with High Exposure and Vulnerability to Climate Extremes. OECD Environment Working Papers No. 1.

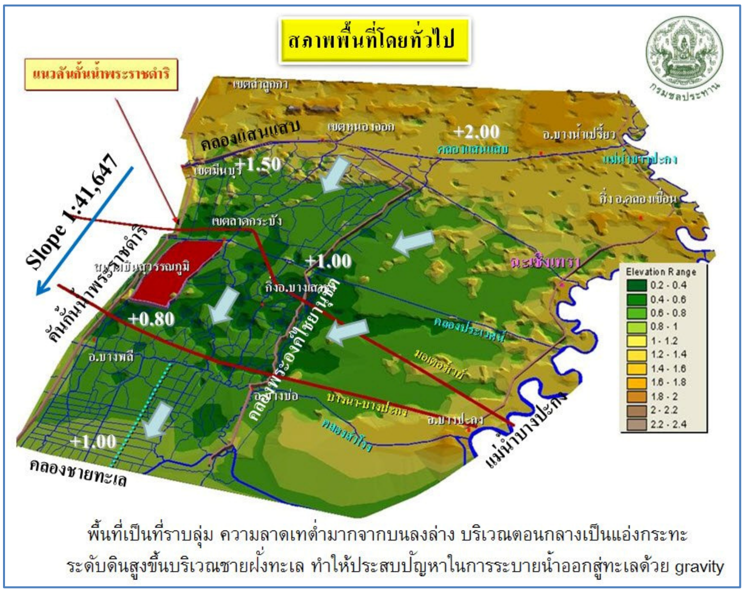

Figure 1: Topography of eastern Bangkok

Eastern Bangkok is therefore naturally suited to serve as a flood plain for the large volumes of runoff heading from the north towards the Gulf of Thailand, as shown in Figure 2. A large portion of Bangkok's most flood-prone territory, shaded blue, is visibly concentrated in the east. Until the mid-20th century, this was reflected in the land use of the area, with much of it protected as an officially designated drainage corridor for the regular flows of floodwater through the city. However, the publication of the first National Economic and Social Plan reconfigured the area as an industrial zone, with profound spatial and environmental effects[47].

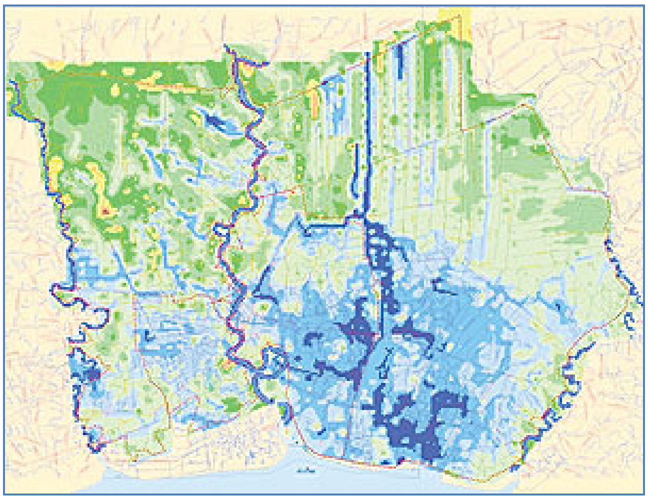

Figure 2: Topographic map of eastern Bangkok. Low-lying areas susceptible to flooding are shaded blue[48]

Since then, much of the landscape has been transformed by ill-advised or irresponsible construction. Megaprojects such as Suvarnabhumi Airport have been constructed in the floodplain and much of

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47 Bangkok Post, 'Heeding his majesty's advice'. December 1, 2011. Retrieved at: http://www.bangkokpost.com/feature/environment/268709/heeding-his-majesty-s-advice

48 *Royal Thai Survey Department.*

the planning regulation that has belatedly been put in place has been ignored[49]. All of these districts to varying degrees now reflect the mixed character of suburban Bangkok, where the city's rapid outward growth has transformed formerly agricultural settlements into morcellated landscapes where traditional livelihoods such as farming still persist alongside industrial and residential uses. Some of the key demographic, environmental and developmental characteristics of each district are summarized in Table 1 below.

District	*Area* (km^2)	*Pop. density (persons/ km^2)*	*Employment*	*Environmental Characteristics*	*Developmental characteristics*
Khlong Sam Wa[50]	110.7	1,398.2	Largely agricultural: paddy fields, farming.	56 canals: one, Khlong Saw Wa, used for transport and the remainder for agricultural irrigation.	
Minburi[51]	63.6	2,092.0	Largely agricultural: rice farming, livestock, fisheries, produce, turf grass.	The most densely populated of the districts. Environmental damage, including increased flooding, from transport infrastructure and other development is threatening agriculture, an important livelihood in the area.	Increasing housing development in response to city expansion. Construction of Suvarnabhumi Airport has also resulted in improved transport links.
Nong Chok	236.3	625.0	Agriculture: 80% Government Officer: 10% Petty trader/SME:	The largest and least densely populated district in Bangkok. Also the most easterly of the four districts and the furthest from central Bangkok.	Relatively undeveloped, given its distance from the city, and still largely agricultural as a result.

[49] Bangkok Post, 'Heeding his majesty's advice'. December 1, 2011. Retrieved at: http://www.bangkokpost.com/feature/environment/268709/heeding-his-majesty-s-advice

[50] Klong Samwa District Office. Retrieved at: http://203.155.220.239/subsite/index.php?strOrgID=001003&strSection=aboutus&intContentID=498%00)

[51] Minburi District Office. Retrieved at: http://www.bangkok.go.th/minburi/. For an overview of the effect of development on agricultural livelihoods, see Sitheechoke, N. and Napompech, K. (2010). *Impacts of Minburi District Development on the Turf Grass Businesses of Bangkok*, Thailand. International Journal of Arts and Sciences, 3(13): 82-94.

			6% Other: 4%		
Lat Krabang[52]	123.9	1227.0	Mainly business and agriculture	Southernmost of the four districts, with the lowest elevation. Located in the catchment area outside the King's Dyke. Has a total of 42 canals.	International airport and warehouses in close proximity, hence the primarily business and agriculture-oriented employment. One major industrial park: the Lat Kra Bang Industrial Park.

Table 1: Profile of case study districts

While the districts have many shared features, including the ongoing importance of agriculture to their local economies, there are also significant differences in terms of their size and demographics. These in turn are strongly determined by the specific environmental and developmental circumstances of each district. For instance, Minburi has experienced rapid residential development as transport links in the district have improved with the construction of Suvarnabhumi airport. This has helped accelerate its population density to 2,092 persons/km^2, the highest of the four districts by some margin. The intrusion of residential and industrial development has transformed the district's agricultural landscape into an incohesive mix, with damaging side effects such as subsidence, drainage problems and disconnected 'islands' of land development[53]. The more outlying district of Nong Chok, on the other hand, retains a relatively low population density and its agricultural character is more pronounced.

[52] Lat Krabang District Office. Retrieved at: http://203.155.220.239/subsite/index.php?strOrgID=001013&strSection=aboutus&intContentID=131%00)

[53] Sitheechoke, N. and Napompech, K. (2010). Impacts of Minburi District Development on the Turf Grass Businesses of Bangkok, Thailand. International Journal of Arts and Sciences, 3(13): 82-94.

2.2 Causes of the 2006 Flooding

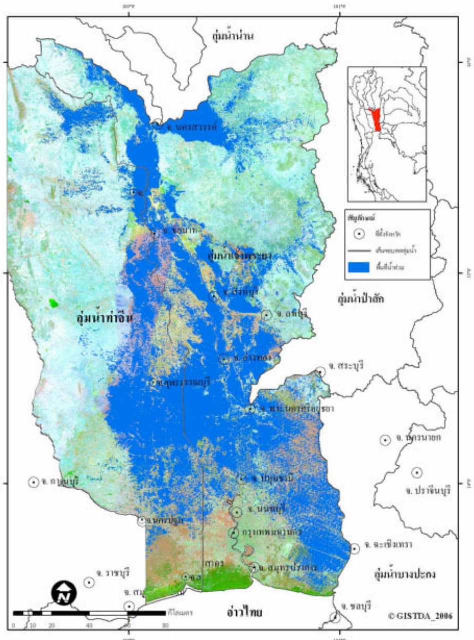

Figure 3: Satellite Image of 2006 Flooded Area in the Chao Phraya River Basin[54]

As with other instances of flooding in Bangkok, the circumstances that led to the city's inundation in 2006 were both predictable and unique. Heavy precipitation, large volumes of runoff from the north of the country and significant sea level rises due to seasonal high tides were all contributing factors. In response, the floodwater was managed by allowing the agricultural land north of the city to flood and also channelling the water to the east of the city, where the case study districts in this report are located. The center of the city was protected by its embankments and drainage infrastructure, though large parts of the surroundings areas (in particular, the case study districts) were inundated[55].

2.1.1 Continuous Heavy Rainfall

In 2006, Thailand was affected by a number of tropical depressions between the months of August and October. These resulted in short periods of intense precipitation across Thailand during this period, on 27-31 August, 9-12 September and 18-23 September. The last, the 'Xangsane' typhoon, occurred on 1-3 October. As Figure 4 shows, the typhoon travelled through Southeast Asia towards the end of September, devastating large parts of the Philippines and Vietnam before reaching Bangkok on October 2.

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54 GISTDA. Summary Report on Satellite Imagery of Flooding in 2006. Retrieved at: http://www.deqp.go.th/index.php?option=com_content&view=article&id=11969%3A2006-10-24&catid=7%3A2010-02-04-06-14-10&Itemid=43&lang=th

55 ADB/JICA/World Bank (2010). *Climate Risks and Adaptation in Asian Coastal Megacities*, p.25. Retrieved at: http://siteresources.worldbank.org/EASTASIAPACIFICEXT/Resources/226300-1287600424406/coastal_megacities_fullreport.pdf

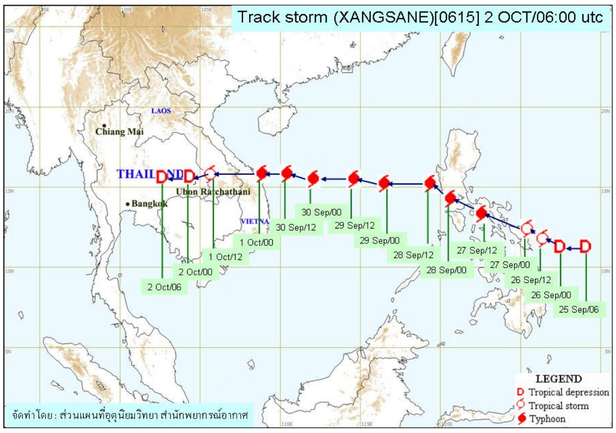

Figure 4: the Xangsane typhoon, 25 September -2 October, 2006[56]

This triggered intense flash precipitation in Bangkok. Though overall rainfall in the BMA during 2006 was not much lower than both the 30 year average and the total in the previous year (Figure 5), when no major flooding occurred, 24 hours of heavy localized rain caused the city to be inundated as its drainage system was unable to cope with rainfall exceeding 60mm/hour. Total cumulative rainfall in Bangkok came to 317.3mm in September and 336.8mm in October. By way of comparison, rainfall totalled just 71.1mm in August and 42.9mm in November[57].

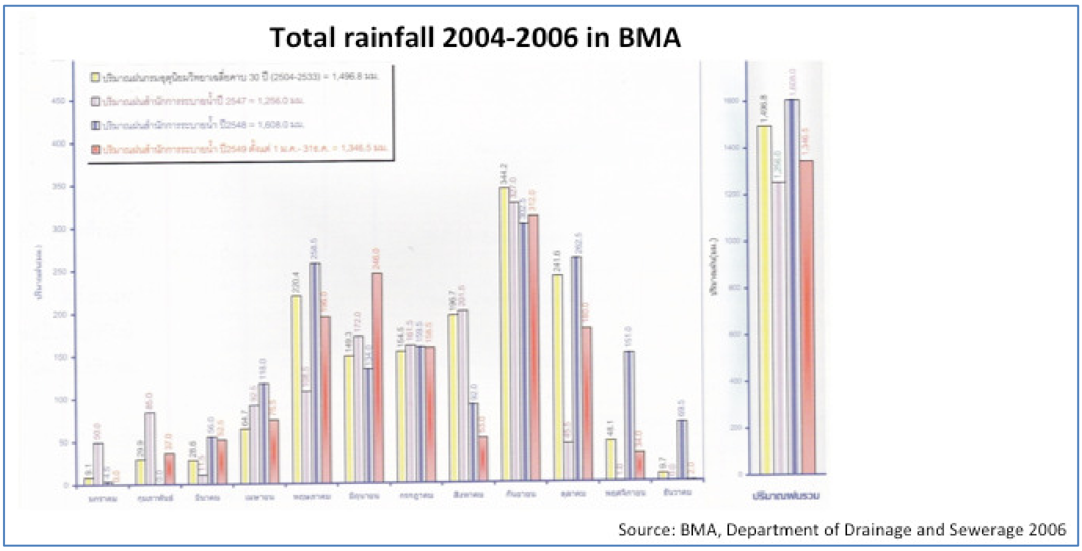

Figure 5: Total rainfall in the BMA, 2004-2006[58]

This is reflected in the very high monthly rainfall in October 2006 (Figure 6). While the total rainfall in 2006 (1,598.7mm) was only slightly larger than in 2010 (1,500mm), in October 2006 the rainfall came to 336.8mm compared to just 241mm for the same month in 2010. In fact, excluding October, the rainfall in the remaining 11 months is almost identical in both years. On the other hand, due to the typhoon, rainfall in October 2006 was 40% higher than the total in October 2010.

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56 Thai Meteorological Department. Retrieved at: http://www.tmd.go.th/index.php

57 Marome, W.A.(2011). *Improving the Characterization of Impact Variables to Extreme Flood Events: A Case Study of the Flood 2006 in Bangkok*. CARII: Building Adaptive Capacity for Managing Climate Change Risks in Coastal Cities. Retrieved at: http://start.org/download/car2/1-marome.pdf

58 Bangkok Metropolitan Administration.

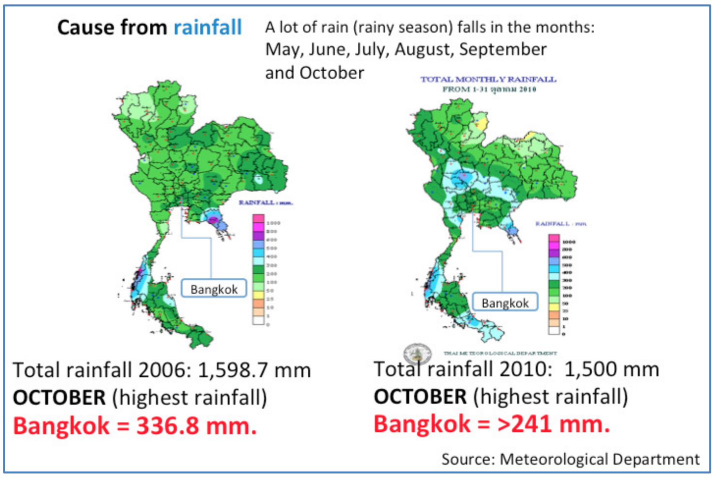

Figure 6: Rainfall in Bangkok, October 2006 and October 2010[59]

2.2.2 High levels of runoff in the Chao Phraya River Basin

A second contributing factor to the 2006 floods was the large volume of runoff from the Chao Phraya River Basin. While 30% of the rainfall is stored in dams and catchment basins, the remaining 70% is released into the alluvial plain and passes through Bangkok in October-November. Typically runoff from the north of the country ranges between a minimum of 1,000-2,000m^3/s and a maximum of 4,000-5,000 m^3/s. The capacity of the Chao Phraya River, on the other hand, is 2,500-3,000 m^3/s[60].

In 2006, as Table 2 shows, over 85% of the annual runoff occurred in September and October.

River Basin	Average Monthly Runoff (mcm)												
	Apr.	*May*	*Jun.*	*July*	*Aug.*	*Sept*	*Oct.*	*Nov.*	*Dec.*	*Jan.*	*Feb.*	*Mar.*	*Total*
Ping	126.5	341.9	511.8	660.0	1326.6	1997.6	1849.6	904.5	440.8	277.6	160.7	127.7	8723.3
Wang	15.4	74.7	89.9	107.8	302.4	477.0	322.4	120.4	48.2	31.0	15.3	12.9	1617.5
Yom	45.7	171.2	277.8	290.3	687.5	1154.6	635.5	208.3	88.6	51.1	26.5	19.7	3656.6
Nan	153.9	344.1	781.5	1558.8	2961.8	3251.0	1577.5	587.7	313.6	220.3	143.8	121.2	12014.8
Pasak	38.2	106.3	180.2	244.3	502.7	928.3	557.2	145.5	76.8	50.7	33.6	33.4	2897.3
Sakae	8.7	32.	57.	49.2	72.3	252.	429.	137	40.	21.	15.	8.5	1124.

[59] Meteorological Department.

[60] http://dds.bangkok.go.th/News_dds/magazine/plan50/plan02.pdf

Krang		3	0			2	4	.9	2	8	3		8
Thachin	3.9	33.3	19.2	18.6	67.5	609.5	501.7	70.1	20.6	11.2	5.6	3.2	1364.4
Chao Phraya	1.7	42.4	20.7	22.4	91.4	871.7	608.4	37.5	17.8	13.4	3.6	0.8	1731.8

Table 2: Average monthly runoff in Thailand's rivers, 2006

Month	**Water volume, Nakorn Sawan Dam (m^3/s)**	**Water volume, Chao Phraya Dam (m^3/s)**	**Water volume, Rama VI Dam (m^3/s)**
May	1,364	1,357	80
June	1,364	1,343	175
July	1,332	1,365	277
August	1,157	741	154
September	3,092	2,426	333
October	5,960	4,188	759
November	3,228	3,183	254
December	629	450	51

Table 3: Monthly water flow in Nakorn Sawan, Chao Phraya and Rama IV dams, 2006[61]

The accumulated floodwater had also strained the capacity of its upstream catchment ponds and dams to the limit. By September 25, the storage of the Bhumipol, Sirikit and Pa Kan dams was already at 91.9%, 92.0% and 103.7% respectively, with a 3,112 m^3/s rate of flow into the Chao Phraya River[62], more than its maximum capacity. As Table 3 shows, the water flow through Nakorn Sawan, Chao Phraya and Rama IV dams rose sharply in September and peaked in October.

2.2.3 Sea Level Rise

A third factor in the 2006 flood was high sea levels. In October 25 and November 7, it peaked at 2.22 MSL: the maximum capacity of Bangkok is only 2.5 MSL. This sea level also severely reduced Bangkok's drainage capacity, thus exacerbating the effects of the runoff and heavy rain[63]. This worsened the effects of the heavy rainfall and large volumes of runoff.

3. Impact assessment of the 2006 flood

Estimating the full extent of the 2006 flooding and its impact requires a detailed and wide-ranging assessment of its effects. Even among these four case study districts, the proportion of inundated area and the accompanying damage varied considerably. Reflecting the mixed character of these districts, as formerly agricultural regions now undergoing rapid suburbanization, the damage extended to national infrastructure such as roads and rail lines, community buildings, businesses,

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61 Department of Drainage and Sewage, BMA.

62 Marome, W.A.(2011). *Improving the Characterization of Impact Variables to Extreme Flood Events: A Case Study of the Flood 2006 in Bangkok.* CARII: Building Adaptive Capacity for Managing Climate Change Risks in Coastal Cities. Retrieved at: http://start.org/download/car2/1-marome.pdf

63 Department of Environmental Quality. Retrieved at: http://www.deqp.go.th/index.php?option=com_content&view=article&id=11969%3A2006-10-24&catid=7%3A2010-02-04-06-14-10&Itemid=43&lang=th

fisheries and farms, along with other less tangible dimensions, such as mental health, that though significant are not always be readily measurable.

Consequently, the full impacts of flooding and other natural disasters on communities is often difficult to capture. In fact, this is an important gap in much of the previous research in this field. However, to understand the true extent of the challenges that affected cities and districts face, it is vital to gauge their more 'invisible' dimensions alongside the immediate physical destruction. In particular, information on social vulnerability in a post-disaster context is frequently limited or elusive. Though these aspects are not so readily quantifiable as damaged infrastructure, for example, they nevertheless play a major role in determining post-disaster hardship and recovery at a community, household and individual level.

This study aims to highlight this gap and the urgent need for an adequate flood-assessment proxy that, by incorporating a variety of quantitative and qualitative measurements, creates a more comprehensive picture of the impacts of flooding on communities and individuals. The research involved two approaches. First, it reviews the available secondary data, such as damage profiles, relief subsidies and mental health assessments, and examines the current information shortfalls. Secondly, it present the findings of fieldwork undertaken in the case study districts, using semi-structured interviews with residents to gain a better qualitative understanding of the 2006 flooding.

3.1 Secondary data

Table 4 outlines a detailed taxonomy of physical, economic, financial, technical, environmental and social flood-related impacts. These extend from tangible effects like property damage to less material considerations, such as psychosocial change: the associated costs are both direct (such as loss of life, damage to physical capital) and indirect (such as reduced consumption, conflicts). Together, these provide a template for a holistic disaster assessment.

Physical	Economic		Financial	Technical	Environmental	Social
	Stock	Flow				
Loss of life and injuries ***Damage to property*** ***Damage to physical infrastructure*** ***Loss of land, crops, livestock***	Damage to physical capital Loss of inventory	Reduction in income generation Effect on investment Reduction in consumption Effect on production Effect on employment generation	Loss of financial capital Effect on public revenue and expenditure Effect on private revenue and expenditure	Disruption of essential supplies like water, electricity Disruption of communication services	***Air or water pollution*** Land degradation	Displacement or relocation Loss of assets Loss of livelihoods Poor quality of life Conflicts Psychophysical and ***psychosocial changes***

Table 4: Impacts of a natural disaster (Source: Patankar, A. 2009)

However, the available data is very limited and often fails to present a meaningful picture of the impacts on the ground. In table 4, the areas where data is available for the 2006 flooding is highlighted, drawing on previous studies and assessments, some conducted in its immediate aftermath. These are discussed in more detail below:

Physical

- *Total inundated area*
- *Damage to property and infrastructure*
- *Loss of agricultural produce*

Environment

- *Water quality*
- *Sanitary level*

Social

- *Psychological assessment*[64]

Unfortunately, in terms of official data there are clear information shortfalls, especially relating to social vulnerability: even the mental health profiling used in the psychological assessment and presented here was conducted informally by nurses working in flood-affected areas. In addition, much of the official data is collected by national agencies at a country-wide level, with no disaggregation of the effects at a local level. Yet gauging flood-related impacts on individual communities, rather than just the country as a whole, is critical to understanding their actual consequences for worst affected. This section is not only summarizes what data is available, but also highlights the substantial gaps, particularly regarding the social and local dimensions of the disaster. In future, if the quality and scope of data collection improves, it will then be possible to develop a stronger, more comprehensive proxy to assess flooding impacts in Bangkok.

3.1.1 Physical effects

Total inundated area

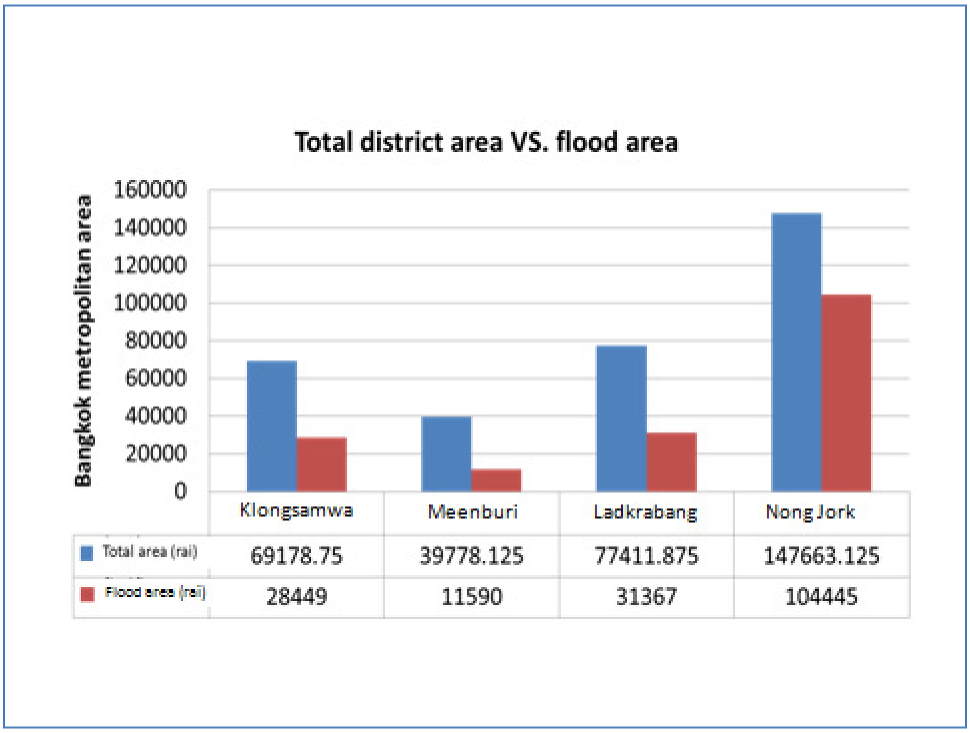

Figure 7: Total inundated area in Klong Samwa, Minburi, Ladkrabang and Nong Jork districts

64 This was an unofficial assessment undertaken by nurses operating in selected flood-affected communities.

Figure 7 shows the extent of inundation in the districts of Klong Samwa, Minburi, Ladkrabang and Nong Jork districts respectively. The total area is 334,331.9 rai, with 175,851 rai (52.6%) flooded. However, the proportion varies substantially between districts, from 29.1% in Minburi to 70.7% in Minburi.

