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Climate Change and Vulnerability of People in Cities of Asia

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Climate Change and Vulnerability of People in Cities of Asia

ICLEI

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ICLEI – Local Governments for Sustainability, is an international, not-for-profit association of local governments and local government organisations that have made a commitment to sustainable development. ICLEI's mission is to build a movement of councils to achieve tangible improvements in environmental conditions through the cumulative impact of local action.

Abstract

More than half the world's population lives in urban areas and urbanisation trends are growing, with Asian cities at the heart of urban growth. Cities play an important role in the climate change arena, both as significant contributors to greenhouse gas emissions, and also centres of innovative activity for reducing emissions. However, cities are particularly vulnerable to the impacts of climate change. An understanding of their vulnerabilities, and how to reduce these vulnerabilities is imperative. This paper explores the sources of greenhouse emissions in Asian cities and the particular vulnerabilities of Asian cities to the impacts of climate change.

Through a review of policies and field-based studies undertaken in two Asian megacities, Jakarta (Indonesia) and Mumbai (India), local community vulnerabilities are explored and innovative adaptive measures identified. The predominant climate related focus for communities researched in both cities was flood mitigation, where community adaptation included such things as raising the floor level of houses, storing clothing in plastic bags on high shelves, and collective community cleaning of rubbish from canals before the monsoon season arrived. However, many of these residents were placed at greater risk of future climate change, due to such things as lack of properly executed and enforced urban planning, poor provision and maintenance of basic services such as water supply, sanitation and waste collection, and poor disaster risk reduction planning.

City governments have a role to play in reducing both greenhouse emissions, and vulnerability to climate change impacts, through activating "levers", such as planning, regulation, purchasing power, network facilitation, education and their civic leadership role.

Key words: cities, urban, climate adaptation, climate mitigation

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Executive Summary

"Urbanization – both as a social phenomenon and a physical transformation of landscapes – is one of the most powerful, irreversible and visible anthropogenic forces on Earth."[1]

More than half the world's population now live in urban areas and cities, and the trend of urbanisation is anticipated to continue, with Asian cities at the heart of urban growth. Cities are important entities in the climate change arena: both as significant contributors to greenhouse gas emissions, and also centres of activity for reducing emissions. However, cities are particularly vulnerable to the impacts of climate change, so an understanding of their vulnerabilities, and how to reduce these vulnerabilities is imperative.

ICLEI Oceania was engaged by the United Nations Development Programme's Asia-Pacific Regional Centre in Bangkok to provide a technical paper on Climate Change and Vulnerability of People in Cities of Asia. This paper would help inform the Asia-Pacific Human Development Report *One Planet to Share: Sustaining Human Progress in a Changing Climate*. Researchers in Australia, India and Indonesia were engaged to assist with this work. A literature review was undertaken to investigate and analyse the importance of cities and urbanisation in the context of addressing climate change and promoting human development for people in Asia. Field-based studies for two mega-cities in Asia, Mumbai and Jakarta, were reviewed to determine what the local challenges and vulnerabilities were to climate change impacts and the adaptation strategies undertaken to date. Additionally, a policy review was undertaken to consider the impact of policies on climate change in the two cities.

Urban centres are focal points of economic growth, job creation, culture, creativity and innovation, but as they rapidly expand, they also exhibit extremes in living standards across their communities, income inequity, and differential access to services. Some of the key challenges that increase the negative impacts of urbanisation in developing countries include short-term planning, lack of capacity of local officials and of the local community to engage with the planning system, poor governance, competing priorities and an ongoing process of decentralisation, without the associated knowledge, skills and resources. Each of these challenges further exacerbates cities' potential contribution to climate change, and its exposure to impacts.

The International Energy Agency estimates cities contribute 71% of global greenhouse gas emissions, either directly or indirectly.[2] These emissions stem from energy used to power cities, (which predominantly comes from fossil fuels), transport, commercial and residential buildings, waste, wastewater and industry sectors. Many of these emissions are increasing in cities not because of the increased number of people, but of the way they live; how they choose to consume goods, to travel etc. City governments can influence these areas, through engaged, transparent, long-term planning, effective implementation of regulations, their own purchasing power, facilitation of networks, education and civic leadership.

Even with strong, global action to reduce emissions, however, the impacts of climate change will not be avoided, and cities, particularly in Asia, are vulnerable to these impacts. One framework proposed to assess the vulnerability of cities to climate change considers their level of exposure to climate change impacts, their sensitivity, or the degree to which it is affected by those impacts,

[1] (Sanchez-Rodriquez, et al. 2005, 8)
[2] (IEA 2008)

and their capacity to adapt to and cope with the impacts of climate change. This may be represented by the formula:

$$\text{Vulnerability} = f(\text{Sensitivity} * \text{Exposure} * 1/\text{Adaptive Capacity})$$[3]

Cities located on coasts, rivers or river deltas are particularly exposed to a range of projected climate change impacts, including coastal erosion, salt-water intrusion and flooding from sea-level rise; flooding or drought from altered precipitation regimes; flooding and other damage associated with more intense storm events; heat waves and increasing temperatures associated with the urban heat island effect. As cities concentrate people and systems, they are more sensitive to the impacts of climate change, and likely to be impacted to a higher degree. The inter-related nature of the systems that keep cities running, including power systems, communications, transport, water supply and sanitation systems, mean that a disruption or poor performance in one system, may have flow on impacts to other connected systems. Disruptions to these systems have a greater impact on poor communities in cities, affecting both their health and livelihood.

In Asian cities, although exposed to multiple climate change impacts, the perception of most cities is that flooding (whether this be caused by increased intense precipitation events, cyclones and storms or sea-level rise) is the focus area for adaptation efforts. To consider the vulnerabilities and adaptation actions of Asian cities in a more localised way, Mumbai (India) and Jakarta (Indonesia) were reviewed more closely, through analysing field-based studies undertaken in these cities.

Both Mumbai and Jakarta are exposed to serious flooding, severe storms, drought, urban heat island effect and heat waves, along with the associated direct and indirect impacts of these conditions on city service provision, health and livelihood. Projections suggest that as a result of climate change, Mumbai and Jakarta will be even more exposed to these impacts. Their sensitivity to impacts is high, as they are the economic centres of their countries, contributing significantly to their respective country's GDP. Additionally, both cities are classed as "mega-cities", with populations of their broader metropolitan regions exceeding 10 million people. A significant proportion of the population, 6.9million[4] in the case of Mumbai and in excess of 700,000[5] people