Damage to property and infrastructure

The physical impact of flooding on districts and communities is multi-faceted. To reflect this, the calculations in this report use a wide variety of measurements and proxies to estimate the cost of the flooding, including damage to property, damage to infrastructure, and loss of land, produce and livestock. These exert, in different ways, direct and indirect burdens on the government, local communities and individual residents.

Table 5 gives an overview of the reported damage in each of the four case study districts on October 5, just after the flooding. In particular, it gives an idea of the physical damage to communal infrastructure and the associated impacts this has on education, social life and mobility for residents.

District	Settlement	Education	Religious	Transportation
Nong Jork		13 schools	3 temples 4 mosques	22 roads
Minburi	4 villages		1 mosque	4 roads
Ladkrabang	30 communities 6 villages	12 schools	6 temples 3 mosques	12 roads
Khlongsamwa	10 communities 1 village	2 schools	3 temples	11 roads

Table 5: Physical damage by district: settlement, education, religious and transport (October 5, 2006)[65]

Table 6 outlines the damage to Thailand's transport infrastructure and the consequent costs of restoring its highways, roads, railways and waterways. These are national figures for the entire country, collected by the Ministry of Transport. In terms of direct costs, such as the repairs to the physical fabric, this is valid as the expense for this is shouldered by the central government rather than the local authorities. What these figures arguably do not capture is the indirect costs of infrastructure damage in flood-affected districts. While the government bears the bulk of the direct costs of repairing and reconstructing roads, waterways and rail lines, the potentially substantial indirect costs that the damage imposes on the local economy is largely passed on to the community.

[65] Government data.

Infrastructure	Damage	Costs
Highways[66]	286 routes on 757 roads: 31 roads with no access.	1,735 million baht ($58 million): 1,650 million baht to rebuild damaged roads and 85 million baht to restore accessibility to obstructed roads.
Rural roads[67]	496 routes: 12 roads with no access. 467.6km of roads and 1,337m of bridge to be rebuilt. 102 pipe and 49 land erosion projects.	1,257.7 million baht (around $42 million)
Railways	6 projects, all in northern Thailand.	300 million baht (around $10 million)
Waterways and dykes	496 routes requiring protection from erosion/deterioration. 12 roads with no access.	226 million baht (around $7.5 million)

Table 6: Damage to national infrastructure and associated costs, Thailand (Ministry of Transport)

Table 7 outlines the damage to Bangkok's rice-growers, both its terms of land damage and crop losses. The total cost, exceeding 84 million baht, highlights the ongoing importance of agriculture in Bangkok, particularly in suburban and peripheral areas such as the case study districts. In the country as a whole, the costs ranged from as little as 0.6 million Baht in Ranong province to as much as 663 million Baht in Nakornsawan.

Bangkok	Total land (km^2)	Affected land (km^2)	Damaged land (km^2)	Crop losses (tons)	Cost (Baht, millions)
In-season rice	92,590 km^2	90.6 km^2	27.2 km^2	12,742.20	84.099

Table 7: Damage to agricultural land and crops, Bangkok

Table 8 outlines the compensation awarded to farmers for flood-related losses. While most goods such as livestock have remained at the same nominal levels and hence in real terms are actually lower in value in 2010 than in 2006, the subvention for rice fields has increased fivefold, from 414 to 2098 baht/rai. The compensation measurements, however, reflect the same flaws that affect the narrow scope of conventional damage assessment: the scope is technical and confined to direct, readily quantifiable outputs. This approach may be beneficial for larger agro-industrial operations that can readily convert their losses into these terms. For smaller-scale, family-managed farms and fisheries, on the other hand, the indirect costs in terms of their long term livelihoods are more complex. These costs are not factored in to conventional compensation frameworks.

[66] Figures collated from 53 provinces in Thailand, as of November 29, 2009.

[67] Figures collated from 57 provinces in Thailand, as of November 29, 2009.

Compensation (Baht)	Compensation (Baht), 2006	Compensation (Baht), 2010
Farm produce		
Rice	414/rai	2,098/rai
Crops	579/rai	2,921/rai
Others	786/rai	4,908/rai
Livestock		
Chicken	27.5/each	27.5/each
Layer chicken	20/each	20/each
Duck	20/each	20/each
Sheep/Goat	1,400/each	1,400/each
Cow (6-24 months)	3,600-15,800/each	3,600-15,80/each
Fishery		
Fish (pond/field)	3,406/rai	3,406 rai
Fish (floating basket/cement pond)	257/m^2	257/m^2
Shrimp/Crab/Shellfish	9,098/rai	9,098/rai

Table 8: Agricultural compensation by product, 2006 and 2011

As table 9 shows, both the damage and subsidies were far greater in 2006, illustrating the substantial difference between the 2006 flood and the more 'normal' event of 2010. In Khlong Samwa, for instance, the total inundated area came to 14,254 rai, at a cost of 7.259 million Baht: in 2010, the coverage was only 494 rai, at a cost of 1.269 million Baht.

District	**Total flooded area (rai)**		**Total flood-affected farmers**		**Total compensation (Baht, millions)**	
	2006	*2010*	*2006*	*2010*	*2006*	*2010*
Khlong Samwa	14,254	494	772	47	7.259	1.269
Minburi	5,877	464	441	54	1.891	1.278
Lad Krabang	14,826	410	325 & 671 (inland fisheries)	32	4.377	0.987
Nong Chok	16,817	1,010	672	52	7.090	2.129

Table 9: Flood-related agricultural impacts and compensation, 2006 and 2010

3.1.2 Environmental effects

Flooding can exert serious strain on local ecosystems, destroying habitats, degrading land quality and contaminating other essential natural resources. One of the main issues during the 2006 flood, was water pollution. Like other forms of environmental damage, the effects are often diverse and long-lasting. Official 'costs', such as government spending on basic rehabilitation, represent only a fraction of the overall burden. Much of this is borne instead, in different ways, by the local communities.

Water pollution

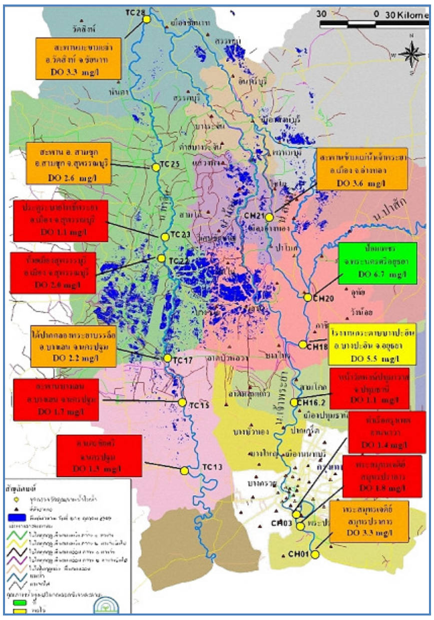

Figure 8: Pollution levels in Thailand's rivers, 2006[68]

In Figure 8, pollution mapping of Thailand's rivers shows that of the 5 main rivers, the two in the flood basin, the Chao Phraya and the Tahjeen, were both heavily contaminated. While the Tahjeen River was classified as 'polluted to very polluted' (with 2-4 mg oxygen/liter), the Chao Phraya was 'very polluted' (<2 mg oxygen/liter). Water pollution in fact represents one of the indirect costs of flooding that affects, among other areas, agricultural fisheries. Hidden costs such as these are generally overlooked in flood damage assessments, and do not feature in compensation payments.

3.1.3 Social effects

The flood-related effects that are arguably the hardest to quantify are social. As a result, these tend to feature less in damage assessments than the physical costs in terms of infrastructure, crops and so on. Yet in reality, the social consequences for individuals and communities may represent a 'second disaster', with long term implications for a city and its residents. Integrating social vulnerability appropriately into disaster assessments is an essential first step to addressing these effects – and a prerequisite for the meaningful recovery of communities struggling with the human cost of environmental catastrophe.

Mental Health

There is a striking absence of official data on the social impact of flooding on communities. The proxy used here, mental health, in fact draws on informal assessments conducted by nurses in flood-affected areas. Figure 9 illustrates the result of these assessments of selected community members

[68] *Pollution Control Department.*

and their high levels of stress, trauma and disorientation. It also illustrates the causal link between the poor psychological state of the subjects and other related health issues.

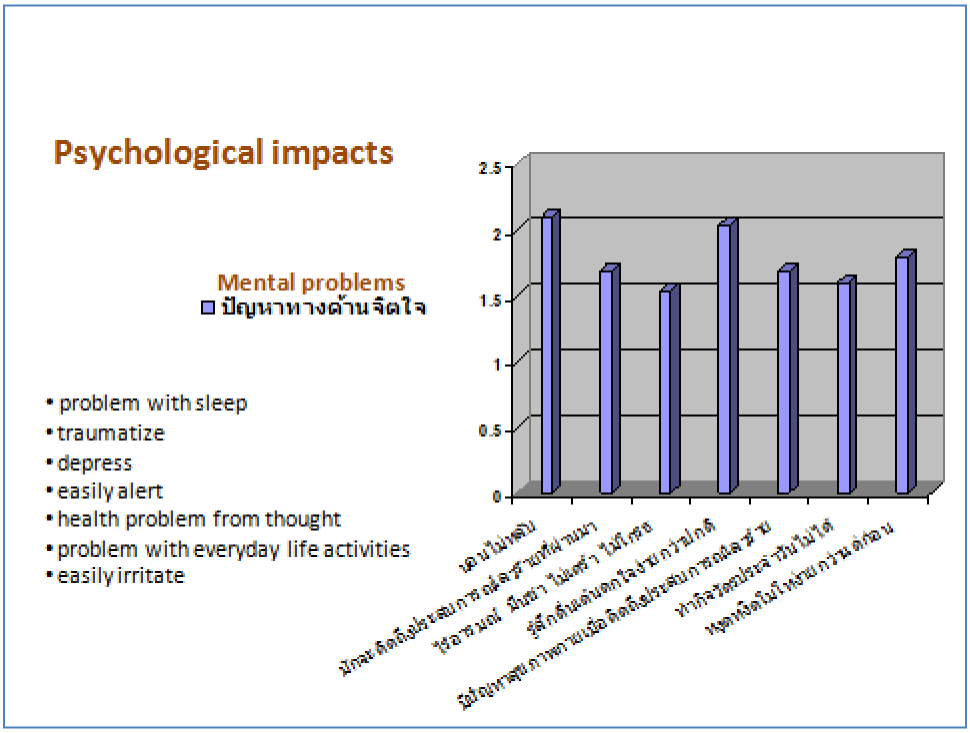

Figure 9: Psychological state of selected members of flood-affected communities, 2006

However, the assessment also reported high levels of psychological recovery, in terms of resilience, adaptability and self-reliance, following a mental health rehabilitation program carried out by the researchers. These findings suggest positive directions for future post-disaster processes in Bangkok, with a strong emphasis on mental health as a significant element within a broader relief and recovery strategy. This should include not only the direct victims of flooding, but also 'secondary' victims such as their relatives and the volunteer workers. Again, this is also an important flood-related impact that is often overlooked.

In summary, the long-term consequences of the disaster on communities are highly localized, social and psychological as well as technical and economic, and involve in addition to the direct costs of damaged goods and infrastructure a variety of 'hidden' indirect costs that are often not recognized in official assessments. In this sense, the relative scarcity of available information highlights the need for more holistic and community-based approach to data collection.

3.2 Fieldwork data

The primary research was conducted in the four selected districts of Nong Jork, Minburi, Ladkrabang and Khlongsamwa, all located outside the King's dyke in eastern Bangkok. A total of 380 surveys were undertaken to assess flood-related impacts across four main sectors: 300 household samples, 50 agricultural samples, 28 business samples and 2 industrial samples, namely the Bangchan and Ladkrabang industrial estates, the only ones in the study area.

12 communities in total from the 4 districts were selected for the surveys. These were a mix of poor and middle-income communities (Table 10).

District	Communities	Income level
Nong Jork	Lampakchee and Lamtaoting	Poor
Minburi	Jairanai, Garden Home and Buakaw	Middle-income
Ladkrabang	Sudthawad and Leabklongmorn	Poor
Klongsamwa	Teerawan and Baanpoon	Middle-income

Table 10: Sample communities in case study districts

In order to gauge the true effects of the flooding, the researchers designed a series of proxies to better measure the impacts, direct and indirect, on livelihoods and the local economy (Table 11).

Sector	Proxies
Household	Flood level / Flood duration / Cost of physical damage / Work absence / Health (physical and mental)
Agricultural	Flood level / Flood duration / Cost of physical damage / Work absence / Product price
Business	Flood level / Flood duration / Cost of physical damage / Work absence / Stock / Custom and trade
Industrial	Flood prevention plan[69]

Table 11: Proxies for gauging flooding effects, by sector

HOUSEHOLD SECTOR					
Proxy variables	**Sub-proxies**				**Total**
Loss Incurred	*Food and utilities*	*Transportation*	*Repairs*	*Flood prevention*	
	15,000	600	25,000	5,000	44,400
Work absence	*Daily income*	*Day (s) absent*			
	300	3			900
Health	*Medication*				
	300				300
					45,600

[69] It was not possible to access information in this sector, either at the employer or factory worker level, and so the impact could not be measured. However, as most of the factory labor force resides close to the industrial estate, the information acquired through the household surveys was an acceptable substitute. In addition, the researchers were able to access information regarding the flood prevention plan of both industrial estates to analyze the gap in their adaptation strategies.

BUSINESS SECTOR					
Proxy Variables	**Sub-Proxies**				**Total**
Loss Incurred	*Lost customers*	*Stock damage*	*Repairs*	*Flood prevention*	
	15,000	5,000	5,000	5,000	30,000
Work absence	*Expenses (workers)*	*Day(s) absent*			
	300	3			900
					30,900

AGRICULTURAL SECTOR			
Proxy Variables	**Sub-Proxies**		**Total**
Loss Incurred	*Field damage*	*Flood prevention*	
	30,000	12,000	42,000
Work Absence	*Daily income*	*Day(s) absent*	
	500	30	15,000
			57,000

Table 12: Proxy measurements for flood-related costs of flooding, by sector

This provides a fuller picture of flood-related costs to individuals and the community. Table 12 above summarizes the average loss for each household, business and farm in the sample communities. While it includes repair costs to housing, vehicles and other equipment, it also extends to the intangible or indirect losses that result from illness, work absence or additional transport costs caused by flooding. Revenue shortfalls or unpaid leave create an added burden that conventional measurements of costs and losses often fail to capture. As Table 12 shows, these indirect costs are substantial for households, businesses and agriculture. In the case of businesses, the indirect costs of lost customers, work absence and the 'invisible' cost of flood prevention in fact exceed the direct costs of repairs and physical damage.

Table 13 is a detailed breakdown of the total costs, sorted by sector, month and district, of the flooding between August and November. For the sake of clarity, the effects on each sector and district is color coded according to its intensity, from 'no impact' (no color) to 'high' (blue), as the legend below the table explains. These measurements are used to assess the relative flooding levels, economic loss, physical damage, health effects and work absence resulting from the 2006 flood. Data is also presented for the less severe flood event of 2010 by way of comparison.

The results highlight the importance of a localized analysis of the impacts of flooding, as both the intensity and the nature of its effects vary considerably from district to district. Of the four, Minburi was the worst affected in 2006 and 2010. The impact was particularly pronounced in September and October, as residents suffered loss of livelihood as a result of economic disruption and health risks.

Work absence is also an important indirect cost in the flooding. In Klongsamwa and Ladkrabang, the two most densely populated districts, some residents were unable to travel to work, especially in October when the inundation was at its peak. Ladkrabang in particular is a major agglomeration economy, with an industrial estate and the then recently constructed Suvarnabhumi Airport, opened in September just before the flooding hit. However, as table 14 shows, work attendance remained relatively unaffected through the flooding, suggesting a comparatively high level of adaptation. Nevertheless, within the agricultural sector work absence was a major problem as fields and land were inundated, in the worst cases potentially extending into weeks.

Interestingly, the impacts were comparable across different income levels. In particular, the relatively low impact of work absence on poor and affluent households was in fact similar for the lowest income (<10,000 Baht/month) and the highest income (>50,000 baht/month) households. From these results, it would seem that low income households demonstrated a relatively high level of adaptation to the flooding. There are probably a number of dimensions to this: for example, the limited ability of low income households to shoulder the costs of work absence, especially when unlike higher income households they may not have the security of formally salaried employment. In this case, the adaptation strategies of low and high income households, however 'successful', are likely to be substantially different in nature.

The survey also illustrated some interesting dimensions to flood preparedness at a household level. The results highlighted poor levels of preparedness in 2006: for instance, only 26% of households had stocked food and only 31% drinking water before the flood. However, this proportion rose substantially for the 2010 flood (to 37% and 41% respectively), suggesting that many households had learnt important lessons from the previous event and prepared more effectively. And when respondents were asked whether in future they would be willing to stock up on food and water supplies before flooding, for both goods around 75% of households stated that they were willing to do so. This suggests that local communities have the capacity to develop better preparation strategies and that there is still further potential to improve on these responses. This is where a well-coordinated strategic partnerships could be very effective.

Health care costs, whether for minor pharmaceutical purchases or more serious referrals, are another important indirect cost that is often overlooked in damage assessments. These costs are often not insubstantial. In Nong Jork, where much of the area is farmland, parts of the district experienced protracted flooding, with some areas submerged in over a foot of water for more than a month. As a result, the generally low income population was faced with a variety of health issues, such as dengue fever and foot-and-mouth disease.

MINBURI

Household Impact (2006)								
Month	Community			Home			Work	Health
	Level	No.	Loss	Level	No.	Loss		
August								
September								
October								
November								

Household Impact (2010)								
Month	Community			Home			Work	Health
	Level	No.	Loss	Level	No.	Loss		
August								
September								
October								
November								

NONG JORK

Household Impact (2006)								
Month	Community			Home			Work	Health
	Level	No.	Loss	Level	No.	Loss		
August								
September								
October								
November								

Household Impact (2010)								
Month	Community			Home			Work	Health
	Level	No.	Loss	Level	No.	Loss		
August								
September								
October								
November								

KLONG SAMWA

Household Impact (2006)								
Month	Community			Home			Work	Health
	Level	No.	Loss	Level	No.	Loss		
August								
September								
October								
November								

Household Impact (2010)								
Month	Community			Home			Work	Health
	Level	No.	Loss	Level	No.	Loss		
August								
September								
October								
November								

LAD KRABANG

Household Impact (2006)								
Month	Community			Home			Work	Health
	Level	No.	Loss	Level	No.	Loss		
August								
September								
October								
November								

Household Impact (2010)								
Month	Community			Home			Work	Health
	Level	No.	Loss	Level	No.	Loss		
August								
September								
October								
November								

Table 13: Intensity of costs by month, district and sector, August-November 2006 and 2010

2006 Flood

PROXY PARAMETERS	Household Sector (300HH)								Agricultural Sector(50)			Business Sector(30)	
	Community				Home								
	<10,000	10,000-30,000	30,000-50,000	>50,000	<10,000	10,000-30,000	30,000-50,000	>50,000	Farm	Livestock	Fishery	Consumer Goods	Services
Flood Level	57.14%	54.07%	52.22%	63.16%	32.14%	41.48%	47.78%	42.11%	45.45%	66.67%	60.00%	68.75%	57.14%
No. of Days Flooded	62.50%	47.41%	52.00%	52.63%	57.14%	38.52%	44.44%	42.11%	78.79%	75.00%	80.00%	56.25%	57.14%
Loss Incurred	44.64%	43.70%	45.56%	31.58%	30.36%	28.15%	28.89%	36.84%	42.42%	50.00%	40.00%	43.75%	50.00%
Work Absence	*	*	*	*	80.36%	87.41%	85.33%	84.31%	90.91%	91.67%	80.00%	56.25%	42.86%
Health	*	*	*	*	66.07%	59.26%	74.44%	68.42%	*	*	*	*	*
Production Price	*	*	*	*	*	*	*	*	75.76%	58.33%	100.00%	*	*
Stock	*	*	*	*	*	*	*	*	*	*	*	31.25%	*
Customer	*	*	*	*	*	*	*	*	*	*	*	43.75%	64.29%

2010 Flood

PROXY PARAMETERS	Household Sector (300HH)								Agricultural Sector(50)			Business Sector(30)	
	Community				Home								
	<10,000	10,000-30,000	30,000-50,000	>50,000	<10,000	10,000-30,000	30,000-50,000	>50,000	Farm	Livestock	Fishery	Consumer Goods	Services
Flood Level	39.29%	31.85%	39.00%	42.11%	32.14%	31.11%	31.00%	36.84%	51.52%	50.00%	60.00%	56.25%	50.00%
No. of Days Flooded	32.14%	30.37%	31.00%	31.58%	32.14%	34.07%	34.00%	31.58%	72.73%	58.33%	60.00%	43.75%	42.86%
Loss Incurred	42.86%	41.48%	41.00%	36.84%	33.83%	35.56%	36.00%	31.58%	39.39%	58.33%	40.00%	31.25%	35.71%
Work Absence	*	*	*	*	87.50%	85.93%	85.56%	89.47%	81.82%	75.00%	60.00%	56.25%	50.00%
Health	*	*	*	*	66.07%	65.93%	67.78%	52.63%	*	*	*	*	*
Production Price	*	*	*	*	*	*	*	*	90.91%	66.67%	60.00%	*	*
Stock	*	*	*	*	*	*	*	*	*	*	*	18.75%	*
Customer	*	*	*	*	*	*	*	*	*	*	*	50.00%	78.57%

Table 14: Intensity of flood impact by sector and income level, 2006 and 2010

	Flood Level	No.of flood days	Loss Incurred	Work Absence	Health
High	30 cm	> month	>10,000	> week	Admission
Medium	15 cm	1-4 week	5,000-10,000	3-5 days	District Officer
Low	5 cm	< week	<5,000	1-2 days	Store Purchases
No Impact	No impact	No impact	No impact	No impact	No impact

Key to Tables 13 and 14

Another important finding from the survey is that that the costs of the flooding, through lost income and damaged infrastructure, is generally more severe for the community as a whole than individual households. This suggests a different perspective on the effects of flooding and the value of viewing its impacts at a community level: the conventional measurements used in official data, besides national aggregations, is typically the unit of the individual household. If the impacts at a community level are more severe, as these results suggest, then this would reinforce the importance of collective adaptation and mitigation strategies at a community level. Currently, preparedness in the event of extreme flooding is generally undertaken privately by individual households, with government encouragement focusing on self-reliance and personal initiative. But to minimize the very substantial community-wide costs of the flooding, there needs to be a platform for collective action.

The results also show that within the agricultural sector, farmland was the worst affected by flooding in both 2006 and 2010, with levels in excess of a foot lasting over a month. Therefore, from one perspective, farmland is arguably the most vulnerable to flooding. Nevertheless, it is important to note that fisheries were the most affected by the increasing cost of production in 2006. The government therefore must factor these different effects into its assessments and compensation strategies to reflect the varying costs to different agricultural sectors.

As for small businesses, the impact is less straightforward and depends in particular on the product of the enterprise. In this case, the sub-proxies that sort the findings by occupation and business type are instructive. For instance, while the service sector was weakened by flood-related disruption, demand for basic consumer goods actually rose among residents who were more reliant on local shops to provide them with food and other provisions. Again, these nuances potentially have important implications for how post-disaster economic recovery strategies should be targeted.

Together, the data on the impacts of the flooding in terms of health, work absence and other costs, direct and indirect, highlight the limitations of the dominant approach to flood protection in Thailand: as largely a matter of water management. This is reflected in its institutional governance and the strongly technical responses to flood-related threats, as discussed in section 4. Yet in reality, flood events impact on education, health, social welfare, community cohesion and other areas that present strategies, with their emphasis on megaprojects and structural investments, generally fail to reach.

4. Adaptation responses

4.1 Current adaptation measures

Bangkok has long been supported by the historic network of *khlong* and the polder system, supported by the King's Dyke, that protect the inner city (see section 1.2.2). Nevertheless, as this study has shown, large areas of suburban Bangkok were inundated in 2006 and at a substantial social and economic cost to local communities. This highlighted the need for further protective capacity and so, as with the 1983 and 1995 floods, further measures were proposed in its wake, including the creation of a diversion canal at the upper Ta Chin river to channel some of the water away from the Chao Phraya[70]. The strategic focus since then - for example the Royal Irrigation Department (RID) master plan - has been primarily infrastructural, with an emphasis on creating and enhancing drainage and pumping[71]. In partnership with the Department of Drainage and Sewage,

[70] Vongvisessomjai, S. (2007). Flood Mitigation Master Plan for Chao Phraya Delta. Paper presented at the 4th INWEPF Steering Meeting and Symposium. Retrieved at: http://web.rid.go.th/ffd/papers/Paper-Session%201/p1-04%20Flood%20Mitigation%20Master%20Plan.pdf

[71] ADB/JICA/World Bank (2010). *Climate Risks and Adaptation in Asian Coastal Megacities*, pp.25-26. Retrieved at: http://siteresources.worldbank.org/EASTASIAPACIFICEXT/Resources/226300-1287600424406/coastal_megacities_fullreport.pdf

the RID developed a 450 km^2 protected area in the eastern suburbs beyond the King's Dike, supported by a system of monitors and flood walls along the main canals to restrict inflows of floodwater from nearby. Three pumping stations have been constructed at Hok Wah Sai Lang, Saen Saeb and Pravetburirom to provide the system with an additional CMS of drainage capacity[72].

Despite the substantial investment in flood protection in the last three decades, the city's flood management system may prove inadequate in the years to come. Already, during the 2011 flooding, it was reported that the system was struggling to cope with the massive volumes of runoff flowing in from the north: according to former officials, the infrastructure had been primarily developed to cope with localized flooding from heavy rainfall[73]. In addition, the King's Dyke is designed to cope with low level flooding, as opposed to a major flood event[74]. In the future, with the effects of climate change, land subsidence and other factors, the existing and planned dykes and drainage may not even be able to protect flood-vulnerable areas such as the western parts of Bangkok against more than a 1-in-10-year flooding event[75]. While Bangkok has a strong potential adaptive capacity, it may nevertheless find that it fails to keep pace with the increasing threat and exposure brought about by climate change and rapid population growth[76].

STRUCTURAL MEASURES	**NON-STRUCTURAL MEASURES**	
Water management	**Land use control**	**Loss reduction**
Main pump	*Land regulations*	
Polder embankments	*Public information/education*	
Dykes	*Flood proofing*	
Retention area (basin)		
Canal improvement	*Flood forecasting/ warning*	
Drainage (inner pumps, sub-khlong, pipes)		*Flood fighting*

Table 15: Structural and non-structural flood prevention measures[77]

[72] Department of Drainage and Sewage, BMA (2009). *Flood Protection in Bangkok*. Paper revised from Vitoonpanyakij, C. (2007). Flood protection in BMA 2006.

Bangkok Post, 'Drainage system not up to task'. October 30, 2011. Retrieved at: *Flood Protection in Bangkok*. Paper revised from Vitoonpanyakij, C. (2007). Flood protection in BMA 2006.http://www.bangkokpost.com/news/local/263836/drainage-system-not-up-to-task[73] Bangkok Post, 'Drainage system not up to task'. October 30, 2011. Retrieved at: http://www.bangkokpost.com/news/local/263836/drainage-system-not-up-to-task

[74] IRIN, 'How to build a flood-resilient city'. November 28, 2011. Retrieved at: http://www.irinnews.org/printreport.aspx?reportid=94319

[75] World Bank (2009). *Climate Change Impact and Adaptation Study for Bangkok Metropolitan Region*, p.xii. Retrieved at: http://siteresources.worldbank.org/INTTHAILAND/Resources/333200-1177475763598/3714275-1234408023295/5826366-1248255995902/executive-summary.pdf

[76] Yusuf, A. and Francisco, H. (2009). *Climate Change Vulnerability Mapping for Southeast Asia*. Economy and Environment Program for Southeast Asia.

[77] Department of Drainage and Sewage. Retrieved at: http://www.rid.go.th/thaicid/_5_article/2550/chanchai.swf

Whether Bangkok proves itself capable of developing comprehensive and holistic responses to climate change and other environmental threats will be of critical importance to the city's future. In part, any long term solution will probably require additional, well-targeted investment in physical infrastructure. The World Bank has already proposed a range of future investments to enhance the capital's pumping and drainage capacity[78]. However, it will need to be accompanied by a broader legislative, regulatory and planning framework to address the multidimensional character of flood-related threats. Much of Bangkok's strategy to date has been characterized by structural and preventive measures, in particular 'megaprojects', with an emphasis on mitigation. As Table 15 shows, structural measures are primarily about the technical aspects of water management, supported by the physical hardware of dykes, embankments, drainage tunnels and so on. But there are also important non-structural approaches that should be implemented, with a focus more on regulating land use and reducing exposure, such as planning regulations and community education. To support the city's adaptation to the reality of climate change in the decades ahead, Bangkok must afford a much greater priority to these measures. Some non-structural measures are already in place. For example, the Flood Control Center is an information and decision making tool, with a flood forecasting system that predicts rainfall intensity across 650 km^2 of the east bank. The focus is still fundamentally on short term mitigation, however: the timeframe is generally 3-6 hours ahead of the flooding[79]. Furthermore, though the coverage within the central part of the city is extensive, there are also striking gaps, as figure 10 shows: there are no centers located in the eastern suburbs, for example, in the case study districts.

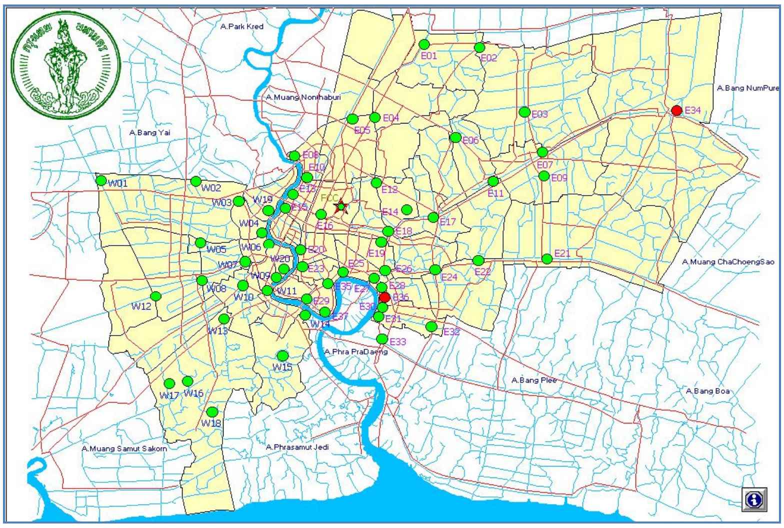

Figure 10: Flood control centers, Bangkok

While there has also been some emphasis on other non-structural measures, particularly in outlying urban areas such as the district in this case study, this arguably reflects expediency rather than a commitment to adaptation: much of Bangkok's existing infrastructure is devoted to protecting its inner centre, while the suburbs of the city are largely unprotected. This has been a major source of

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[78] In eastern Bangkok, where the case study communities are located, pumping capacity to channel floodwater into the Tha Chin River and the Gulf of Thailand is still inadequate, according to the study: it suggested expanding pumping capacity from 737 to 1,065 m^3/s and so raising the total capacity of the canals from 607 to 1,580 m^3/sec. In the western area of the city, the three major pumping stations at Khlong Phasi Charoeng, Sanam Chai, and Khun Rat Phinit Chai currently have a combined capacity of only 84 m^3/s. Other approaches, already proposed by the BMA, include a coastal erosion protection strategy and embankments along the shoreline of the eastern area of the Chao Phraya River to protect the industrial community area from rising sea levels. The study estimated that for1m1-in-30 year flood in an A1F1 climate scenario, the inundated area in Bangkok and Samut Prakarn provinces would be reduced by 51%, from 744.3km^2 to 362.1km^2. It found that the funding necessary to protect Bangkok from a 1-in-30- year or 1-in-100-year flood event was 35 billion or 49 billion baht respectively, and concluded that in both cases the investment would be economically feasible. ADB/JICA/World Bank (2010). *Climate Risks and Adaptation in Asian Coastal Megacities*, pp.56-57. Retrieved at: http://siteresources.worldbank.org/EASTASIAPACIFICEXT/Resources/226300-1287600424406/coastal_megacities_fullreport.pdf

[79] http://www.unescap.org/idd/events/2009_EGM-DRR/ThailandFlood%20Protection%20in%20Bangkok.%202009.pdf

tension during flood events, such as in 2011, when the capital's protective infrastructure failed to protect large swaths of the city's suburbs from inundation. In fact, by blockading the flow of the floodwater from entering the city, this 'flood protection' was regarded by some flood-affected residents as an aggravation. In Khlong Sam Wa, for instance, there were standoffs between locals and the police over community demands that the sluice gate there be opened to relieve flooding in the area[80], with residents subsequently breaking a hole in it[81].

To date, the emphasis has been weighted too heavily on mitigation and short term prevention, generally through structural means. The BMA's strategies focus primarily on three approaches:

- **Flooding prevention:** this is achieved through both structural and non-structural measures. While the former is typically employed in dense, inner city districts, the latter is often favored in low density residential and agricultural areas. This potentially suggests that in suburban areas, such as the case study districts, full prevention may not be achievable, but the negative effects of inundation can be substantially reduced through effective adaptation measures.

- **Post-flood disaster recovery:** focused on immediate mitigation through operating and maintaining pumping and drainage capacity, as well as developing a short term action plan. In 2006, this included the installation of additional pumps in high risk areas, the release of surplus water into irrigation areas and upstream water retention.

- **Medium-term post-flood disaster recovery**: maintaining existing infrastructure and constructing additional capacity to sustain and enhance protective capacity, accompanied by measures to prevent and resolve flooding. Careful coordination, monitoring and evaluation is necessary to achieve this.

The weaknesses of this approach are clear, especially in the context of chronic land subsidence and a rapidly changing climate. What is needed instead is a meaningful strategy of long term adaptation that would prepare Bangkok for the possibility of 'safe failure'. This would mean that, in the event of the partial or total failure of its protective infrastructure against a future flood, the capital would be sufficiently adapted to recover quickly and without catastrophic consequences. This is a far securer approach than relying solely on infrastructure for protection, while doing little to improve the city's adaptive capacity. If Bangkok's history of flooding has demonstrated anything, it is that even well-developed infrastructure is not infallible.

There have, in fact, been urgent calls along these lines for many years. After the 2006 flooding, for instance, there were proposals to develop a broader developmental vision for the capital that would minimize its exposure to future flooding. Additional flood protection was planned and budgeted at a national and city level until 2014, along with a long-term land use plan up to 2057 with designated development nodes and protected zones for environmental drainage[82]. In practice, though, the effectiveness of these measures has been weak. For decades, what regulation has been put in place has frequently been sabotaged, ignored or circumvented. One example, back in 1992, is the BMA's belated planning restrictions in the eastern floodplain, with detailed zoning for landfills and housing. Had these regulations been observed, it is likely the eastern area of Bangkok would have retained

[80] Bangkok Post. Khlong Samwa still tense. October 31, 2011. Retrieved at: http://www.bangkokpost.com/breakingnews/264082/khlong-samwa-still-tense

[81] Bangkok Post. Khlong Samwa sluice gate 'fixed'. November 2, 2011. Retrieved at: http://www.bangkokpost.com/breakingnews/264440/khlong-samwa-sluice-gate-fixed

[82] ADB/JICA/World Bank (2010). *Climate Risks and Adaptation in Asian Coastal Megacities*, pp.25-26. Retrieved at: http://siteresources.worldbank.org/EASTASIAPACIFICEXT/Resources/226300-1287600424406/coastal_megacities_fullreport.pdf

more of its natural capacity as a floodway, and the destruction inflicted by the 2006 flooding in the case study districts would have been substantially lower. Yet in practice, the code was widely ignored[83]. Bangkok also has a system of 'green diagonal' zoning in areas of Khlong Samwa,Minburi, Ladkrabang and Nong Chok, where the construction of most property types is prohibited and limited to single houses on a plot of 1,000 *wah*. Regulations also impose a minimum of 100 *wah* for houses in certain areas to the west of the city. This is intended to benefit farmers and provide them with the land they need for cultivation. However, through a legal loophole the regulations have been exploited to facilitate the construction of luxury housing in areas such as Thonburi, in western Bangkok[84].

In the wake of the 2011 flooding, the city is now proposing to introduce designated floodway zones in the eastern and western suburbs of Bangkok, protected by development restrictions, in its forthcoming 2012 city plan[85]. Whether this time the regulations are properly imposed remains to be seen and will depend in no small part on the city's ability to resolve the ongoing issues of fragmented governance and poor cooperation described in sections 4.2 and 4.3.

4.2 Flood governance and strategic frameworks

By their very nature, flooding and other environmental disasters are multidimensional in their devastation: their solutions must therefore be multidimensional too. Rising sea levels, for example, will necessitate improved neighborhood dykes and drainage, as well as a well-managed coastal retreat strategy and substantial infrastructure to protect harbors. Similarly, the growing frequency of extreme weather events will require a holistic range of responses that encompasses prevention, mitigation, adaption and short term relief and involves a variety of stakeholders, from central government and the local authorities to communities and the private sector. Measures should include flood-proofed buildings and better drainage, but also extend to related areas such as energy diversification. As for coping with the immediate aftermath of a natural disaster, preparation should be both 'top down' and 'bottom up': effective emergency planning by the relevant public bodies should be balanced, at a household level, with measures like an emergency stock of provisions to ensure a period of self-sufficiency if supplies are disrupted by a major flood event[86].

This approach requires a holistic and highly integrated collaboration between different departments and administrations. In practice, however, Bangkok's flood governance is a major obstacle to effective action. Historically, Thailand's institutional authority has suffered from fragmentation by multiple agencies with autonomous, overlapping or conflictual mandates. Tensions and contradictions, often highly politicized, also exist between central and local governing bodies. This pattern is evident is in Bangkok's flood adaption policies. The lack of cooperation and integration between these various bodies has in fact been identified as one of the main obstacles to future flood management in the basin[87]. The barriers are typically:

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[83] Bangkok Post, 'Heeding his majesty's advice'. December 1, 2011. Retrieved at: http://www.bangkokpost.com/feature/environment/268709/heeding-his-majesty-s-advice

[84] Bangkok Post. Lessons learned for city planning. December 12, 2011. Retrieved at: http://www.bangkokpost.com/business/economics/270348/lessons-learned-for-city-planning

[85] Bangkok Post, 'Floodways key to keeping capital safe'. November 20, 2011. Retrieved at: http://www.bangkokpost.com/news/local/267040/

[86] Bangkok Metropolitan Administration, Green Leaf Foundation and United Nations Environment Programme (2009). *Bangkok Assessment Report on Climate Change 2009*. Bangkok: BMA, GLF and UNEP

[87] Sapphaisal, C. (2007). Planning and Flood Mitigation for the Chao Phraya River Basin. Retrieved at: http://www.rid.go.th/thaicid/_5_article/2550/chukiat.swf

- **Specialist/institutional**: reflecting designated technical expertise or even ingrained special interests.

- **Local/central**: reflecting conflicting or overlapping responsibilities.

- **Geographic**: reflecting the absence of a substantive coordinating authority within greater Bangkok.

Figure 11 summarizes the different central and municipal government bodies responsible in various ways for flood prevention/relief and post-disaster recovery. What is immediately clear is the divergent roles and mandates that each organization has, with specific institutional remits to prevent, alleviate and resolve flood-related issues such as pollution, road maintenance, mental health and environmental degradation. In fact, a variety of sector-specific agencies are operating within the broad remit of flood management, including the Electricity Generating Authority of Thailand (EGAT), the Royal Irrigation Department (RIG) and the Public Works Department (PWD)[88]. The Ministry of Agriculture and Cooperatives is responsible for agricultural water management and flood protection for a large number of urban centers. The Ministry of the Interior, on the other hand, deals with disaster preparedness and prevention at a local level. Meanwhile, the Ministry of Natural Resources and Environment develops climate change adaptation research, and the Ministry on Science and Technology plans future water management strategies for the country[89]. Flood protection within the Chao Phraya Basin is also fragmented by central and local administrative mandates. There are administrative bodies with localized governance remits, such as the Local Administration Department (LAD) and the BMA within Bangkok[90], as well as city-level specialist units such as the Department of Drainage and Sewage and the Flood Control Center, both responsible for different aspects of flood prevention in Bangkok[91]. As a result, flood protection strategies may involve a wide array of different actors with separate mandates[92].

But while this might at first appear as positive evidence of a multidimensional and integrated disaster prevention approach, due to Thailand's institutional divisions the overall effect is not cooperative and holistic. For instance, the confused institutional structure means that there is often little clarity among stakeholders over which agencies are overseeing various aspects of flood protection: respondents in the surveys undertaken for this report demonstrated a range of divergent opinions on which department was primarily responsible, suggesting poor linkages between public authorities and communities. Furthermore, in important ways, the BMA has only limited control over its own flood protection strategy. Firstly, in terms of financing, there is the BMA's requirement to secure funding for its flood protection through grant subsidies from the national government, rather than locally controlled levies. Secondly, in terms of governance, it has no formal influence over flood-related issues outside its geographic remit, such as water management strategies

88 Sapphaisal, C. (2007). Planning and Flood Mitigation for the Chao Phraya River Basin. Retrieved at: http://www.rid.go.th/thaicid/_5_article/2550/chukiat.swf

89 Stockholm Environment Institute. Scoping Assessment on Climate Change Adaptation: Thailand. Retrieved at: http://www.pnclink.org/pnc2011/english/ppt/Dusita%20KRAWANCHID.pdf

90 Sapphaisal, C. (2007). Planning and Flood Mitigation for the Chao Phraya River Basin. Retrieved at: http://www.rid.go.th/thaicid/_5_article/2550/chukiat.swf

91 http://www.unescap.org/idd/events/2009_EGM-DRR/ThailandFlood%20Protection%20in%20Bangkok.%202009.pdf

92 For example, existing proposed dam projects jointly managed by EGAT and RID; dike alignment by RIG, LAD and BMA; a polder system to protect municipal areas involving BMA and PWD; non-structural issues such as legislation by LAD; and the extension of flood protection areas in the eastern suburbs by RID and DDS. Department of Drainage and Sewage, BMA (2009). *Flood Protection in Bangkok*. Paper revised from Vitoonpanyakij, C. (2007). Flood protection in BMA 2006.

upstream, particularly the release or retention of runoff in the country's major dams. While flooding in the city may be significantly affected by these issues, they are generally formulated by the Ministry of Agriculture and Cooperatives, with no official platform for the BMA to advise or influence its decision making. Thirdly, the authority of the BMA is also limited in other ways, in relation to other local bodies. While Bangkok itself has extended far beyond its original boundaries and now encompasses the surrounding 5 provinces, this is not reflected in a single executive agency: the BMR still comprises multiple autonomous authorities with only limited shared cooperation. This means that the BMA has little or no say over many decisions that in practice impact heavily on Bangkok city. For instance, while the BMA has imposed regulation on natural floodways in areas of Bangkok province, including the eastern suburbs, it has only been able to impose these controls within its own geographical remit, not throughout the BMR. Therefore it had no control over the construction of Suvarnabhumi airport within the neighboring province of Samut Prakan, even though the development in the heart of the eastern floodplain had a predictable impact on the drainage capacity of the area, and is now a major obstruction to the natural flow of floodwater from the north[93].

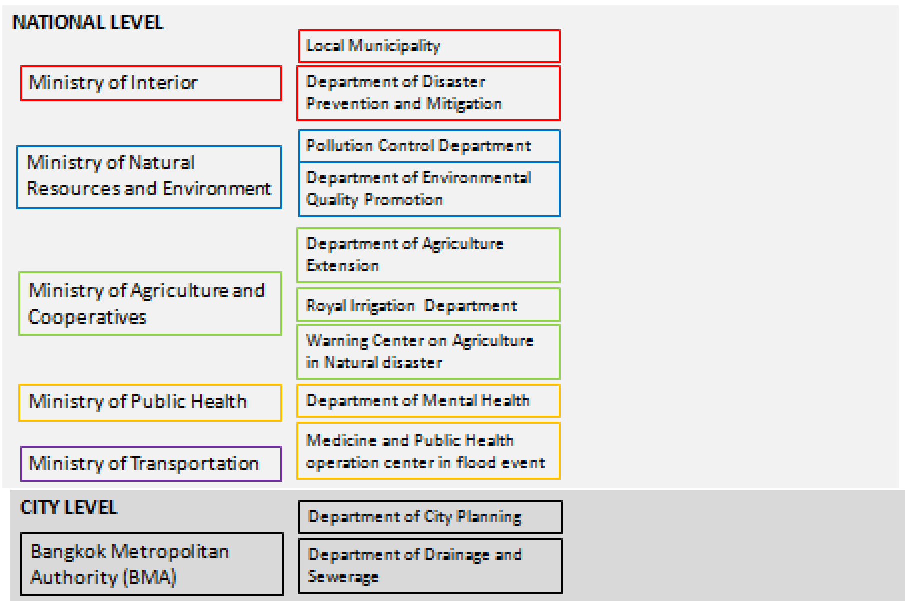

Figure 11: Governance framework for disaster prevention and emergency relief

What is also striking is the strong institutional emphasis on short term solutions, as figure 12 shows: the priority focus areas of the different agencies within the management framework are reactive and immediate. Though the Department of City Planning and the Department of Drainage and Sewage have some medium term vision, there is no substantive overarching policy framework to develop a long term strategy. Furthermore, strategy is constrained significantly by the four-year terms that govern political office at both the city and national levels. The substance of government policy and action plans are structured to a considerable degree around these cycles, while long term strategic frameworks remain largely conceptual.

93 Bangkok Post, 'Heeding his majesty's advice'. December 1, 2011. Retrieved at: http://www.bangkokpost.com/feature/environment/268709/heeding-his-majesty-s-advice

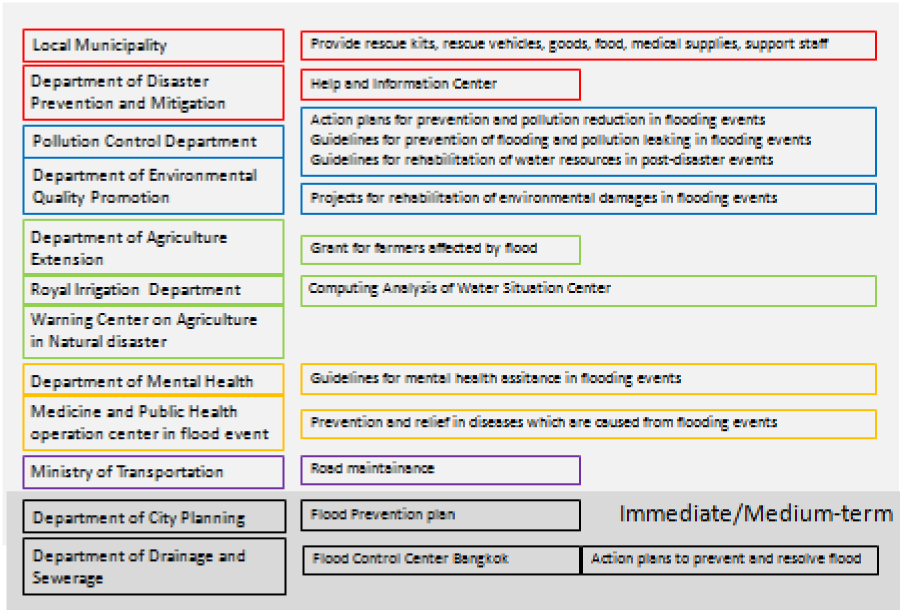

Figure 12: Governance framework for post-disaster recovery

These two issues - weak institutional integration, and short term priorities - are particularly evident in Bangkok's climate change policies. Officially, climate change has been acknowledged by the government as a national threat since the Seventh National Economic and Social Development Plan (1992-1996)[94]. But to effectively alleviate the effects of climate change requires, as the BMA has acknowledged, the involvement of a wide variety of sectors including public health, building regulations, renewable energy generation, disaster monitoring, disease surveillance, community engagement, water services, transportation and recycling[95]. However, though there has been some degree of integrated strategic development at a national level, and even recognition among different agencies (including bodies within the BMA) of the need for greater institutional cohesion, this has not translated into a comprehensive and integrated policy approach. For instance, while the Bangkok 5-Year Action Plan for Climate Change acknowledged the need for cross-sectoral cooperation, it largely overlooked the critical issue of vulnerability reduction[96]. The World Bank also found that, while a number of municipal bodies within the BMR had developed future strategic frameworks, climate change considerations had not been factored into their projections[97].

Developing an adequate long term response to flooding will require an integrated and multi-disciplinary policy framework, coordinated to ensure coherence but flexible enough to accommodate localized strategies. However, this will be difficult to achieve without substantive institutional reform.

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[94] Bangkok Metropolitan Administration, Green Leaf Foundation and United Nations Environment Programme (2009). *Bangkok Assessment Report on Climate Change 2009*. Bangkok: BMA, GLF and UNEP

[95] Bangkok Metropolitan Administration, Green Leaf Foundation and United Nations Environment Programme (2009). *Bangkok Assessment Report on Climate Change 2009*. Bangkok: BMA, GLF and UNEP

[96] Hutanuwatr, K. (???). A Preliminary Review on Frameworks for Thai Climate Risk and Approaches in Social/Economic Vulnerability Assessment in Bangkok. Retrieved at: http://startcc.iwlearn.org/doc/Doc_eng_21.pdf

[97] ADB/JICA/World Bank (2010). *Climate Risks and Adaptation in Asian Coastal Megacities*, pp.56-57. Retrieved at: http://siteresources.worldbank.org/EASTASIAPACIFICEXT/Resources/226300-1287600424406/coastal_megacities_fullreport.pdf

4.3 Private sector and local community participation

In the context of climate change and other environmental threats, Bangkok will need to develop a longer term, cross-sectoral vision that engages the participation of diverse stakeholders and maintains a local as well as a national strategic focus. Yet to do so will require a substantial realignment of the government's approach in favor of a more open and collaborative relationship with other stakeholders, particularly the private sectors and local communities. These efforts, at present partial at best, could galvanize a more coherent and cooperative adaptation response.

4.3.1 Private sector

When tackling climate change, government authorities must make efforts to collaborate more effectively with the private sector. Businesses and industry themselves have a vested interest in improving flood protection systems, given their exposure: for instance, the cost of the 2011 flooding to the manufacturing sector alone has been put at $32 billion[98].

Since 2006, the BMA has undertaken some initiatives to promote partnerships along these lines, such as the 2007 BMA Declaration of Cooperation on Alleviating Global Warming Problems, with 36 private and public sector signatories[99]. More recently, in the wake of the 2011 floods, a coalition of state and private sector bodies was up to help prevent future disasters[100]. The government has also suggested that it will offer 'soft loans' to industrial operators to invest in flood protection infrastructure[101]. This shows at least positive recognition of the need for better cooperation, even if the long term effectiveness of this commitment has yet to be determined.

The Bang Chan Industrial Estate, in the case study district of Min Buri, is an interesting example of a private sector approach to flooding. This was the first large industrial estate to be constructed and as a result is relatively central, located within a low-lying section of Minburi that is inside the King's Dyke. Since 2006, it has taken substantive steps to develop an independent flood protection strategy. This has a number of elements, including:

- *Strengthening protection* through more sandbags.
- *Maintaining drainage* systems to ensure effective floodwater dispersal.
- *Continuously evacuating* excess water.
- *Ongoing monitoring* of water levels.
- *An emergency response team* to prepare and respond to flood threats.

Among the structural measures the industrial estate has taken is the development of a detailed map of the water channels into and out of the Lorlae and Sanaab canals (Figure 13).

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98 World Bank. The World Bank supports Thailand's post-floods recovery efforts. December 13, 2011. Retrieved at: http://www.worldbank.or.th/WBSITE/EXTERNAL/COUNTRIES/EASTASIAPACIFICEXT/THAILANDEXTN/0,,contentMDK:23067443~menuPK:50003484~pagePK:2865066~piPK:2865079~theSitePK:333296,00.html

99 Bangkok Metropolitan Administration, Green Leaf Foundation and United Nations Environment Programme (2009). *Bangkok Assessment Report on Climate Change 2009*. Bangkok: BMA, GLF and UNEP

100 http://www.bangkokpost.com/news/local/271028/disaster-centre-established

101 The Nation. Govt to helo finance flood-barrier construction. January 19, 2012. Retrieved at: http://www.nationmultimedia.com/business/Govt-to-help-finance-flood-barrier-construction-30174077.html

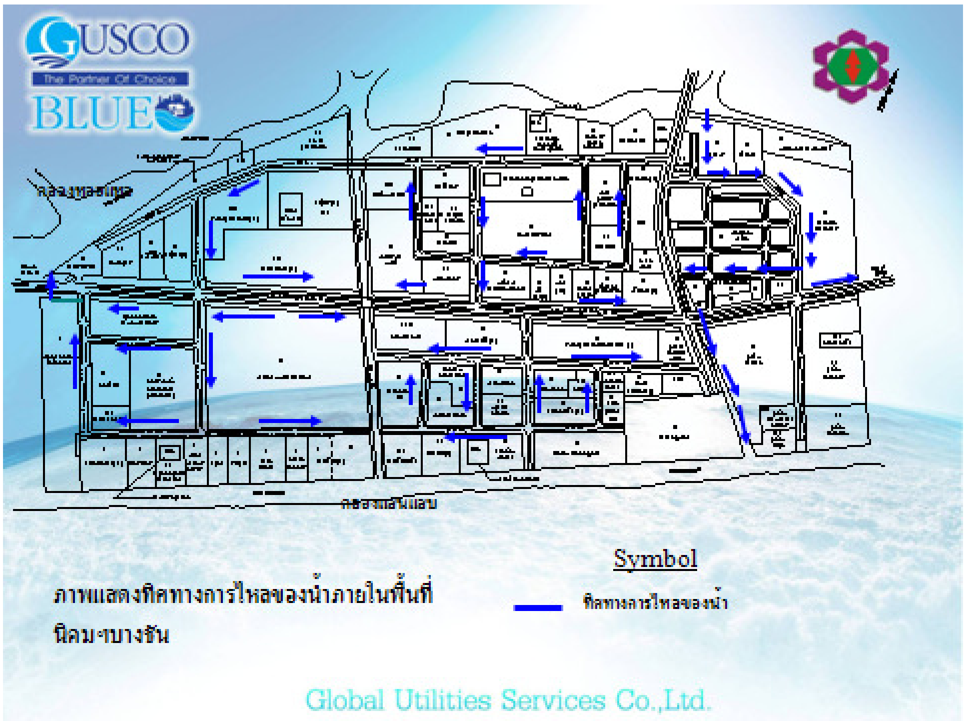

Figure 13: Water channels into and out of the Lorlae (top) and Samsaab (bottom) canals, Bang Chan

A network of sluice gates and drainage stations has also been installed, as shown in figure 14, to manage the circulation and evacuation of floodwater through the estate.

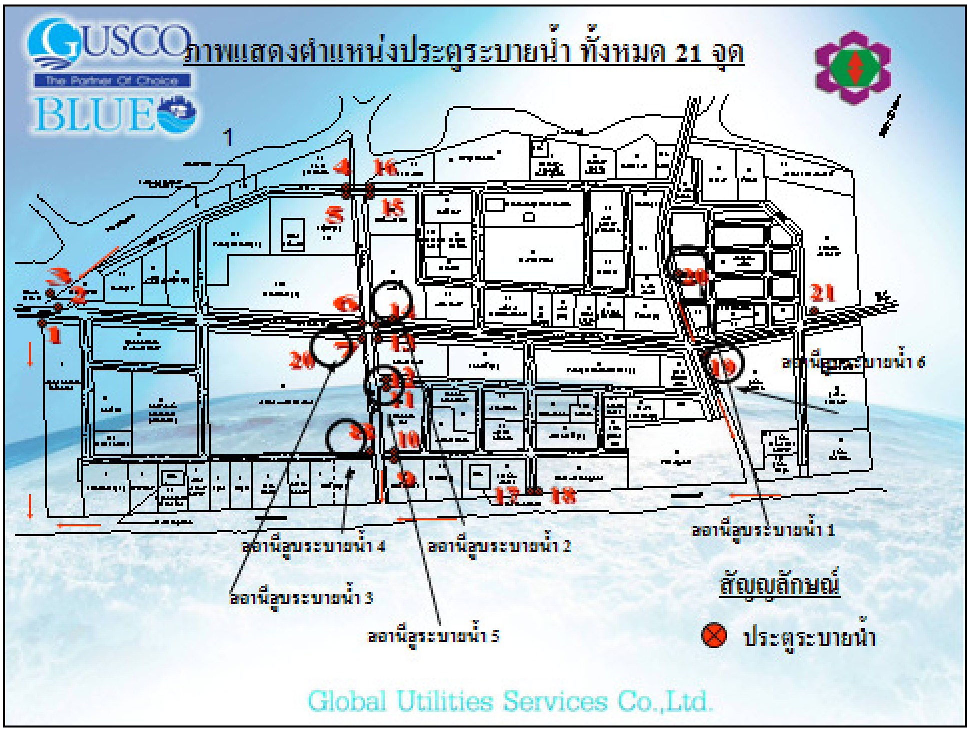

Figure 14: Sluice gate (red cross) and drainage station (circled area) network, Bang Chan

However, while these responses suggest a growing sense of initiative, the strategy is compromised by two fundamental weaknesses. Firstly, the focus is still on flood prevention through heavy structural investment, with little in the way of actual adaptation. Secondly, there was no meaningful participation of the local communities. Yet the canals around the estate are a public and the water management decisions of a large industrial estate such as Bang Chan has potentially serious implications for surrounding communities, particularly during flooding. A collective response, therefore, involving local stakeholders and with a substantive adaptation component, would have been more appropriate. Community participation, as discussed in the next section, should be a central component in public sector as well as private sector flood management strategies.

4.3.2 Local communities

It is also essential that the government develops a more collaborative relationship with local flood-vulnerable communities. Engaging communities in the design and delivery of flood-related strategies not only raises the probability of effective uptake and implementations, but also enhances their quality by allowing local knowledge and experience to inform the response.

There have been some tentative efforts. For example, in 2008 the BMA implemented a 'canal water quality improvement' campaign to raise awareness of the importance of canal environments, with the participation of local canal-side communities[102]. Still, there is still a widespread lack of sustained and substantive cooperation between different bodies and institutions. This is due in large part to the absence of a clear platform or institutional structure to facilitate cooperation, both among individual communities and also between them and other sectors, in particular public authorities. This was particularly clear, as mentioned in section 4.2, when participants in the research surveys conducted for this report were asked to name which agency, in their opinion, was responsible for various aspects of flood prevention and protection. The range of responses suggests that linkages between the relevant authorities and local residents were not well-developed or clearly defined.

As part of its study, the research team for this report conducted community workshop[103] in December 2011 with the aim of developing a clearer picture of flood-related challenges and responses during the 2011 flooding in 3 communities (Buakaw, Wangtongpattana and Jaroenchai) in the area. The overall objective was to outline possible collective adaptation strategies for these communities in the future. To maximize the benefits of the meeting, participants were invited from a range of stakeholder groups. Around 20 participants were in attendance, including a hydrology expert from the Ministry of Natural Resources and the Environment, the team researchers, urban development experts, a workshop facilitator, 3 community leaders and other local residents.

As a result of the discussions, a clear picture emerged of the physical and social/communal problems experienced in the area as a result of the flooding:

Physical problems

- *Water stagnation* – particularly in low-lying areas and in older communities where the more recent surrounding communities were located on higher ground.
- *Mobility and transport issues* – some roads were impassable as a result of flooding.
- *Waste* – uncollected garbage and waste was a potential pollutant health hazard.
- *Ineffective drainage* – blockages occurred in the drainage systems and canals, reducing local drainage capacity.

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102 Bangkok Metropolitan Administration, Green Leaf Foundation and United Nations Environment Programme (2009). *Bangkok Assessment Report on Climate Change 2009*. Bangkok: BMA, GLF and UNEP

103 The community workshop was conducted in the Buakaw center on the morning of December 25, 2011, between 1030 and 1200. Around 20 participants were in attendance, including a hydrology expert from the Ministry of Natural Resources and the Environment, the team researchers, urban development experts, a workshop facilitator, 3 community leaders and other local residents.

Social/communal problems

- *Lack of collaboration* – communities did not cooperate effectively with neighboring communities.
- *Slow official response* – there were some delays in district-level responses
- *Health threats* - both physical (through dengue fever and polluted water) and mental (through stress and trauma)
- *The absence of a community-level advance warning system* – insufficient information provided to communities regarding the intensity and timing of flooding.

Drawing on these insights, the participants together developed the outline of a possible strategic framework to promote a more effective collective response to water management and future flooding adaptation:

- *Greater cooperation between communities* – this could be facilitated through the use of community surveys and the creative of a collective drainage channel by clearing the surrounding canals to allow water on Buakaw Road, the main route between the 3 communities, to drain into the Bung Kwang or Sansaab canals.
- *Plan and indentify the primary access points and transport routes* – in the event of future flooding, the participants determined that the 2 main routes would be accessed through 174 Ramkhamhang road and the Thanakorn community as these are at the highest elevation.
- *An expanded flood prevention system* - plan for a larger inundation zone for the water flow through the Bung Kwang canal
- *Drainage maintenance* - canals and drainage systems should be cleared regularly by district authorities and other related organizations.
- *Water pump installation* – a water pump should be permanently installed in the area to drain floodwater into the Bung Kwang canal
- *Community flood warning system* - develop several flood markers in the area as reference points for community residents to gauge flood levels and prepare after official warnings.
- *Pre-disaster waste management plan* – remove household waste regularly from the flood-prone areas to prevent water pollution and treat household waste with a sanitary tank. As the communities were built before the Estate Act, when no regulations existed requiring a communal sanitary tank, a local sanitary tank should be installed south of the community near the Bung Kwang canal.

The research team is also preparing a flood prevention map for the communities, informed by these findings. This workshop, bringing together local knowledge and professional expertise on an open platform to facilitate productive knowledge-sharing, serves as a potential blueprint for mainstream approaches. By engaging with the community, public officials would develop a better understanding of specific localized flood-related impacts and also be able to harness their involvement productively in a collective adaptation framework. As the concluding section of this report highlights, this should be a central component of Bangkok's flood adaptation in the future.

5. Conclusion: Mainstreaming adaptation into long-term planning

This study highlights the very real threats that Bangkok will face in the future as climate change and other environmental hazards exert increasing stress on the fabric of the city. Yet at the same time, alongside these authoritative projections, the recent past should also serve as a vivid reminder of the city's vulnerability. In this study, the 2010 flooding was used as a baseline comparator to assess how much progress, if any, the city had made in protecting itself from inundation. Unfortunately, however, as the fieldwork for this report was concluding the city was presented with an even more extreme flood event. 2011, it transpired, was one of the worst years in the capital's history as much of Bangkok was submerged beneath floodwater. According to the Federation of Thai Industries, the cost to the seven hardest hit industrial estates could reach $13 billion, involving 891 factories and a total of 460,000 workers[104].

While there is not room in this study to examine the various causes of the flooding in detail, it is worth noting a number of elements that highlight the persistence of many key issues. Firstly, the official response to the flooding was sharply criticized for its lack of institutional coordination, the divisive relationships between different agencies and the strong degree of politicization that accompanied relief efforts. While some institutional reforms have been made since 2006, the overall challenges of fragmented governance were still apparent. A recent seminar on the flood highlighted the absence of an integrated and inclusive management approach to flooding disasters, and the role this played in amplifying its destructive impact[105]. Secondly, the spatial limitations of the city's structural fortifications were also evident. In today's context, when Bangkok is a sprawling metropolis with much of its population and industry concentrated in the suburbs outside its core, the strong focus on securing the city centre does little to alleviate the suffering of hundreds of thousands of the city's residents. In fact, as the frequent assaults by flood-affected communities on barriers and dams showed, the protection of inner Bangkok was sometimes regarded as coming at the expense of other neighborhoods that were forced to suffer deeper and more prolonged bouts of flooding as a result[106]. Thirdly, the primary response in the wake of the flooding has been on maintaining and extending the city's physical infrastructure. In January 2012, it was even rumored in the media that a number of experts in the country's water management committee were considering resigning over the government's plans to invest hundreds of billions of baht in additional infrastructure - measures that they believed would not be spent effectively nor resolve the country's long term challenges[107]. Finally, though, commentators diagnosed the same pressing need for a more considered and effective approach to city planning and land regulation[108].

What is clear is that, if Bangkok fails to adapt successfully in the future, flood disasters could become a regular and recurrent problem for large areas of the city. The costs will not only be the substantial direct effects of damaged housing and lost livelihoods, but also the longer term implications for Bangkok as a national centre and regional hub. In the wake of the 2011 flooding, some parliamentary lawmakers have even proposed that the capital be moved to the higher land elevation of Nakhon Nayok[109]. While Bangkok has successfully overcome the challenges of its natural setting in the past, as its economic and demographic vitality testifies, it needs to develop a sustained and meaningful strategic response to a future of climate change and environmental instability if its strength as a global city is to be maintained. It is not clear that infrastructure alone will be able to provide residents of suburban areas like the districts in this case study protection from future flooding. As noted earlier in this report, it was clear during the 2011 flooding that some local

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104 IRIN, 'How to build a flood-resilient city'. November 28, 2011. Retrieved at: http://www.irinnews.org/printreport.aspx?reportid=94319

105 The Nation. 'Give all parties a say in managing water: Panel'. January 3, 2012. Retrieved at: http://www.nationmultimedia.com/national/Give-all-parties-a-say-in-managing-water-Panel-30173056.html

106 For example, see Loy, I. 'Why a Bangkok neighbourhood flood barrier was torn down'. Public Radio International, The World. November 7, 2011. Retrieved at: http://www.theworld.org/2011/11/why-a-bangkok-neighborhood-flood-barrier-was-torn-down/

107 The Nation. Experts threaten walkout on flood prevention schemes, source claims. January 10, 2012. Retrieved at: http://www.nationmultimedia.com/national/Experts-threaten-walkout-on-flood-prevention-schem-30173458.html

108 Bangkok Post. Lessons learned for city planning. December 12, 2011. Retrieved at: http://www.bangkokpost.com/business/economics/270348/lessons-learned-for-city-planning

109 IRIN, 'How to build a flood-resilient city'. November 28, 2011. Retrieved at: http://www.irinnews.org/printreport.aspx?reportid=94319

communities considered that the infrastructure protecting inner Bangkok was making their own situation worse.

Firstly, flood protection measures must develop **a long term planning vision**. Too much effort is expended on reactive measures once flood events have already occurred, with limited preparation for or anticipation of projected future trends. Furthermore, strategic directions are often only partially or inconsistently implemented, as with development restrictions in the eastern parts of Bangkok where the case study districts are located. For outlying areas such as these, far from the city centre and in many cases located in flood-prone territory, the protection afforded by infrastructure will only go so far. Adaptation to the realities of climate change and environmental instability, for example through well-designed land use regulations and rigorous forecasting, will be essential for the city to achieve a 'safe failure' when a future flooding event exceeds the capacity of the city's defenses. In the wake of the 2011 floods, it has been announced that parts of Khlong Sam Wa, Minburi, Nong Chok and Lat Krabang will be designated as flood zones in the draft Bangkok development plan, published in 2012. Future housing developments will be denser, vertical condominium-style complexes alongside designated water drainage routes where construction will not be permitted. Western areas of Bangkok will also be preserved for drainage, with largely agricultural land and high rise housing alongside the electric train routes.

Secondly, this approach must be underpinned by **a strategy of collective adaptation**. One of the key findings of this study was that the damage caused by the 2006 flooding was typically higher at a community level than for the average household. This suggests that a platform for meaningful communal cooperation, drawing on the middle ground between highly centralized public interventions and the 'privatized' approach of household preparedness and self-reliance, would be extremely valuable.

Going beyond internal communal collaboration, there needs to be a broader vision of **meaningful stakeholder participation** between communities, government and the private sector. The data from this research shows the substantial direct and indirect costs that businesses incur as a result of the flooding. At present, the interaction between them and the government is primarily defined by compensations and subsidies. Yet given their substantial interest in developing a more secure and adaptive flood response, the government could engage them in partnerships to help strengthen preparedness - for example, by developing adequate protective infrastructure for vulnerable industrial estates that, unlike the measures adopted at Bang Chan, extend beyond mitigation to adaptation and involve other relevant stakeholders such as local communities. Through substantive communication and outreach, the government could also ensure a more harmonious post-disaster response in flood-hit communities (for instance, by educating them about the necessity of protective barriers that may worsen flooding in their districts and compensating them appropriately for the added cost these may impose). The findings from the surveys in this study showed that, though preparedness at a household level had been relatively poor in 2006, responses had improved considerably by 2010 and interviewees expressed a strong willingness to do so. But government-community partnerships should be a two-way process and be conducted in a spirit of genuine partnership. In this sense, the community workshop conducted by the researchers of this study in December 2011 with community members and a government expert should be considered as a blueprint for a more participatory approach.

Fourthly, flood protection strategies must consider not only the technical and economic implications of flooding, but also the **social and human dimensions**. Flooding has been widely regarded in the past as a water management issue, rather than a complex phenomenon that impacts on livelihoods, urban development and other fields. Yet as the study findings show, the risks of flooding are not only environmental, but socioeconomic. In particular, the research highlighted the substantial indirect costs, in terms of medical care and livelihoods, for households and communities. Flood prevention therefore requires an integrated approach that spans health, waste management and the dynamics of agglomeration economies. It cannot be successfully achieved through engineering alone. The reason why many megaprojects fail is because they seek to 'solve' purely technical problems while largely overlooking the important social realities that play a major determining role in the resilience and vulnerability of flood-prone areas.

Fifthly, to be effective, adaptation strategies must be supported by **adequate and multidimensional data**. As the review of the available secondary data section on the flooding showed (section 3.1), previous risk assessments have been hampered by information shortfalls, ranging from a lack of baseline climate data to the marginalization of non-technical considerations such as socioeconomic vulnerability, water security and health profiles. The research for this study highlights the importance of localized data, with a focus on the specific impacts on districts and communities, to identify the worst affected areas. Furthermore, it shows how the size and nature of flood-related impacts varies by occupation, income group and business type. Replicating this fine-grained approach to data collection and analysis in future, with a focus on the holistic and local impacts, would help develop a clearer picture of flooding effects on the ground - leading in turn to better responses.

Finally, to help achieve all of the above, the dysfunctional nature of the city's flood management must be addressed through **national and municipal governance reform**. This should resolve a broad range of ongoing challenges, including poor institutional coordination, deficient city planning, funding constraints, poverty-related vulnerability and building code development. These in turn will require better cohesion between national and municipal bodies, stronger cooperation between BMA and neighboring provinces of the BMR, and a supervisory platform or executive body to integrate the competing interests of different agencies into an overarching strategic framework. A nuanced flood protection strategy will also necessarily require a site-specific perspective and potentially the decentralization of some authority to districts and communities. Responses should also be holistic, partnering different disciplines and agencies to create cross-sectoral responses to the complex problems of flooding and other environmental disasters.

By integrating these approaches into an informed and collaborative strategy that recognizes the effects of flooding on not only the physical fabric of the city but also its citizens and communities, Bangkok may be better placed in the future to face the very real threats of climate change and environmental disaster.

6. Bibliography

ADB/JICA/World Bank (2010). *Climate Risks and Adaptation in Asian Coastal Megacities*.

Askew, M. (2002). *Bangkok: Place, Practice and Representation*.

Bangkok Metropolitan Administration, Green Leaf Foundation and United Nations Environment Programme (2009). *Bangkok Assessment Report on Climate Change 2009*. Bangkok: BMA, GLF and UNEP.

Bangkok Post. Drainage system not up to task. October 30, 2011.

Bangkok Post. Floodways key to keeping capital safe. November 20, 2011.

Bangkok Post. Heeding his majesty's advice. December 1, 2011.

Bangkok Post. Khlong Samwa sluice gate 'fixed'. November 2, 2011.

Bangkok Post. Lessons learned for city planning. December 12, 2011.

Baker, P. and Phongpaichit, P. (2005). *A History of Thailand*.

Chantavanich, S. and Vungsiriphisal, P. (2005). *Bangkok, Thailand: Need for Long-Term National and Municipal Policies*. In Balbo, M. (ed.), *International Migrants and the City*.

Department of Drainage and Sewage, BMA (2009). *Flood Protection in Bangkok*. Paper revised from Vitoonpanyakij, C. (2007).

Dutta, D. et al. (2008). Climate *Perturbation and Coastal Zone Systems in Asia Pacific Region: Holistic Approaches and Tools for Vulnerability Assessment and Sustainable Management Strategy*.

Dutta, D. (2011). An integrated tool for assessment of flood vulnerability of coastal cities to sea-level rise and potential socio-economic impacts: a case study in Bangkok, Thailand. Hydrological Sciences Journal, 56(5).

GISTDA. Summary Report on Satellite Imagery of Flooding in 2006.

Hewison, K. (1996). 'Emerging Social Forces in Thailand: New Political and Economic Roles'. In Goodman, D. and Robinson. R. (eds.), *The New Rich in Asia: Mobile Phones, McDonald's and Middle Class Revolution.*

Hutanuwatr, K. (2009). A Preliminary Review on Frameworks for Thai Climate Risk and Approaches in Social/Economic Vulnerability Assessment in Bangkok.

IMAC. *The Intermodal Service Integration for the Improvement of Mobility, Accessibility, Sustainability and Livelihood for Bangkok Metropolitan Region (BMR) and Surrounding Area*.

IRIN, 'How to build a flood-resilient city'. November 28, 2011.

Jarupongsakul, T. (2000), *Geomorphology Aspects Affecting the Occurrence of Floods andinfluencing the Drainage in the Lower Central Plain, Thailand*. In Jarupongsakul, T. (ed.), *Analysis and Preparation for Flood-Risk Map in the Lower Central Plain, Thailand.* Cited in McGrath, B. and Thaitakoo, D. (2008) *Changing Landscape, Changing Climate: Bangkok and the Chao Phraya River Delta*. In *Places,* 20(2).

Lat Krabang District Office. Official data.

Loy, I. 'Why a Bangkok neighbourhood flood barrier was torn down'. Public Radio International, The World. November 7, 2011.

Minburi District Office. Official data.

Murakami, A. et al. (2005). Trends in urbanization and patterns of land use in the Asian mega cities Jakarta, Bangkok, and Metro Manila. Landscape and Urban Planning 70: 251–259.

Nitivattananon and Noonin (2008). Citied in Bangkok Metropolitan Administration, Green Leaf Foundation and United Nations Environment Programme (2009). *Bangkok Assessment Report on Climate Change 2009*. Bangkok: BMA, GLF and UNEP

Marome, W.A.(2011). *Improving the Characterization of Impact Variables to Extreme Flood Events: A Case Study of the Flood 2006 in Bangkok*. CARII: Building Adaptive Capacity for Managing Climate Change Risks in Coastal Cities.

Marome, W. A. (Forthcoming). The urbanization of injustice. In Horayangkura, V., Jamieson, W. and Mallikamarl, P. (eds.), *The Design and Development of Sustainable Cities*.

National Statistical Office. Official data.

Nicholls, R.J., Hanson, S., Herweijer, C., Patmore, N., Hallegatte, S., CorfeeMorlot, J. Chateau, J. and Muir-Wood, R. (2008). Ranking Port Cities with High Exposure and Vulnerability to Climate Extremes. OECD Environment Working Papers No. 1.

Panya Consultants (2009). Climate Change Impact and Adaptation Study for Bangkok Metropolitan Region. Report commissioned by the World Bank.

Phien-Wej, N. et al. (2006), Land subsidence in Bangkok, Thailand. Engineering Geology, 82(4).

Sapphaisal, C. (2007). Planning and Flood Mitigation for the Chao Phraya River Basin.

Sintusingha, S. (2011). *Bangkok's Urban Evolution: Challenges and Opportunities for Urban Sustainability*. In Sorensen, A and Ogata, K.(eds.), *Megacities: Urban Form, Governance and Sustainability*.

Sitheechoke, N. and Napompech, K. (2010). *Impacts of Minburi District Development on the Turf Grass Businesses of Bangkok*, Thailand. International Journal of Arts and Sciences, 3(13): 82-94.

The Nation. Give all parties a say in managing water: Panel. January 3, 2012.

The Nation. Govt to help finance flood-barrier construction. January 19, 2012.

Tohiguchi, M. et al. (2002). *Transformation of the canal-side settlements in greater Bangkok*. Journal of Architecture, Planning and Environmental Engineering, 55(1).

Vongvisessomjai, S. (2007). Flood Mitigation Master Plan for Chao Phraya Delta. Paper presented at the 4th INWEPF Steering Meeting and Symposium.

UNDESA. *World Urbanization Prospects: the 2009 Revision Population Database*.

UNESCO World Water Assessment Programme (2003), Chapter *16: Chao Phraya River Basin, Thailand*. In *UN World Water Development Report 1: Water for People, Water for Life*.

World Bank. The World Bank supports Thailand's post-floods recovery efforts. December 13, 2011.

Yusuf, A. and Francisco, H. (2009). *Climate Change Vulnerability Mapping for Southeast Asia*. Economy and Environment Program for Southeast Asia.

7.3 Case study of Manila

Enhancing Adaptation to Climate Change by Integrating Climate Risk into Long-Term Development Plans and Disaster Management: The Case of Manila, Philippines

By Emma Porio

With the assistance of Cora Bolong, Rachel Austria-Nacingayo and Fatima Joven

December 2011

Part I

Introduction

The Philippines ranks third in the world in terms of being at risk to climate change-related risks and disasters. Over the years, the number and scale of natural disasters have increased and its effects intensified by the lack of preparedness among the affected communities and most of all, on the part the government, non-government, and private sectors to respond pro-actively.

In early July 2008, the World Bank estimated that the Philippines loses P15 billion annually[110] to disasters like typhoons and floods. This amount represents about 0.7 percent of the gross national product (GNP). In October 2009, Typhoons *Ondoy* (Ketsana) and *Pepeng* (Parma)[111] caused a total of Php 3.8 billion in damages and Php 24.8 billion in immediate losses to agriculture, fisheries, and forestry sector. Immediate reconstruction costs were estimated to be about US$ 4.42 billion or almost 3 percent of the national GDP for the next three years (Joint Assessment of Typhoons Ondoy and Pepeng, World Bank, 2009).

The Philippines gets an average of 20 typhoons annually. In 2009, Metro Manila weathered 10 strong typhoons bringing about heavy rainfall and floods to the metropolis. In 2011, damages of typhoons Pedring and Quiel were estimated to amount to Php 15 billion. Meanwhile, as this report is being written, tropical storm (later upgraded into typhoon) *Sendong* (international name, Washi) brought heavy rainfall and flash floods to Northern Mindanao and Eastern Visayas in southern Philippines killing over a thousand people, higher than those lost/killed during the Ondoy and Pepeng in 2009. This is the worst climate-related disaster in the last decade to have hit the Philippines. Initial estimates of damages to property and agriculture is estimated to reach P1.03 billion; although not as high as that of Ondoy and Pepeng, the loss of lives, physical injury and displacement is much higher (1, 572 deaths, 1,079 missing, 1, 792 injured, and 102, 899 families displaced). Initial assessments showed that unpreparedness on the part of the affected communities and the government agencies/officials in charged of disaster risk reduction was a major factor in raising the damages and costs of the disaster. This study, hopefully, will contribute to the making of a culture of preparedness, adaptation and resilience among us, Filipinos, and to other similar groups at risk to the effects of climate change. A partial list of deadly typhoons/storms in 2011 showed damages to property, agriculture and fisheries to have reached more than P20 billion (see Appendix A). Thus, investments on disaster and climate risk vulnerability assessment are crucial to minimize losses from these calamities (Porio 2011).

The Study, Data Collection, and Structure of the report

With funding support from the Asia Pacific Network for Global Change Research (APN) and coordinated by the Somaiya Institute of Management Studies and Research, Mumbai (along with the other research partner in Bangkok, Thammasat University)[112], this report is based on a study

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[110] But this amount seem to be an underestimate as seen in the partial list of 2011 storms/typhoons and related damages in the appendix.

[111] Hereinafter these events will just be referred to by their local names, *Ondoy* and *Pepeng*.

[112] Coordinated by Dr. Archana Patankar of the Somaiya Institute of Management Studies and Research, Mumbai and Dr. Anand Patwardhan of the Indian Institute of Technology (IIT), Mumbai and collaborated by Dr. Ann Marome Wijitbusaba of the Asian Institute of Technology fro the Bangkok Case Study and Dr. Emma Porio of the Ateneo de Manila University for the the Metro Manila case study.

conducted from April 2011-December 2011 in Metro Manila, particularly in the Pasig-Marikina flood basin, with special focus on the cities of Marikina and Pasig. These cities suffered extreme flooding brought about by the tropical storm, *Ondoy* in late September 2009 and *Pepeng* in early October 2009.

In this study, the impacts and responses to *Ondoy* in these cities were compared to another flooding event in 2011, the heavy rains and floods brought by *Pedring* and *Quiel* in September 2011 and early October 2011. Until tropical storm *Sendong* hit northen Mindanao and Eastern Visayas in December 2011, these were considered the worst to have brought extreme flooding to the national capital.

Part I of the report provides an introduction to the political and economic context of Metro Manila and its relationship to the climate change-related events and processes. Part II presents the findings regarding flood vulnerability and impacts/responses in the cities of Marikina and Pasig, a major flood basin of Metro Manila (see figures 1-9 below). Part III outlines the prospect of mainstreaming climate vulnerability assessments/profiles into long-term urban development policies and programs.

This study focuses on the institutional measures adapted at city/local government, community and household levels in response to the extreme flooding of Ondoy (Ketsana) in 2009. The overall aim of the study is to enhance climate change adaptation by integrating climate risk into long-term development plans and disaster risk management.

Methodology/Data sources

The study utilized three major data sources, namely, 1) secondary data sources, 2) key informant interviews, 3) household and commercial surveys, and 4) focus group discussions (FGDs). A main secondary source utilized here to complement the current APN survey is the 2008 climate change household survey conducted by the author in the three flood plains of Metro Manila.

This study interviewed 200 households[113], sampled from those severely flooded communities in the extreme flooding of Ondoy in late September and Pepeng in early October 2009 located in the flood basin of the Pasig-Marikina River Basin, one of the three flood basins of Metro Manila (see map below). The other two flood basins are located in the cities of Kaloocan, Malabon, Navotas, and Valenzuela (KAMANAVA) and in the city of Taguig and the municipality of Pateros known as the West Mangahan area. These areas often experience flooding coming from the nearby riverine systems and the regular tidal/storm surges (see figure 1 below). To obtain the losses/damages and responses at the commercial-industrial level, the study conducted a survey of 100 commercial-industrial units or 50 in each of the cities.

The above data sources were supplemented with key informant interviews and FGDs among local and national officials, civil society leaders, influential private sector leaders, and community leaders/residents. Overall, the study assessed the vulnerability of Metro Manila residents and commercial-industrial establishments to extreme flooding in 2009 (Ondoy and Pepeng), their adaptive responses and potentials for mainstreaming these adaptations to urban planning, governance, and to medium/long-term development.

113 Originally, the study planned to interview 300 households obtained through systematic sampling with a random start but had to reduce this to 200 because the people were tired of being interviewed about the effects and their responses to Ondoy. In the same manner, 100 owners/managers of commercial and industrial units were expected to be interviewed in both cities but in the end we were able to process 87 interview protocols because 13 respondents had several call backs that eventually we dropped them out of the sample.

1. Metro Manila: Demographics, Urban Development, Environment and Socio-Economic Characteristics

In third world cities like Metro Manila where urban growth and sprawl remains largely unregulated, the vulnerability of populations, especially marginal sectors, to climate change-related effects like floods is quite high, reducing their potential for adaptation and resilience.

Metro Manila or the National Capital Region (NCR) has a land area of 636 square kilometers in semi-alluvial plain formed by the sediment flows from the Meycauayan and Malabon-Tullahan river basins in the North, the Pasig-Marikina river basin in the East (Bankoff 2003), and the West of Mangahan river basin. These river systems used to be actively used as transport gateways to the central district of Manila until heavy siltation and the land-based transport rendered this system ineffective (see maps below).

The NCR is composed of a coastal margin with a reclaimed area in Manila Bay, the central plateau, and the Marikina Valley. The city is open to Manila Bay on the west and connects to a large lake, Laguna de Bay, on the southeast. Thus, "the metropolitan area is a vast drainage basin that experiences frequent inundations from overflowing rivers and storm waters that render the existing system of *esteros* (modified natural channels) and canals constructed during the Spanish and American colonial periods inadequate" (Liongson 2000 cited in Bankoff 2003). Manila and the surrounding cities are prone to flooding alongside Marikina Valley and along the coast of Laguna de Bay. The effects of climate change on these river systems are highlighted by sea level rise (SLR) and increases in monsoon rains, typhoons, and floods. Traversing the north-south direction of the metropolis are several fault lines: 1) Marikina Valley Fault, 2) Philippine Fault, 3) Lubang Fault, 4) Manila Trench, and the 5) Casiguran Fault. This environmental context interacts in complex ways with the patterns of human activities in the metropolis, giving rise to patterns of survival strategies among the residents and institutional and regulatory responses of the local government units and the national government agencies in charged of disaster risk reduction and management policies and programs (Porio 2011).

With Metro Manila as the center of political, economic, and socio-cultural activities of the nation, its vulnerability to climate changes becomes heightened. Its strategic location by Manila Bay and the mouth of the Pasig River accounts for the growth of the capital city. Being near a river and a good harbor made possible the development and expansion of the city of Manila to its suburbs in the last 30 years. With large in-migration and rapid population growth, the city expanded to the suburbs, surrounding municipalities, and to risky areas for habitation (e.g., swampy areas, near or above *esteros* or water canals, along the river or earthquake fault lines, etc.). In response to this rapid population growth, urban infrastructural development continued though not as well as expected for a burgeoning population. This is seen in increased investments in housing, basic services (water, sewerage, electricity), and infrastructure (roads, bridges, flyover, etc.). While large public and private investments try to operate within existing regulatory frameworks, the ability of government agencies to impose building and infrastructure standards is quite weak. Meanwhile, the growth and expansion of informal settlements have gone largely unregulated. Thus, in Metro Manila, many buildings and infrastructure are built on dangerous and risky areas (e.g., near the seashore or flood zone, unstable ground and prone to landslides, etc.), without permits (Porio 2011).

Socio-economic forces like land use, infrastructural development, building practices, urban development policies and programs have greatly shaped the settlement patterns of the city. The lack of effective interaction among these forces had resulted in a built environment that poses high risks to residents and infrastructure alike. Rapid urbanization, population growth, and the weak infrastructural and economic bases of the metropolis have heightened its vulnerability to the effects of climate change. Metro Manila's population expanded from 5.93 million in 1980 to 7.95 million in 1990, 9.93 million in 2000 and is projected to reach 19.43 million in 2020. In 2007, the National

Statistics Office (NSO) reported that Metro Manila has 12 million residents but the average daytime population is about 16 million (see Figure 1 below). In 2000, the population density in the metropolis was 15, 617 persons per square kilometer but is projected to increase to 29, 146 in 2020. These forces have dramatically increased the demand for goods and services as well as the waste generation in the metropolis. Since this trend shows no signs of abating, the impacts of climate change on the vulnerable populations of the metropolis will definitely be heightened in the coming years (Porio 2010).

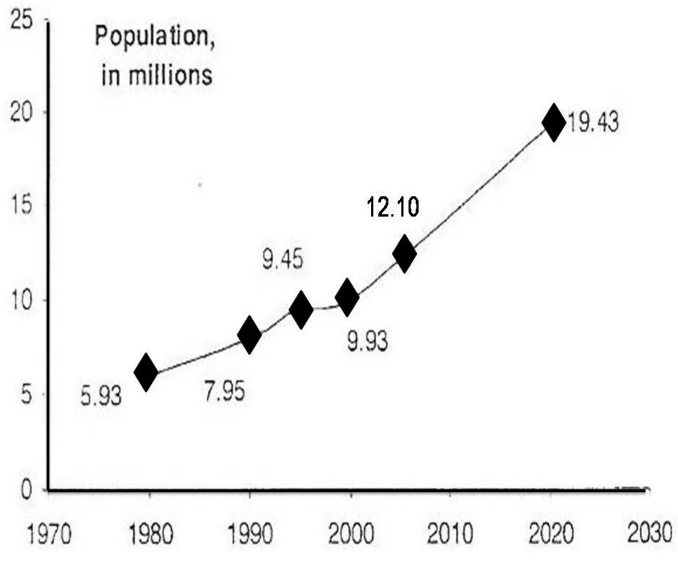
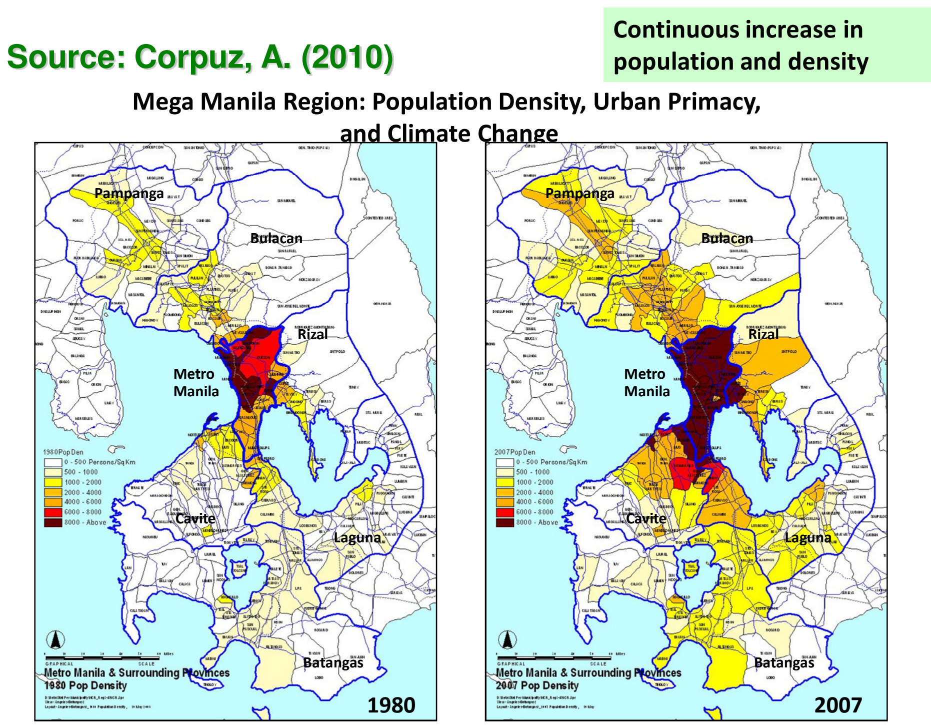


Figure 2. Population Trends of Metro Manila (1970-2020)



Adding more vulnerability is the large portion of the population in the metropolis that does not have security of tenure in their housing, jobs, and livelihood sources. The 2008 Philippine Asset Reform Report Card estimated that only 61 percent of households in Metro Manila have sufficient access to basic services. Most informal settlements (mostly urban poor) do not have adequate access to the water and sewerage nor electrical services. Of the national housing backlog of 4 million households (or about 24 million people), about 6 million is accounted by Metro Manila alone. The Philippine Human Development Report of 2010 estimated the Philippines to have a poverty incidence of 32 percent. With high poverty incidence and population density and the shortage of proper services, Metro Manila has become very vulnerable to storms, typhoons and floods in recent years (Bankoff 2003).

Metro Manila's primacy and the lack of rural development have lead to large number poor and lowly-skilled migrants looking for work in the city. Because the economy expanded in services and light export-oriented (e.g., electronics, assembly work) industries, majority of the migrants are young, single, and female. This female-dominated migration stream feeds on the migration of Filipino women overseas, who in turn, get absorbed in the services sector of their places of destination. Locally, most of these migrants get absorbed by the informal economy where entry is easy because the skills demand is not high but the remuneration levels and job security in this sector are low (Porio 2011).

1.1 Environmental and social characteristics

The 2008 survey of flood-prone households (Porio 2011) showed that these vulnerable communities are located near in low-lying areas, mostly wetlands/swamp lands, around the following river system and its tributaries (Pasig-Marikina River, Napindan River in West Mangahan, and the Malabon and Tullahan Rivers in the KAMANAVA areas) which are connected to the sea through Manila Bay and to the lake system of Laguna de Bay. Aside from their being flood prone, these areas also suffer the effects of heavy monsoon rains, typhoons, and the regular tidal surges. Most of the surveyed households belong to informal or slum/squatter settlements, with no security of tenure in their housing and no adequate access to basic services like water, electricity, sewerage and drainage systems. The households in these communities regularly suffer the risks from floods, water surges during storms and high tides, in addition to sickness of household members and from lack of community security (e.g., incidence of drug abuse, theft and other petty crimes).

1.2 Climate change, environmental, and social risks

The social and physical location of these flood-prone communities make them vulnerable to storm surges and floods from typhoons and heavy monsoon rains from June to November, the traditional rainy season for Metro Manila. The Pasig-Marikina flood basin is prone to flash floods from the Sierra Madre mountains while the KAMANAVA flood basin is particularly susceptible throughout the year to the effects of sea level rise (SLR) and tidal storms or surges. During the last few years, the residents also reported changes in the climate patterns marked by increases in water levels during tidal/storm surges as seen in the water marks left of their house posts. These pose additional risks to their household appliances, garments, and higher losses in their work days.

1.3 Economic risk and social vulnerability

The 2008 climate change survey also showed that while respondents recognized the risks of floods and storm/tidal surges to their homes and communities, economic problems were their over-riding concern. This was followed by security-related risks like thefts/hold-up, fire, and drug abuse in their neighborhoods. These security-related issues are closely linked to the physical congestion and economic insecurities (i.e., high unemployment/underemployment) of their communities/families. Given these socio-economic risks, their vulnerability to the effects of typhoons, floods, and sea level rise (SLR) or storm/tidal surges increasingly becomes heightened (Porio 2011).

In turn, these household level risks and vulnerabilities also increase with the expansion of residential, commercial, and industrial development in their immediate localities and cities. This could be observed in the rapid expansion of construction projects around the Mangahan River Basin, which do not have the necessary infrastructure support like proper drainage, sewerage, and road systems. The consequent flooding become intense as the areas near the Napindan Channel and Laguna de Bay are not really suitable for habitation nor for commercial-industrial use as these are mostly wetlands. Meanwhile, these have not deterred building activities in these areas because developers just fill up the marshy areas and raise the building height of ground floors.

One major source of risk in these flood-prone areas is the continuous building of temporary structures in already congested, informal settlements alongside formal residential subdivisions located in/near danger zones of the community. Respondents reported that land filling activities of middle/upper-class real estate development have increased the flooding and environmental damage as traditional waterways have disappeared with these activities. Substandard sewerage and road systems have also worsened the living conditions of the urban poor informally settled around these areas. Informal housing built against dike walls, along creeks, rivers, tributaries, and swampy areas abound in this part of the metropolis. Slum lords, taking advantage of the expanding rental markets and the lack of regulation by local officials, also contribute to the risks faced by those residing in nearby factories of Pasig City, Taguig City, and the fish port in Navotas City. Heightening the risk exposure of these households are inadequate services like water, electricity, health and substandard roads, drainage, and sewage systems (Porio 2011).

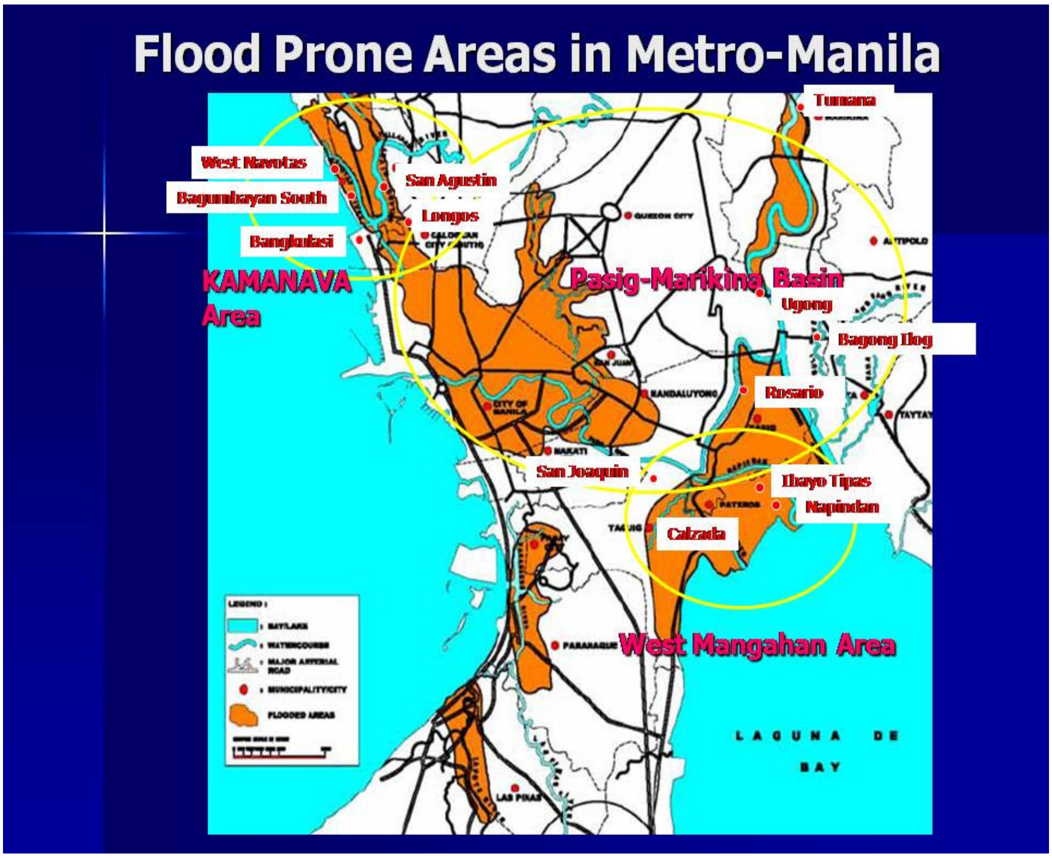


Figure 1: Map of the Flood Prone Areas of Metro Manila River Basins (yellow circles). Source: JICA Research Institute and Porio (2009)

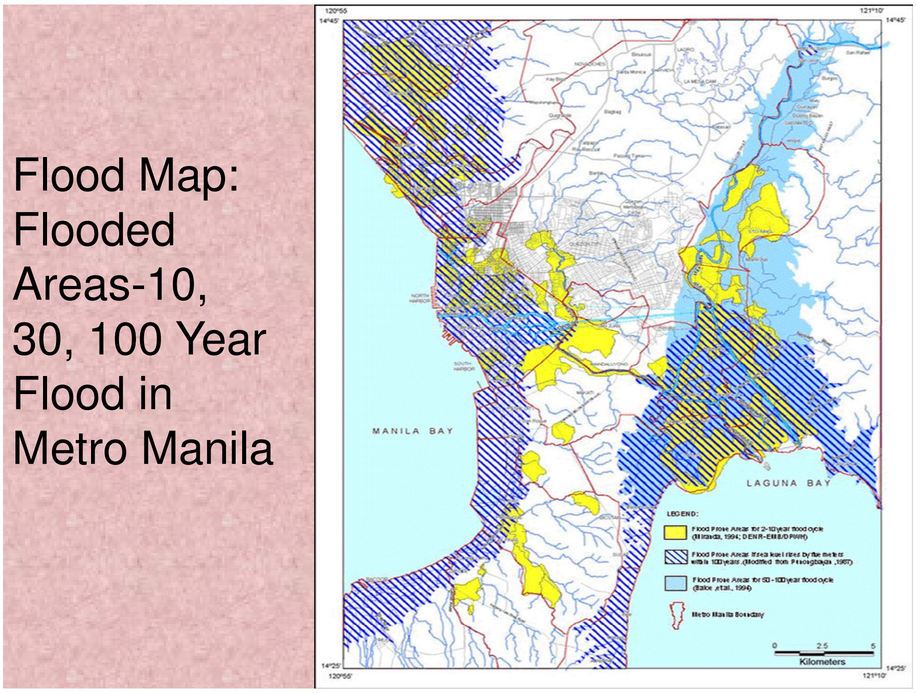


Figure 2: Map of Metro Manila Showing Flooded Areas in 10, 30, 100 Year Floods.
Source: JICA Research Institute (2009).

The following sections show the geographical characteristics of the specific study sites, namely, Marikina City and Pasig City. As the following topographical and flood maps will show, the two cities are very vulnerable to flooding because they are located in the heart of the Pasig-Marikina flood basin, just below the Marikina watershed nestled in the Sierra Madre Mountain Range and the Montalban hills. Nearby is also the La Mesa Dam and watershed. So, during the Ondoy floods in 2009, the cities of Marikina and Pasig, literally became a depository basin for the volume of water from the heavy rains (180mm) equivalent to 1 month rainfall. Moreover, the West Valley fault also runs through these cities making them vulnerable to earthquakes and subsequent liquefaction.

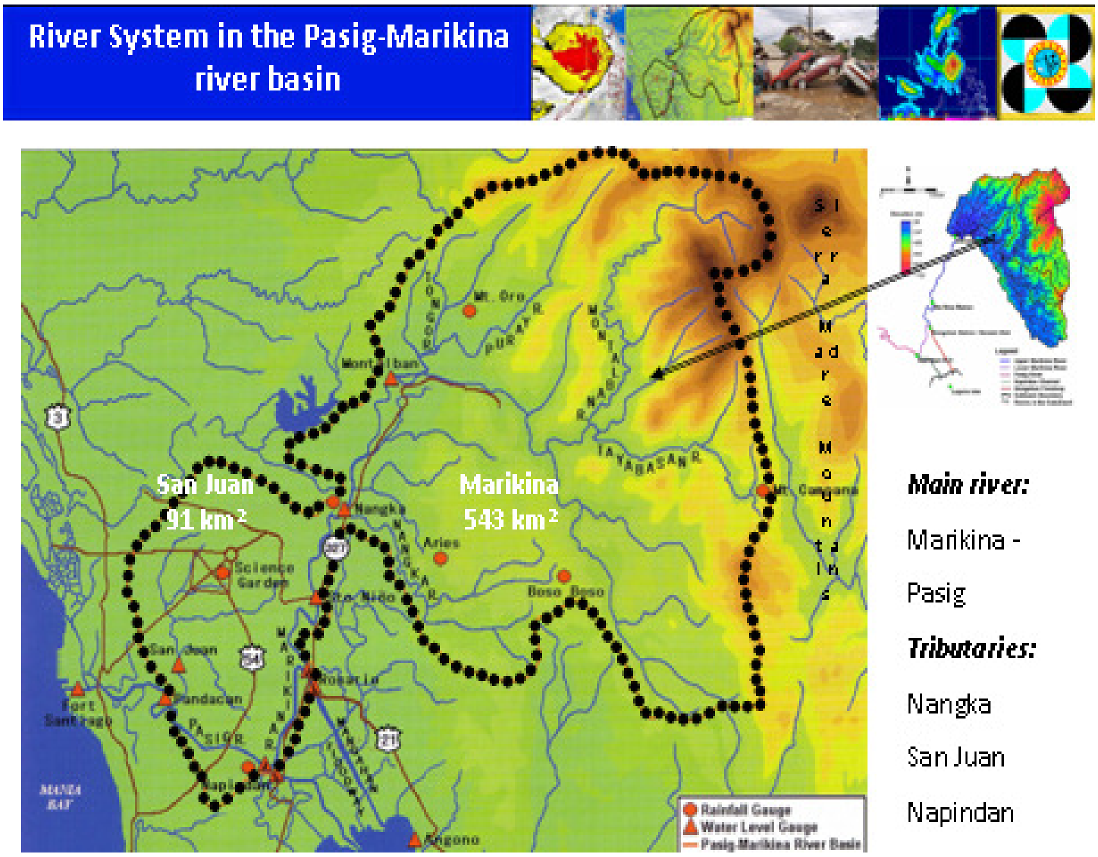


Figure 3: Marikina-Pasig River Basin. Source: Marikina City Disaster Risk Reduction Management (DRRM) Office

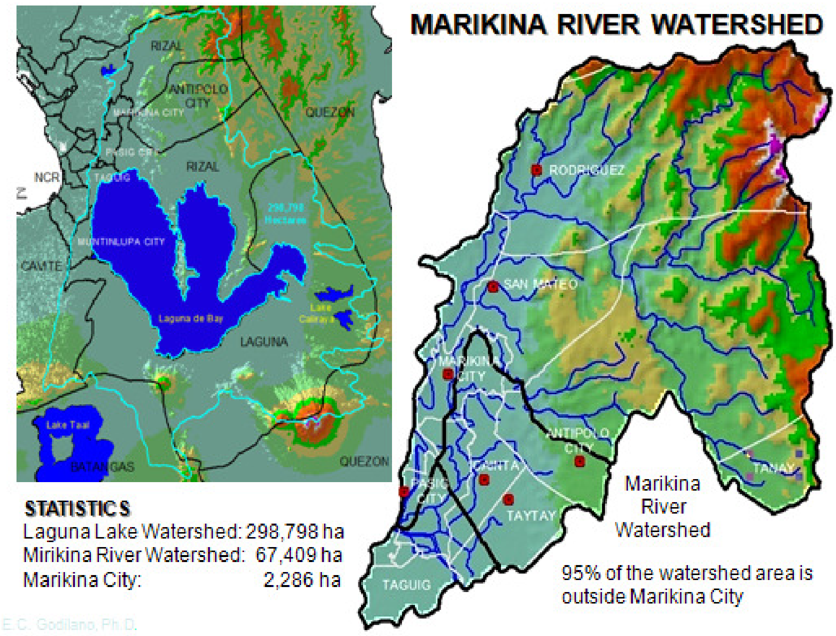


Figure 4: Marikina-Pasig River Basin. Source: Marikina City Disaster Risk Reduction Management (DRRM) Office and the Metro Manila Earthquake Impact Reduction Study (MEIRS 2004)

Watershed Area

Description	Area	
	Hectares	Percent
Upper Marikina	54,412	81
Lower Marikina	12,997	19
Total	**67,409**	**100**

Rivers/Streams Length

Description	Rivers/Streams	
	Km	Percent
Upper Marikina	499	77
Lower Marikina	152	23
Total	**651**	**100**

Climate Change Impacts

Impacts	Hectares	Percent
Landslide	12,114	18
Soil Erosion	21,336	32
Flooding	16,692	25
Not Affected	17,267	26
Total	**67,410**	**100**

E.C. Godilano, Ph.D.

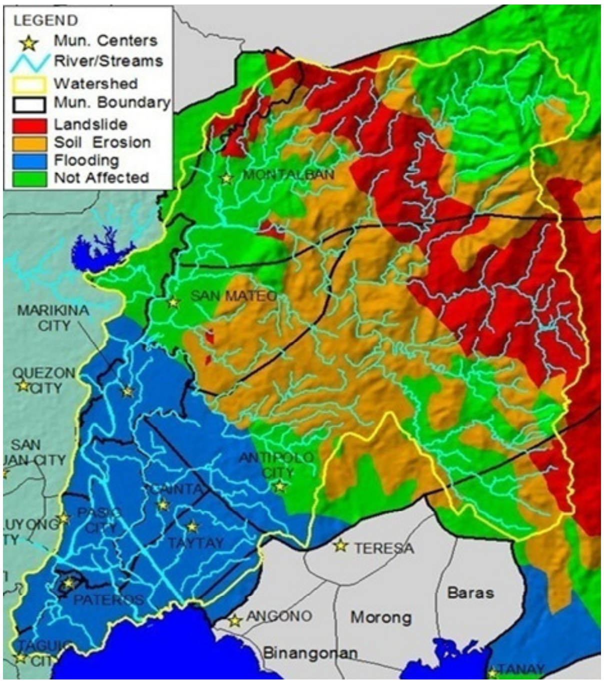


Figure 5: Marikina Watershed and Marikina-Pasig River System Source: Metro Manila Earthquake Impact Reduction Study (MEIRS 2004)

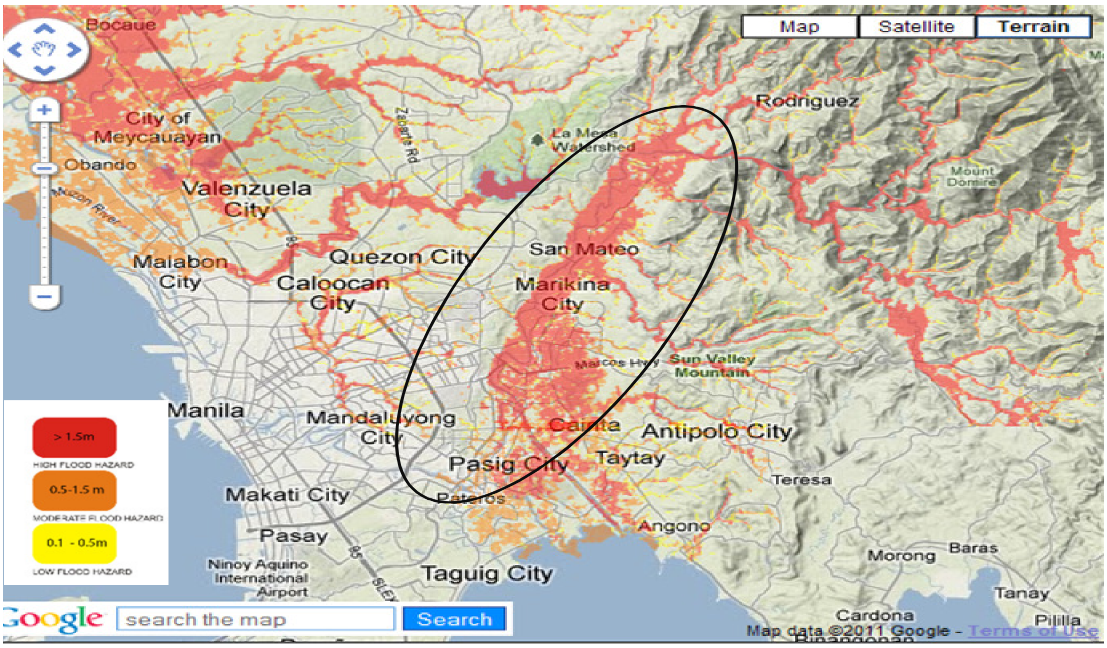


Figure 6: Terrain/Topography of APN Study Sites in Metro Manila (Marikina City and Pasig City)

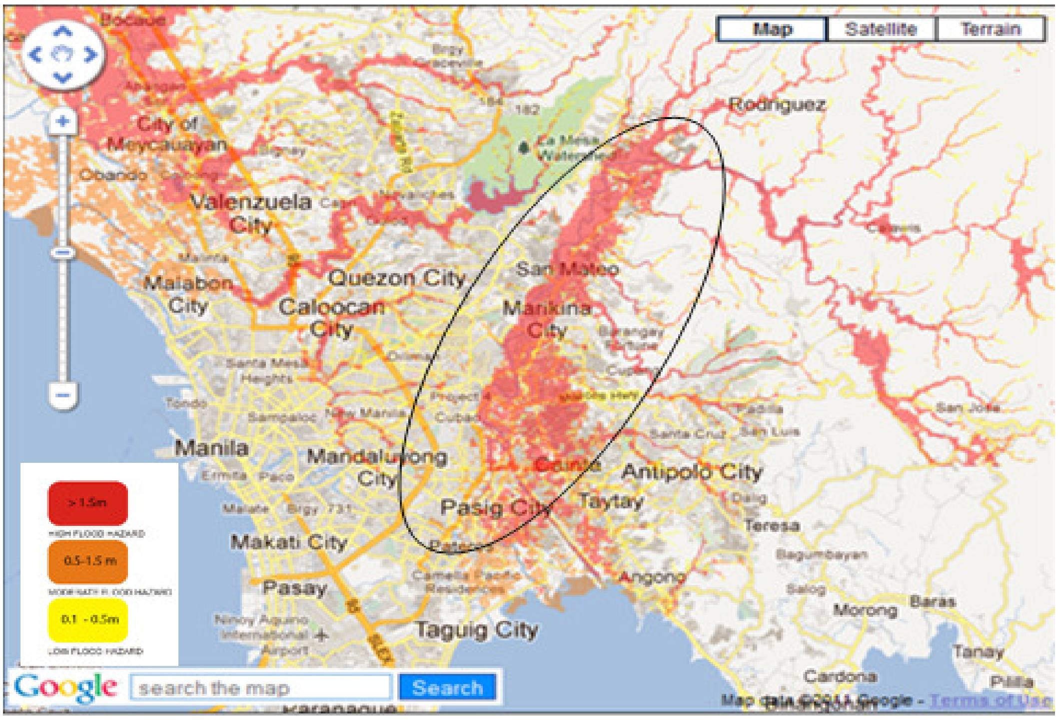


Figure 7: Flood Map of Metro Manila and APN Study Sites (Marikina City and Pasig City)

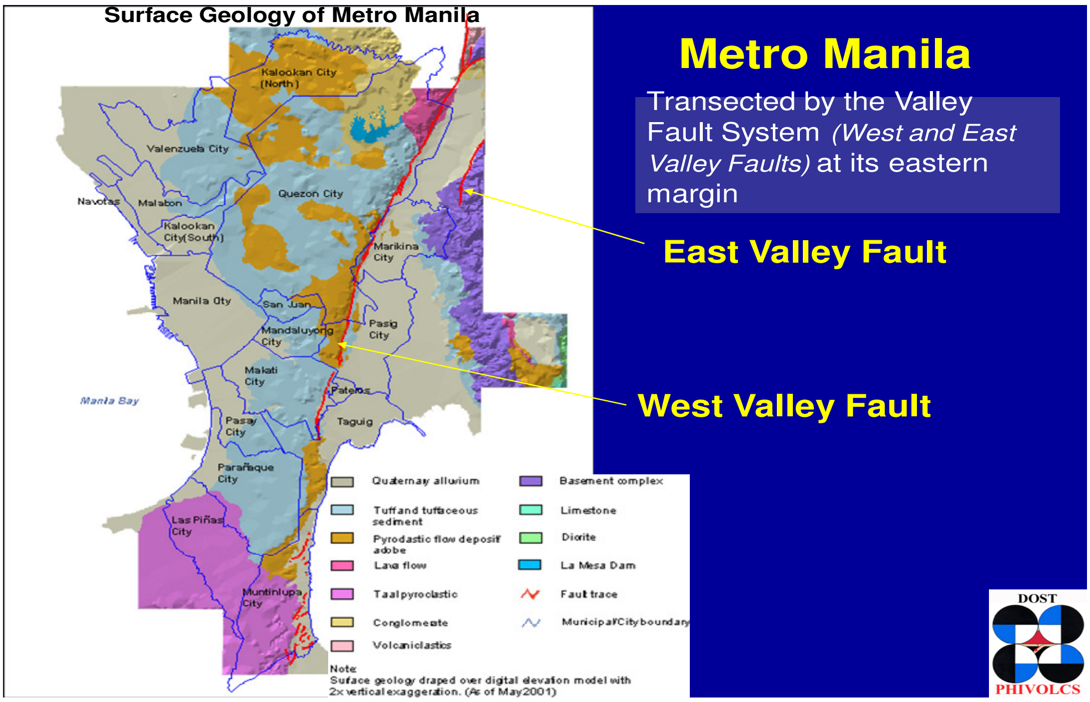


Figure 8: Earthquake Fault Lines (East-West Valley) Transecting Metro Manila Source: Metro Manila Earthquake Impact Reduction Study (MEIRS 2004)

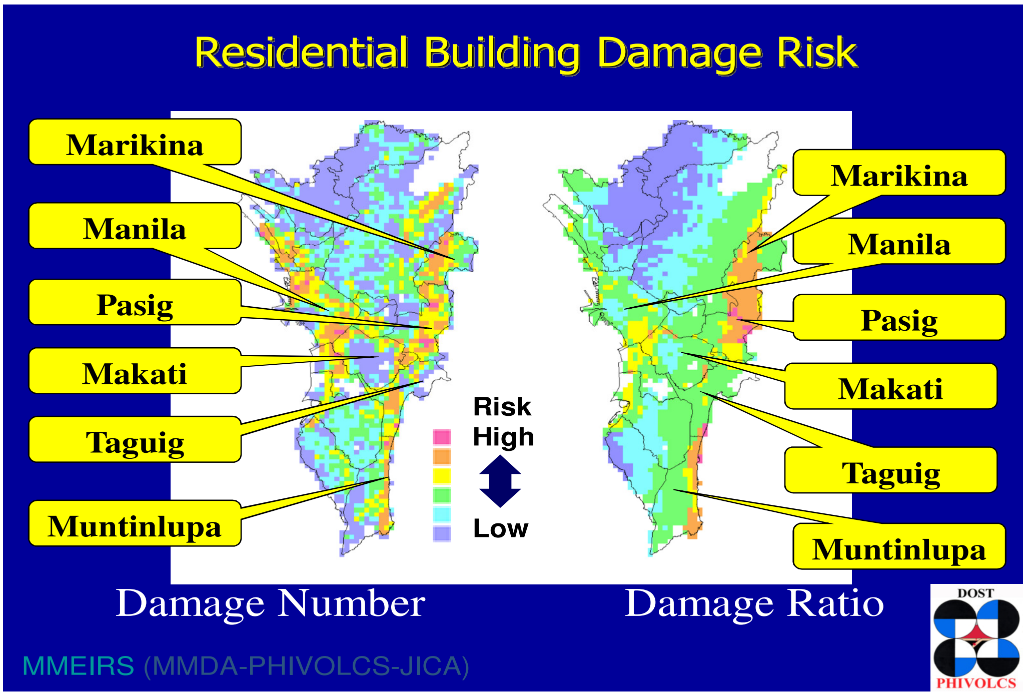


Figure 9: Projected Residential Building Damage Due to Earthquake, Source: MEIRS Study (2004)

1.4 Other Complicating Forces

Other factors like earthquakes could intensify the damage impact of extreme floods like that of Ondoy. The MEIR Study (2004) projected that the impact scenario for Metro Manila in 7.2 magnitude earthquake from the West Valley Fault (located along the cities of Pasig and Marikina, see figures 8-9 above) could damage:

- ~40 percent of the residential buildings (175,000-heavily damaged; 345,000-partly damaged)
- ~38 percent of the 10-20 story buildings
- ~14 percent of the 30-60 story buildings
- ~28-35 percent of the public buildings (8-10 % -heavily damaged; 20-25%-partly damaged)
- Estimated 33,500 deaths and 114,000 injuries
- Additional deaths from fires

The above projected earthquake damage impact could make extreme flood events like those of Ondoy in 2009 and Pedring in 2011 (see picture below).

Typhoon Pedring brings heavy rains and flooded Roxas Boulevard in Manila (*Photo by Rem Zamora for abs-cbnNEWS.com*)

1.5 Topography of Metro Manila and Climate Change Vulnerability of Populations

The topography and geological characteristics of Metro Manila and its inherent vulnerability to strong winds and floods were revealed during the height of the typhoon Pedring in late September 2011. Its susceptibility to the storm surges and strong winds pummeling on Manila Bay makes its foundation quick to be saturated with water making it weak. Rough winds caused a section of the breakwater to collapse, and blew Manila Bay's waters past the seawall and onto Roxas Boulevard. For the first in history, the public saw the main thoroughfare, the United States Embassy, Sofitel in the CCP Compound, restaurants along the Bay flooded. The waters even reached the Baseco Compound, a 14 hectare property owned by Manila Port Authority, and informally settled by 6,000 urban poor families.

According to the head of the of the Department of Science and Technology, the following factors lead to the collapse of the Manila Bay Seawall (along Roxas Boulevard), namely, 1) heavy monsoon rains continuous for four days, 2) strong storm surge 3) high tide, 4) soft soil and subsidence, 5) strong rough winds.

The climate authority suggested stronger compliance (enforcing stricter building and zoning codes, evacuation of people once the storms and surges hit the bay, etc.) to safer engineering solutions.

1.6 Socio-economic and demographic characteristics of "at risk" population in Manila' major flood basins

The following description is mainly based on the 2008 household survey conducted in the three flood basins of Metro Manila, namely, 1) Pasig-Marikina, 2) West Mangahan, and KAMANAVA Area (see figure 1 above). Based on the survey, the respondents were mostly female (86 percent) as they were the ones available/open to be interviewed, compared to the unwilling male members of the household. Their ages ranged from 18-92 years old, with a median age of 42 years old. They were mostly legally married (61 percent), or were in live-in/cohabitation arrangements (20 percent), while the rest were widowed, separated or single (18 percent). Their mean household income was P10,033 per month but their median monthly household income was P8,000, suggesting some disparity among the respondents. Of the communities surveyed, West Navotas and San Joaquin in Pasig and Ibayo Tipaz in Taguig City had the lowest monthly median incomes of P8,000 while Longos in Malabon City and Bangkulasi in Navotas City (KAMANAVA Basin) with P23,250 and P18,000, respectively, had higher median income levels. Most of the very poor households (old, widowed/separated, no income and dependent on the relatives' food support), also came from these low income communities. These urban poor settlements remain very vulnerable because of dilapidated housing structures and absence of services and drainage systems in their water-logged environments. Most respondents had 8.5 years in schooling and only respondents from Malabon attained some college education (11.20 years). Their low education and income, in part, explain their low levels of formal employment as most of their earnings were from the underground economy.

Part II

2. Impacts and Adaptation Responses to the 2009 Ondoy Extreme Flooding

2.1 Description of the APN Study Population in Metro Manila

2.1.1 Socio-economic characteristics

Most of the respondents from the 10 sample communities came from households (HH) with average size of 5.5 members (5 for Marikina City and 6 for Pasig City). Most of them had an average number of 3 children, except in the upper-class communities of Industrial Valley Complex in Marikina City and in Sta. Lucia, Pasig City where households had an average of 2 children. In terms, of male-female ratio of HH members, Pasig City had an equal ratio but Marikina had more females (3) than males (2) in their households. Moreover, their average ratio of earning members to dependent HH members was one (1) for three (3) members or 66 percent dependency. Almost a quarter (22 percent) had elementary education, 53 percent with high school education, and 26 percent had college education. But all respondents, on the average, had 10 years of schooling.

2.1.2 Housing characteristics and community socio-eco strata

The materials that their homes were made of seem to reflect the socio-economic stratification of the people in these cities. Twenty-nine percent had houses made of second hand or scrap materials, while 63 percent had houses made of GI sheets, lumber and cement for flooring, and 8 percent had GI sheets for roofing and tiles or cement for their flooring. These households seem to represent the low-income, lower middle to upper middle, and upper class strata, respectively. This is supported by the income and occupational profiles. About 30 percent were retired or unemployed/underemployed, while slightly over a third (34 percent) of them were professionals and skilled workers, and 35 percent into trading/marketing activities or overseas workers. Their average schooling is 10 years or high school graduate while their median income is P16,000/month (average mean income: PP42,000). The average income here of respondents is double that of the poverty income threshold of Metro Manila which is P9,000/month for a family of five.

At the time of the floods, most (74 percent) of their housing structures were single-storey and only a few (26 percent) were made of two storeys or more. The floor areas of their homes averaged from 50-80 sq. meters. Most (68 percent) of these buildings and housing structures, however, were constructed within the last 10-20 years while 22 percent were 30 years older or more. On the whole, most of them (83 percent) owned their dwellings while the remaining sample population were either renters or living rent-free in their dwelling and home lot. According to the owners, they hardly conduct regular maintenance or repair of their homes, except when there is occasional need to do it.

Based on the structures of their homes and the housing materials used by the respondents in Pasig City, their capacity to adapt to floods and other climate change-related effects do not seem to be well-developed. In this city, more than half of the homes (56 percent) were single detached, consisting of one floor only and made of not very strong materials. But the residents of Marikina City, however, seem to fare better because about half of their homes had two floors or more. But in general, most (80 percent) of them do not regularly maintain their homes; they only do occasional repairs when needed. Thus, the culture of safety and preparedness is not at all present among the residents, despite the fact that they already experienced a major deluge ("delubyo" the local term for extreme flooding, akin to the biblical floods during Noah's time) during the 2009 *Ondoy* floods. A bit of an exception is the one-third of Marikina City who had either raised their floors or have added a second or third floor to their homes after the *Ondoy* floods. In part, this is because these households have the capacity to make these improvements or adjustments to the extreme flood events.

That at the time of the survey, there were more housing structures in Marikina City which were made of more than one storey could be the effect of post-*Ondoy* rehabilitation efforts. After the *Ondoy's* devastation, the Marikina local government encouraged residents to leave the ground floor open so waters could freely flow through their homes and make the 2nd and other floors for habitation. In fact, the re-drafted building code of the city that is now being deliberated for approval by the city legislative council requires that all new construction must leave the ground floor open for waters to pass and the second floor for habitation (for elaboration see later section on institutional responses to floods).

The above socio-economic patterns become more meaningful when considered within the larger context of Metro Manila's vulnerable poor. According to the Asian Development Bank (2009), over 35 percent of Metro Manila's population lives in informal settlements, suffer from "insecure land tenure, lack adequate health and educational facilities, and (are) unable to access capital, credit or social safety nets. They are further exposed to makeshift housing, unsafe water, poor sanitation, crime, fire and sudden flooding".

2.1.3 Major problems encountered during flooding

Most of the respondents identified the following major problems that they encountered: 1) shortage of transport, fuel, food and water supplies, 2) disruption of electricity, water distribution, and communication services 3) garbage/mud pollution, 4) sickness, 5) rise in price of commodities, 6) damage to their housing structures, and 7) children unable to go to school while their parents also could not report for work. In the latter case, some schools in Marikina City and Pasig City were closed for almost a month during the Ondoy floods in September-October 2009 because either these were used as evacuation centers or were heavily damaged. Most factories in the flooded areas also closed and/or relocated to other places outside the city after the 2009 floods, resulting in enormous loss of work for the residents.

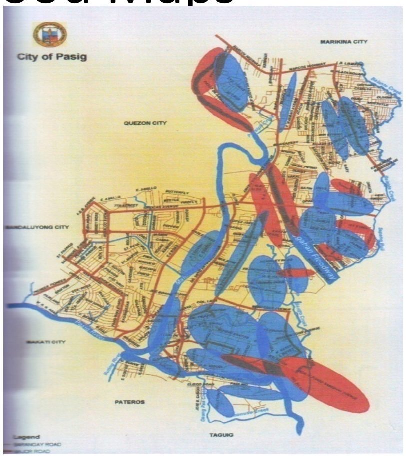
2.2 Specific Impacts of Flooding: Damages to Home/Property, Losses and Absences from School and Work

Majority (90 percent in Marikina City; 71 percent in Pasig City) asserted that that they suffered highly from the Ondoy floods in 2009. But in 2011 only a few (1-4 percent) of them were highly affected by Pedring and Quiel floods in 2011 (see photo above in page 14). Perhaps, this is in part because the rains in 2011 were not so heavy and occurred in a span of 2-3 days compared to 180mm rainfall (equivalent to 1 month rainfall) in six (6) hours during Ondoy.

Pasig City Flood Maps

SEPT. 26, 2009
Typhoon ONDOY

First Hit early morning 5 am to 8 am
2nd Hit morning 9 am onwards
Flooded Areas



Water Level:
RED – 2 feet up
BLUE – 2 feet below→70 percent flooded

FLASHFLOOD along major and minor streets.
Houses near the river (Santolan) water level reaching 20 feet above with strong current.

2.2.1 Damage/repair to housing structures

On the average, the flood waters in their homes reached an average of 20 ft., while in some it reached the maximum height 30 ft. in 2009. But of the two cities, Marikina had suffered more with 75 percent of their dwelling structures fully or partially damaged while only 35 percent of Pasig had suffered the same.

2.2.2 Major repairs and reconstruction

Most (81 percent) of their major repairs and reconstruction were concentrated on adding and repairing/repainting the floors, walls, and roofing of their homes while the rest (19 percent) either constructed a new home, fixed their plumbing, drainage system and toilets. The length of time needed to repair or reconstruct their houses was dependent on the extent of the damage and the availability of resources. On the average, it took them 30 days to complete the repair and reconstruction of their homes, with a small minority (10 percent) unable to do so because of not having the resources to do it or were prevented by the authorities to reconstruct their homes as these were located in danger zones. In Marikina, affected residents spent an average of P141,000 but maximum of P4 million (compared to P12,000 in Pasig City but maximum of P150,000) to repair their damaged homes and appliances. Overall, it took them an average of 2.5-3 months to completely reconstruct their damaged dwelling structures. The disparity is due to the fact that extreme flooding in Marikina hit more upper/middle-income households while in Pasig City the extreme floods (in terms of height and length) devastated mostly low and middle-income households.

2.2.3 Assets

In terms of losing household assets, almost half (45 percent) of the surveyed households reported having lost severely, while 30 percent lost mildly and 16 percent had negligible losses. Severe losses mean losing most of their household appliances and electronic equipment/gadgets. Negligible loss could mean an electric fan becoming inoperable or losing some household utensils/things.

2.2.4 Loss of workdays/schooling due to damage/interruption of basic services

On the average, 30 man-days were lost by the residents in 2009 because of the flood damage to their homes, basic services, and infrastructure (roads, bridges and water channels) while in a few (5 percent) households the number of days lost totaled 365 days or equivalent to 1 year. For example, the water supply was interrupted for 22 days in 2009 (compared to zero in 2011). In the same manner, electricity could not be delivered for about a month (Marikina) and 14 days (Pasig) to about half of the sample population in 2009 compared to almost nil (1 day) in 2011. Children's schooling also suffered with about 70 percent of the households unable to send their children to school. In terms of income loss, the respondents averaged losing P21,000 per household (average salary of public school teacher is P10,000) with some reaching P500,000 income loss due to Ondoy floods in 2009 compared to P20,000 during the Pedring and Quiel floods in 2011.

2.2.5 Sickness/Diseases during Floods

Most (almost 80 percent) of the respondents suffered from coughs/colds and fever due to the floods. About 40 percent complained of diarrhea and stomach ailments. About one third (32 percent) said they suffered from skin diseases/allergies. But it is quite alarming that almost one-fifth of the respondents suffered from deadly diseases like leptospirosis (18 percent) and dengue (15 percent).[114] Majority (84 percent) of the respondents were also alarmed with the increase of climate/flood-related diseases such as diarrhea, dengue, and leptospirosis. As shown in the summary of expenses table below, these diseases also happen to be quite costly among medical services. In subsidized government health centers/hospitals, treatment for dengue could cost P35,000 - P60,000 while treatment for leptospiroses ranged P10,000 to P50,000. In private hospitals/medical centers, expenses could be double or triple these amounts.

On the average, they spent P 6,517 for medical expenses, with some families spending a maximum of P70,000 during the Ondoy floods. Of those who got sick, only half (50 percent) of them said they were benefited by the medical services provided by the government and/or non-government organizations (NGOs). But majority of them said they were able to receive free medicine, first aid kits and services like water chlorination and dengue-infested area fumigation or defogging.

2.2.6 Loans

Only a fifth (20 percent) of them took out loans because of the 2009 floods; with an average loan of P10, 517. Of those who have taken loans, about half of them paid interest of less than 10 percent while the other half paid high interest ranging from 12-30 percent per month! Of those who have loaned money, only half of them (50 percent) were able to pay their debt/loan at the time of the survey. The used the loaned money to build and repair their homes, replace equipment and livelihood losses.

2.2.7 Summary costs of basic services before, during, and post-Ondoy floods

Below is a comparative summary table of costs and losses incurred prior, during, and after the Ondoy floods based on the recollection of respondents during FGDs. The number of absences from school and/or workdays lost rose a 100 percent for both men and women. But their average income losses rose to 300 hundred percent for male-headed households but a bit lesser (200 percent) for women-headed households. This is perhaps due to the longer closure of factory-based work for males while home-based work for females opened earlier than the former. But the worst is the increase in their expenditure for medicines, sanitation, and health care which rose a thousand percent during the Ondoy floods.

114 The percentages do not add up to 100 percent because of multiple responses.

Comparing male and female-headed households show that women bear a heavier burden in times of disasters, especially during extreme floods during *Ondoy* as seen in the tables below. But in non-extreme situations like that of *Pedring* and *Quiel* in 2011, the damages were negligible.

Summary of Costs/Losses Due to Floods (monthly)

	Pre-Ondoy		Ondoy Period		Post-Ondoy	
	Men HH	Women HH	Men HH	Women HH	Men HH	Women HH
Absences from school	6	8	14	17	6	7
Number of workdays lost from sickness due to flood	5	7	9	10	5	8
Number of work days lost due to flood	6	8	20	22	6	9
Average income loss due to floods	P1,715	P3,250	P7,250	P6,450	P2,750	P3,400
Average amount of spent on medicine	P300	P400	P3,200	P3,000	P500	P450
Average losses (appliances, etc.)			P25,000	P20,000		
Average income	P6,250	P5,000	-	-	P6,500	P4,200

Source: Porio (2011).

Summary of Costs of Basic Needs/Services (in pesos, monthly, US$ 1=P43)

	Pre-Ondoy		Ondoy Period		Post-Ondoy	
	Men HH	Women HH	Men HH	Women HH	Men HH	Women HH
Food	P6,000	P5,800	P2,500 + relief goods	P2,000 + relief goods	P6,500	P6,000
Water						
• Drinking	P50	P45	P240	P240	P60	P50
• Cooking/washing utensils	P80 (well) P500 (piped)	P80 (well) P550 (piped)	P80 (well, long lines) P1,500 (piped)	P80 (well, long lines) P1,500 (piped)	P80 (well) P740 (piped)	P80 (well) P700 (piped)
Energy/electricity	P2,000	P1,800	P5,000	P4,500	P2,000 (wet) P3,000 (dry)	P1,800 (wet) P2,500 (dry)
Sanitation/Laundry (mud, waist deep; cleaning – 2 weeks – one month)	P300	P310	P2,000	P2,000	P360	P320
House repair			P1,500 – P15,000	P1,000 – P8,000		

Source: Porio (2011)

Percent Increase/Decrease of Costs/Losses Between Men- and Women- headed Households Due to Floods (monthly)

	Pre-Ondoy		Ondoy Period		Post-Ondoy	
	Men HH	Women HH	Men HH	Women HH	Men HH	Women HH
Absences from school	⬆33%		⬆21%		⬆17%	
Number of workdays lost from sickness due to flood	⬆40%		⬆11%		⬆60%	
Number of work days lost due to flood	⬆33%		⬆10%		⬆50%	
Average income loss due to floods	⬆90%		⬇-11%		⬆24%	
Average amount of spent on medicine	⬆33%		⬇-6%		⬇-10%	
Average losses (appliances, etc.)			⬇-20%			
Average income	⬇-20%		-		⬇-35%	

Source: Porio (2011)

Percent Increase/Decrease of Costs/Losses Between Men- and Women- headed Households Due to Floods (monthly)

	Pre-Ondoy		Ondoy Period		Post-Ondoy	
	Men HH	Women HH	Men HH	Women HH	Men HH	Women HH
Absences from school	⬆33%		⬆21%		⬆17%	
Number of workdays lost from sickness due to flood	⬆40%		⬆11%		⬆60%	
Number of work days lost due to flood	⬆33%		⬆10%		⬆50%	
Average income loss due to floods	⬆90%		⬇-11%		⬆24%	
Average amount of spent on medicine	⬆33%		⬇-6%		⬇-10%	
Average losses (appliances, etc.)			⬇-20%			
Average income	⬇-20%		-		⬇-35%	

Source: Porio (2011)

Cost of Health Services in Health Center/Hospital to Climate Change-Related Complaints

Service	Estimated Cost
Ordinary check-up	PhP300-500 up to 1,500
Sputum analysis/check-u[	PhP750-1,500
1. Dengue (referred to public hospitals where patient pay minimal payment)*	PhP35,000-60,000
2. Leptospirosis (referred to public hospitals where patient pay minimal payment or free)*	PhP10,000-50,000
Services given pro-bono or charge minimally to urban poor by medical missions	
Blood analysis	P2320 = PhP750-3,200
Urine analysis	P90 = P700
Blood typing	P90 = P700
ECG	P90 = P1,500 – 2,500
X-ray	P90 =P500
Physical Exam A (including Blood Chem, Blood typing and ECG)	P490 = P2,500

Source: Porio (2011)

3. Adaptation Strategies to Floods/Monsoons: Family/Household Level[115]

Most of the adaptations made by families/households can be categorized into the following: 1) physical-structural adjustments, and 2) changes in lifestyles and habits. Of the physical-structural type of adaptation, quite a substantial number (about one-third) added a floor or raised the floor and strengthened the foundation of their homes. They also moved the storage of goods, valuables, and irreplaceable goods to a higher level so these won't get wet or damaged (60 percent). They also prepared ready packed clothes/toiletries and emergency supplies like flashlights, boats and secured emergency evacuation place with relatives/friends. Meanwhile, they also become more diligent in cleaning their surrounding canals/drainage channels for garbage/debris (35 percent). Almost all of them asserted that they try to monitor the weather through radio/TV. The local warning system installed by their local governments alerted them to the rising water levels in the river and direct them to prepare and evacuate. A small minority (5 percent) said they just pray to god to protect them.

Not surprisingly, in preparation for bad weather and floods, most families (89 percent) prepared or stocked on food like rice and groceries, water and medicines. Only a third of the respondents said they stocked on candles, flashlights and other emergency supplies. For electricity, 90 percent of them contacted the local provider, the Manila Electric Company, in case of electricity disruption, while a minority called their community officials and/or neighbors/electricians. Almost three-fourths of them said the provider's response was quite or moderate, only a few (about 10 percent) said the response was slow and the remainder saw no need to contact anybody. In the same manner, the majority (88 percent) contacted their water provider, Manila Water, for disruption in water services. Only a few (12 percent) said they contacted their barangay/community officials, neighbors and

[115] Many of these percentages do not add up to 100 percent as these are multiple responses.

friends. Again, majority (67 percent) said the provider's response was very quick or moderately quick. Only 2 percent said it was very slow while the remainder did not see any need to contact their water provider.

When asked whom do they contact when their homes gets flooded, majority of them (49 percent) contacted their city/barangay disaster reduction office while 17 percent called their neighbors, friends and relatives and the remainder (35 percent) did not call anybody but relied on their own selves. Of those who called for help from their officials and neighbors/relatives, majority of them (95 percent) found the latter's responses very quick or moderately quick and only 5 percent found the response very slow.

3.1 Funding support for relief/rehabilitation needs

When queried about their funding needs during floods, not surprisingly almost all off them (99 percent in Pasig and 90 percent in Marikina) said food and other basic subsistence needs should be given priority by the officials. But in Marikina which was severely hit by the floods almost half (43 percent) wanted assistance in housing/shelter and reconstruction. Others said they needed fund support for clothes (61 percent in Marikina compared to 27 percent in Pasig), medicines (6-11 percent), and livelihood restoration (3 percent).

3.2 Preparation, insurance and compensation

An overwhelming 83 percent have no form of insurance whatsoever while a small minority (17 percent) had purchased life, property and medical insurance. This small minority had employment in the formal sector and/or came from upper-income groups. But after the Ondoy floods in 2009 and Pedring/Quiel floods 2011, only 9 of the 17 percent were able to make insurance claims. Most of them could not file claims because damages due to the Ondoy floods belong to the category of "fortuitous events" or "acts of God" and not covered by their insurance.

3.3 Response and recovery.

When queried about flood assistance, an overwhelming 83 percent claimed to have been assisted by the local/city government with food and clothing. They received this assistance on the average after 48 hours, minimum 14 hours and maximum of 504 hours (or about 21 days). Only 1 percent claimed to have received financial assistance of P4,000 (about US$ 9) because of the death of a family member during the flood.

During and after the floods, the following measures were taken by the barangay/city government to reduce the impact of flooding in their communities:

1. Evacuation of residents, especially those in informal settlements along the rivers, creeks and other danger areas
2. Clearing and rebuilding of roads and bridges
3. Rebuilding of the water supply network
4. Clearing and rebuilding of water channel and drainage networks (including rip-rapping of river/creek walls and elevating water dikes)
5. Pumping flood waters out of the area
6. Relocation/resettlement of affected residents
7. Acquisition of equipment/supplies necessary during calamities (e.g., rubber boats, fire trucks)
8. Defogging of mosquito infested areas, especially those with high incidence of dengue cases
9. Capability building programs (training/seminars, information campaigns/dissemination)

In short, the immediate, medium and long-term responses of the city/local government can be summarized into: 1) evacuation, 2) restoration of basic services and 3) rebuilding of infrastructural support. Given the above interventions, majority of the respondents (65 percent) feel satisfied with the interventions provided by the national/local government agencies. A small number (35 percent) wished the government could provide better services such as water, sewage and sanitation but most of all sustainable livelihood and land/housing for those displaced by the floods. Thus, when asked who is responsible for preventing and responding to hazards and calamities, an overwhelming majority (70 percent) pointed to the barangay/city LGU as the one responsible while others identified the family (17 percent), civil society (8 percent) and the private sector (5 percent) as being responsible.

Glaringly highlighted in the identified medium and long-term responses of the city governments of Marikina and Pasig is the absence of a continuous-systematic training and capability program for the staff of the agencies responsible for disaster risk reduction and, more importantly, for the vulnerable, flood-prone communities and residents.

When asked whether they knew of the existence of their own barangay and/or city disaster risk reduction and management council (DRRMC), only 25 percent were aware but only 7 percent knew of their location in the barangay and/or city hall. Logically, only 5 percent and 2 percent were aware of the emergency numbers and website of the DRRMC, respectively. And only 2 percent had contacted their emergency numbers to ask for information about typhoons/floods or assistance.

Surprisingly, majority of them (86 percent) have heard of climate change and have accepted it as part of environmental change. In fact, when asked how they understand the phenomenon, majority were able to enumerate the following indications: ozone depletion, sea level rise, air pollution, heavy rains/floods, droughts, water shortage, melting of glaciers and rapid/intense weather changes. But they were not agreed on the causes of climate change as they gave varying responses like: environmental pollution (50 percent), increasing population (36 percent), and God's wrath/mankind's sins (14 percent). But on the whole, they acknowledge that the major causal forces of climate change are: people's lifestyles (68 percent) as mainly responsible, followed by inaction or negative actions of government (20 percent), industries (10 percent), and God (2) percent).

Majority of them (71 percent) obtained their information from television while some heard it from friends/relatives (13 percent), radio (8 percent), government agencies (2 percent) or have read about it in magazines/newspapers (7 percent). Thus, almost everyone (83 percent) think climate change is a serious problem that local/national governments should take into consideration in formulating their urban planning policies and implementing their development programs.

When asked what the government should do to prevent or mitigate the effects of climate change, they enumerated the following:

- Stricter norms for pollution reduction (26 percent)
- Decrease vehicles and enhance public transport (24 percent)
- Effective implementation of regulations/laws (30 percent)
- Eradicate factories and other polluting industries (10 percent)
- Rehabilitate environment like planting trees (10 percent)

When community residents were asked what they can do as individuals to help their government tackle the effects of climate change, an overwhelming 50 percent said to strictly follow proper environment waste management policies (reduce, reuse, recycle), observe government laws and ordinance (25 percent) and the remainder (25 percent) directed people to plant trees and conserve energy. In the same manner, when they were asked for suggestions on how the city or barangay's disaster risk reduction and management council (DRRMC) should do their work so the latter could respond better to their needs, only very few (less than 10 percent) could suggest that DRRMC monitor flooding more effectively. This is quite logical because as indicated earlier only a quarter (25 percent) were aware of the DRRMC's existence.

3.4 Risk communication.

In Marikina City, communicating the risk of city flooding is very much institutionalized in their early warning system, indicated by the siren signals (e.g., first siren is preparation for evacuation, with water level at 14 meters) according to the water level in the Marikina bridge (e.g., third siren is evacuation, water is reaching the critical level of 16 meters). Meanwhile, Pasig City has also installed an early warning system communicated through the city's disaster risk reduction management council (chaired by the mayor) and to the barangay/community DRRM counterpart bodies (chaired by the barangay captain).

But in other parts of the metropolis, communicating flooding and related to people and making them move accordingly constitute the most challenging task for LGUs as most residents do not want to leave their homes because of theft/loss of belongings. They'd rather climb up to the ceilings/roofs of their houses than move.

4. Damage and Losses from Commercial-Industrial Establishments and Adaptive Strategies

The commercial and business survey targeted 100 establishments (50 in each city) but the study ended processing only 85 research protocols. Fifteen protocols were not included in the data processing because these remain incomplete interviews despite several call backs or recalls. And there was no more time for substitution due to weather problems (typhoons, heavy rains and floods).

4.1 Physical characteristics, building type and ownership

Majority (65 percent) of them were constructed 1-storey buildings while the remainder (35 percent) were constructed multiple storeyed and/or multiple buildings/structures. Majority (41 percent) of the buildings were made of reinforced concrete with steel, blocks, bricks, wood and metal while the remainder (59 percent) was made of a combination of blocks, bricks, wood, metal, and steel. Majority (55 percent) of the establishments were renting the buildings that they were using and only 45 percent owned them. Thus, it is understandable why only 43 percent do regular maintenance of their buildings and premises while the remainder do it only occasionally. The total area occupied by the establishments ranged from 22 - 2,500 sq. meters, with a mean value of 1, 412 sq. meter and a median value of 300 sq. meters, suggesting a high disparity among the establishments. Most (62 percent) of these buildings were 1-20 years old while 18 percent were 21 to over 40 years old and the rest did know when or how old were their build structures. But overall, the buildings were on the average 15 years old.

4.2 Number of shifts/work hours

While a majority (62 percent) had only 1 work shift, 38 percent of the establishments had 2-4 workshifts; with 42 percent of them had workers staying/living in the premises. The number of workers ranged from 4-268 workers with an average of 29 workers per establishment. About 42 percent have employees staying/living in the premises of the commercial-industrial establishments.

4.3 Specific damages/losses and expenses for repairs

Most damages here were incurred only during the extreme floods of 2009, not in 2011 (the comparative year). With regards to damages to their buildings and properties, the respondents reported an average of P85,316, with values ranging from a miniscule P1,500 to P1 million; while damages to equipment, appliances and furniture amounted to a median average of P100, 000 (mean average: P925, 816; minimum of P3,000 and a maximum value of P12.8 million). Including other damages, respondents reported having incurred total damages of median average of P140,000 (mean average: P1.3 million; minimum value of P3,000 and a maximum value of P13.3 million).

Their expenses for repair for buildings amounted to median average of P10,500 (mean average: P90,580), with minimum value of P400 to a maximum value of P1 million. Meanwhile, their expense repairs to equipment/appliances amounted to a median average of P50,000 (mean average: P319,434), with a minimum value of P1,000 and a maximum value of P2 million. Including other repair/replacement expenses, their total expenses incurred amounted to a median average of P63,400 (mean average: P283,942), with a minimum value of P13,000 and a maximum value of P479,788).

After the floods, other costs involved disinfecting, sanitation and rehabilitation. The respondents reported spending a median average of P5,000 (mean average: P24,237), with minimum value of P150 to a maximum value of P300,000. Flood fighting/control costs on the other hand, yield a median average of P37,500 (mean average: P63, 484) with minimum value of P1,770 and a maximum value of P300,000. Costs of removing debris from the premises amounted to a median average of P8,000 (mean average: P52,232), with a minimum value of P300 and a maximum value of P500,000. Meanwhile, the respondents reported a median average loss of net income due to flood interruptions of P50,000 (mean average: P192,142), with a minimum value of P1,000 and a maximum value of P1 million. Total annual revenue lost to floods had a median average of P225,000 (mean average: P1.9 million), with a minimum value of P3,000 and P2.2 million.

4.4 Major problems encountered by establishments

Major problem encountered by establishments (population affected ranged from 54-90 percent) was the 1) lack of access to transport due to damages in bridges/roads, equipment, and heavy mud sludges, 2) disruption of communication, water and electricity services, 3) shortage of fuel, food supplies, and other necessities, and 4) the commensurate rise in prices of these basic necessities. Given these problems, work in factories, offices and service establishments have to be stopped as well, ranging from 4-8 weeks.

4.5 Work stoppage during floods and loss of work afterwards

Majority (96 percent) of the establishments stopped work or closed operation because of damage to their physical structures, equipment and/or their places remained inaccessible due to the floods. The median average height of floods was almost 4 meters (mean average: 5.42 meters), with a mimimum value of a fraction of a meter to a maximum of 20 meters. The average time needed to recover was 1-2 months; minimum time was 1 week and maximum time was 1 year and 11 months. Thus, on the average in both cities, 27 people lost their jobs (minimum value of 7 and a maximum value of 150 workers, suggesting a wide range of the size of the establishments and damages as well).

Comparing the floods in 2009 and 2011, definitely the floods in the latter years were negligible in terms of damages and other impacts. In fact, in 2011, the average total damage was only P10,000. To summarize, most business and commercial establishments in this study faced high exposure and vulnerability to flooding and other climate-related risks. Majority of them only had one storey buildings which were mostly submerged at the height of Ondoy floods; thus, they incurred high damages to their buildings/equipment as well their repair and replacement.

5. Institutional and Regulatory Responses: Structural-physical, Political- Economic and Cultural

In general, respondents in the survey blamed the following activities for the extreme floods: illegal logging, mining, quarrying in the upstream Marikina watershed and the consequent siltation, clogging, of the river systems and minor water channels. The increasing pollution and overfishing of Laguna Lake overfishing (manifested in the overpopulation of fish cages, most of them cemented, thus obstructing water flow) also compromised the draining capacity of the lake of the volume of dumped water from the uplands like the Marikina watershed, the Wawa Dam, and the La Mesa Dam.

The above geo-physical and man-made sources of floods and related disasters have also been intensified by the uncontrolled/unregulated real estate and commercial development in the uplands of Marikina (e.g., Antipolo, Montalban, Binangonan, Taytay, etc.). This is further compromised by the settling of large populations of informal settlements in danger areas like along river lines and hills, slopes, and ravines prone to landslides. Most of these areas have weak/temporary housing, low infrastructural support, and low access to basic services.

Given the above challenges and learning from the lessons brought about by the disastrous events of 2009 and the lesser floods of the past two years, several policies and programs were enacted by Congress. Two overarching frameworks for adapting to climate change were crafted, the 2010 National Disaster Risk Reduction and Management and the 2011 National Framework Strategy on Climate Change. Each was drafted in compliance with the law by virtue of the “Philippine Disaster Risk Reduction and Management Act of 2010” and the “Climate Change Act of 2009” The first provides for the creation of the National Disaster Risk Reduction and Management Council; the second, for the Climate Change Action Plan approved for implementation by President Benigno Aquino III towards the end of November 2011.

Former President Macapagal-Arroyo signed into law the Disaster Risk Reduction and Management Act of 2010, amending the 30-year old Presidential Decree 1566, the old law covering risk reduction and management matters. This law mandated that each city/municipality must institute each have a disaster risk reduction and management plan. Meanwhile the Climate Change Action Plan made the first law more actionable by specifying the programs to be implemented by the Climate Change Commission and the other agencies of the Aquino government.

The crafting of local risk reduction and management plans at the barangay (community), city, and provincial levels, one of the principal outcomes of the law, provide a very promising scenario. These local plans drawn locally and elevated to the city level make design strategies contextually-specific and more appropriate, responsive and effective for local needs.

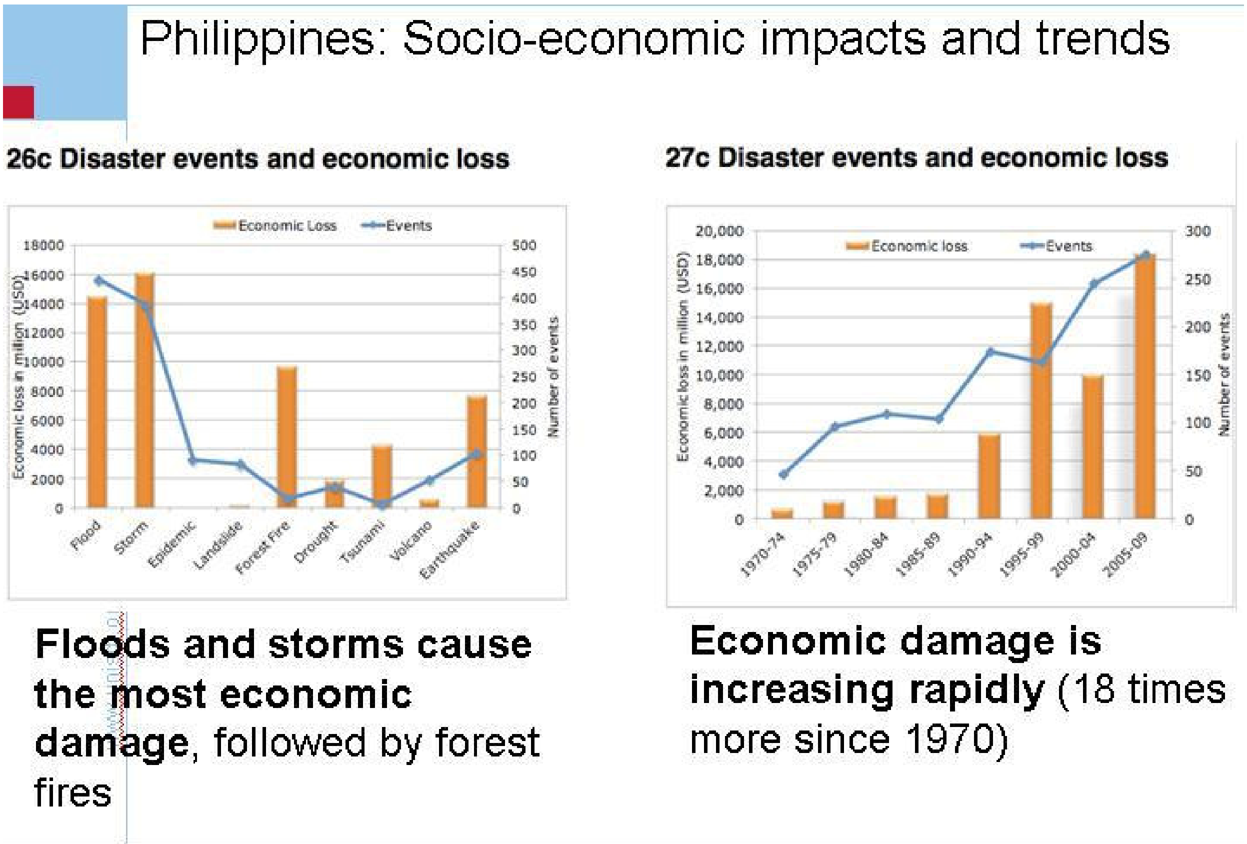
6. Strategies of Private Sector and Communities

Were the adaptive responses of private sector and communities enough? Did these led to into medium and long term capacity on the part of the business sector and the community? Most of the manufacturing sector relocated their activities to other parts of the city where flooding is less likely to occur. For example, Pure Foods in Marikina City transferred their manufacturing to Laguna, a province located nearby the national capital region while others moved to higher ground (the 30 percent that were not flooded during Ondoy like Marikina SSS vilages). This was a strategy adapted by large commercial and industrial establishments in the city like the conglomerate, Fortune Tobacco. For those who remained or did not relocate, they just strengthened their buildings or build upper floors where they conduct their business. Meanwhile in Pasig, most of the factories were compelled by the City Environment Office (CENRO) to follow safety standards. So, majority of them who refused to follow the safety standards imposed by the city moved to cities and municipalities who were not so strict in imposing environmental laws. Overall, this poses problems when considered at the macro level, because local government units (LGUs), in order to attract business often relax the compliance standards that they impose on business/commercial establishments.

Part III

7. The Prospective Scenario: Mainstreaming into Long-Term Planning and Development

As shown in the tables below, it is imperative that climate change-related vulnerabilities and risks be mainstreamed into long-term development planning and development.



Source: Velasquez, J. (2011).

The above tables show that floods and storms have caused the most economic damage to the country. Damages from floods and storms have increased 18 times since the 1970s. Thus, the fundamental lesson that has to be inscribed into our people's life-ways and our institutions is the urgent need to develop a culture of disaster prevention, mitigation, adaptation and safety behavior. But Philippine society especially government institutions seem to refuse to take responsibility in implementing the required engineering, land zoning, infrastructure planning and sustainable relocation of people. Meanwhile, commercial and other private sector interests and informal settlers continue to build over, across, beside waterways or in mountain slopes/hills that obstruct, constrict, deflect water/river flows. Presumably environmentally certified programs and riverside beautification projects continue to be made heavily of concrete preventing water absorption and flAmidst this bleak contemporary scenario, the following rehabilitation and recovery design principles have been suggested by government officials, business/community leaders and residents, especially the city disaster reduction and management councils along with their urban planning offices.

7.1 Rehabilitation and recovery.

From the household/commercial surveys, key informant interviews and focus group discussions (FGDs) among key stakeholders, the respondents suggested the following principles for recovery and reconstruction.

- Design of the recovery and reconstruction program must be transparent, accountable and must deliver evidence-based results and outcomes.
- The approach must be community-based, people-centered, and equitable approaches; and reduction of future risks in recovery and reconstruction.

If followed, these principles will enhance the effectiveness of recovery and reconstruction efforts, increase transparency and accountability, and ensure that resources are distributed and applied to those really in need. In fact, most of these are embodied in the 2010 National Disaster Risk Reduction Management Framework and the 2011 Climate Change Action Plan.

- Flood management: Given its vulnerability to flooding, protecting Metro Manila requires institutional changes, comprehensive planning, and investment in both restoration and infrastructure for effective flood management system.
- Housing: The vast majority of damage to housing stock was concentrated in the informal sector, so reconstruction means providing better alternatives for informal settlers.
- Disaster Risk Reduction: The existing disaster risk reduction system needs to become more proactive, coherent, and effective; and
- Local Governance: LGUs should have the key role in implementing the recovery and reconstruction program and future measures to mitigate disaster risks.
- Enterprise sector: A mix of financing mechanisms are needed to help small and medium-scale enterprises recover from damage and losses and to implement rehabilitation and relocation plans.

Six major strategies specifically for reducing flood and earthquake impact in Metro Manila:[116]

- Enhance legal framework and institutional capacity for effective disaster management system
- Build capacity for relief and recovery
- Strengthen community-based preparedness system for disasters
- Strengthen/"climate-proofed" buildings, structures, especially infrastructure system
- Enhance the national and local governments' system resistance to earthquakes and floods
- Promote research and technology for disaster prevention, mitigation and adaptation

7.2 On-going and Future Action Plans

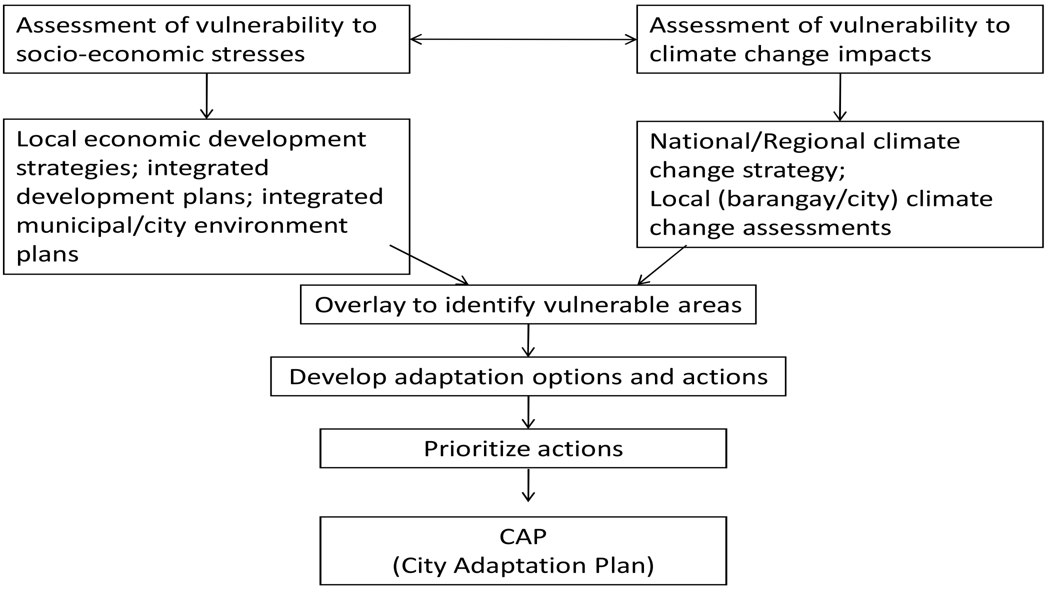
- Response and recovery planning (evacuation plans, crisis management plan, resource assessment and allocation, public safety, search and rescue)
- Preparedness and awareness (short term actions): e.g., school safety programs, public information, community preparedness
- Mitigation and Prevention (long term actions): e.g., building code implementation and enforcement, land use planning and zoning, insurance and risk transfer
- Capacity building: equipment acquisition, training (e.g., first aid, search and rescue), certification and qualification, organizational-institutional strengthening

[116] Most of these were gleaned from the FGDs (focus group discussions), KIIs (key informant interviews) and household interviews. But most of these are also embodied in the 2004 MEIRS study, the 2010 National Disaster Risk Reduction and Management Framework and in the 2011 Climate Action Plan.

To summarize, this study found that Metro Manila, in particular, the cities of Marikina and Pasig are highly at risk to floods and have suffered severely from extreme flooding impacts of *Ondoy* (Ketsana) and *Pedring* (Parma) in 2009.

Adapting McGranahan et al (2007), this study recommends the following process of integrating or mainstreaming the findings of this study into a "City Adaptation Plan for Climate Change" as shown in the structures created and processes illustrated below.

Process for Developing a City Adaptation Plan for Climate Change (cf.McGranahan et al)



One major innovation that this study would like to suggest is to complement the above process with a bottom-up process whereby the particular environmental and social-political-economic vulnerabilities (as reflected in their local risk and vulnerability maps and data bases produced through participatory action research methods) of the affected communities are also taken into consideration. This can be integrated in the "Local Climate Action Plans" and the "Local Disaster Risk Reduction and Management Plans" which builds into an integrated "Municipal/City Climate Action Plans" and "Municipal/City Disaster Reduction and Management Plans". Highlighted in these localized plans and city-wide integrated plans/programs are the particular community and household adaptive strategies that are empowering, effective, transparent, and accountable.

The integration of climate vulnerability assessments and climate action plans into the urban planning and development of the city should be spatially-anchored and should recognize the overlaps among political-economic and environmental boundaries. This should be calibrated in the management/decision-making structures in urban governance systems. More importantly, it should reconcile these boundaries within the context of centralized-decentralized models of governance. If these issues are calibrated well at the governance level, then moving towards water-based urban design, vertical urbanism and green economy, technologies and architecture can be programmed or mainstreamed into urban development.

References

1. Adger, W. Neil (2000). Social and Ecological Resilience: Are They related? *In* Progress in Human Geography, vol. 24 (3):347-364.

2. Adger, W. Neil (2003). Social Capital, Collective Action, and Adaptation to Climate Change *in* Economic Geography 79 (4):387-404

3. Bankoff, Greg. (2003) Constructing Vulnerability: The Historical, Natural and Social Generation of Flooding in Metro Manila *in* Disasters 27 (3): 95-109.

4. Berkes, F. et al. (2001) Adapting to Climate Change: Social-Ecological Resilience in Canadian Western Artic Community. Conservation Ecology 5(2):18.

5. Blaikie et al. (1994) At Risk: Natural Hazards, *People's Vulnerability and Disasters*. London: Routledge.

6. Birkmann, Jorn (2009). Assessing Vulnerability in the Context of Multiple-Stressors. United Nations University, Institute for Environment and Human Security.

7. Buika, James et al., (n.d.). A United States-Japan-Philippines Collaborative Planning Process to Implement a Multi-Hazard, Urban Risk Reduction Strategy for Marikina City, Philippines.

8. De Sherbinin, et al. (2007) Population and Environment.Annual Review of Environment and Resources 32: 345-373.

9. Galgana, Gerald, et al. (2004). Visualizing Sea Level Rise in Navotas by GIS and Terrain Modeling *in* Journal of Environmental Science and Management 7 (1):1-9.

10. Marikina City Government (2004). "Sound Practice No. 5".

11. IPCC (2001): Climate Change 2001: Impacts, Adaptation and Vulnerability: Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press.

12. Klein, R.J.T. and R.J. Nicholls. 1998. Coastal zones. In *Handbook on Methods for Climate Change Impact Assessment and Adaptation Strategies*, I. Burton, J.F. Feenstra, M.L. Parry, J.B. Smith, and R.S.J. Tol (eds.). Version 2. United Nations Environment Programme and Institute for Environmental Studies, Amsterdam, pp. 7-1 to 7-35.
13. Patankar, Archana and Anand Patwardhan. 2009. Enhancing Climate Change Adaptation by Integrating Climate Risk into Long-Term Development Plans and Disaster Management. A research proposal submitted/approved by the Asia Pacific Research Network (APN).
14. Porio, Emma. 2009. Vulnerability, Adaptation, and Resilience to Floods and Climate Change-Related Risks Among Marginal, Riverine Communities in Metro Manila. Research report submitted to the JICA Research Institute.

15. Porio, Emma. 2010. Vulnerability on Flooded Riverlines in Urban Philippines: The Case of Metro Manila. Paper presented in the Regional Conference on Environments of the Poor, Asian Development Bank, Oct. 25-27. Forthcoming in the "Environments of the Poor", Institute of Southeast Asian Studies, Singapore.

16. Porio, Emma. 2011. Vulnerability, Adaptation, and Resilience to Floods and Climate Change-Related Risks Among Marginal, Riverine Communities in Metro Manila. In Journal of Asian Social Science 39: 425-445. Brill Publishers (Netherlands).

17. Porio, Emma. 2011. Gender, slum poverty, and Climate Change in flooded riverlines in Metro Manila. Paper presented in the Seminar Series on Gender and Climate Change, Asian Development Bank (ADB), April 27-28.

18. Sairinen, R. and L. Peltonen (N.D). Adapatation Strategies for Climate Change in the Urban Environment. FINADAPT/Appendix 13. WP 13: Urban planning. www.ymparisto.fi/download.asp?contentid=15988

19. Velasquez, Jerry. 2011. http://www.facebook.com/notes/jerry-velasquez/why-we-need-more-drr-work-in-the-philippines/320230661331687 (posted by a UN Expert on Climate Change and Disaster Risk Reduction).

20. Winters, Paul, et al (1998). Economic and Welfare Impacts of Climate Change on Developing Countries *in* Environmental and Resource Economics 12: 1-24.

21. World Bank (2009). Philippine Typhoons Ondoy and Pepeng: A Joint Assessment. Sector Reports. Typescript. 77 pp.

Appendix A. Deadly Storms/Typhoons (Out of the 19) in 2011 in the Philippines (plus earthquakes)

Month	Name of Storm	Damages	
January	Typhoon Basyang and other storms	Deaths - 68; Missing - 26; Displaced - 2 million Damages to property/agriculture: P1.78 billion	
March	5.2 magnitude earthquake (Ilocos) 5.8 magnitude earthquake (Manila)	Minor damage	
May	Typhoon Bebeng	Deaths - 44; Displaced – 500,000 in 12 provinces mostly in Bicol; Damage – P1.37 billion (or US$ 31.7 million)	
June	Typhoon Falcon	Deaths – 70; Displaced – 69,000; Damage – P10 billion	
July	Typhoon Juaning	Deaths – 52 ; Damage P1.7 billion	
August	Typhoon Mina	Deaths – 16; Damage P1.009 billion	
September	Typhoons Pedring & Quiel	Deaths – 77 ; Displaced – almost 1 million; Damage – P15 billion	
December 16	Typhoon Sendong	Deaths – 1585; Missing – 1,079; Injured – 1, 979; Damages – P1.03 billion	
December 27	5.1 earthquake (Surigao, Northern Mindanao)	Minor damage	

7.4 Young scientist's report

INTERNSHIP REPORT

Project title: Asia Pacific Network for Global Change Research (APN) funded research project *'Enhancing adaptation to climate change by integrating climate risk with development planning and disaster management'*

Project duration: June 1 —July 31, 2011

Name of the Student Intern: Ms. Jyoti Nair

Report:

Any city has its own threshold capacity to overcome the hazards but it is the adaptive capacity of the city that helps it to live with it when it bound to face the event recurrently. For Mumbai floods are one such event which is not new. The extremity of the 2005 event caused the people to raise questions on the adequacy of the existing system to help the people and infrastructure survive through any such extreme event in near future. To tackle this issue the municipal authority came up with several measures to reduce the flooding. Through the project the aim is to identify such specific infrastructure redevelopment projects or strategies being undertaken to minimise the impacts. The study aims at identifying the medium and long term measures to tackle hazards such as climate related extreme events. Since, the project aims not just on climate change but also focuses on the disaster management aspect of the risk climate change is accompanied with; helped me shift focus from change in the climate and consider the disasters that we should foresee.

The application part of all what we read with regard to climate change is not very different from theory yet when it comes to on field work things were a revelation to me. The objective of the project was explained to me on the very first day and with that in mind I have learned through the work the ground realities of adaptation.

My participation in the project has taught me several new things. Apart from the subject based knowledge, the exposure has taught me few more nuances of communication skills.

Through the course of the internship the tasks allocated and completed are:

1. To identify case studies relevant to the study through literature review: This helped me get acquainted with this form of scientific writing and gave me a broad and fresh perspective of the flooding situation and the studies done worldwide.

2. To construct questionnaire for focused group discussions and personal interviews with the local government officials.

3. To Interview local government officials based on the questionnaire: meeting with the officials was an experience in itself. With the caliber of the authority they have it was an great opportunity to meet some high level officers such as Ms. Uma Adusumilli, Chief urban Planner of MMRDA , Mr. Mahesh Narvekar, Chief Officer, Disaster management cell and all the Asst. Municipal commissioners at each ward covered. And the interviews helped understand how the system deploys work and configures the project responsibilities. The interviews with the officials at BMC, detailed many facts about the ongoing infrastructure development projects such as BRIMSTOWAD and how they came into action post 2005 flood event. The vision to perceive any hazard of such magnitude was lacking until 2005 and it required an event of such magnanimity to open the eyes to the potential vulnerabilities. The ward level difficulties were discussed at ward level and asked for their view on the ongoing project development at the particular ward. Being a centralized system the local level

officials complained of the existing hierarchy but they were well equipped through the disaster management authority to face hazards. We found that the perceptions on climate change were fairly scientifically correct and a challenge sighted was the garbage accumulation in the drainage system due to irresponsible public's lack of civic sense. There were missed reviews on the priorities of development over environment or vice versa.

I want to thank Dr. Archana Patankar, Project leader, for taking me into the project as the student intern thereby helping me fulfil my academic criterion and giving me an opportunity to be able to interact with the local level government officials. I am grateful for her patience; and the guidance she provided me through the two months. Also, I want to extend my gratitude to Ms. Reema Ved, Research Associate, for being a friendly senior and for accompanying and supporting me through the interviews.

I look forward to take this exposure to help me focus better on the research goals I have to set for myself in the near future.

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7.5 List of acronyms/abbreviations

APN- Asia-Pacific Network for Global Change Research

APTU- Faculty of Architecture and Planning, Thammasat University

BMR- Bangkok Metropolitan Region

BRIMSTOWAD- Brihanmumbai Stormwater Disposal System

CRF- Central Relief Fund

CENRO- City Environment Office

DMC- Disaster Management Cell

DMAP- Greater Mumbai Disaster Management Action Plan

DRRM- Disaster Risk Reduction Management

EGAT- Electricity Generating Authority of Thailand

FGDs- Focus group discussions

GDP- Gross Domestic Product

IIT- Indian Institute of Technology

IRDR- Integrated Research in Disaster Risk

ICSU- International Council for Science

IPCC- Intergovernmental Panel on Climate Change

INR- Indian Rupees

KAMANAVA- Kaloocan, Malabon, Navotas, and Valenzuela

LAD- Local Administration Department

LGUs- Local Government Units

MCGM- Municipal Corporation of Greater Mumbai

MMRDA- Mumbai Metropolitan Region Development Authority

NSO- National Statistics Office

NCR- National Capital Region

OECD- Organization for Economic Corporation

PWD- Public Works Department

RID- Royal Irrigation Department

RIG- Royal Irrigation Department

SIMSR- K.J. Somaiya Institute of Management Studies and Research

START- Global Change System for Analysis, Research and Training

UNEP- United Nations Environment Programme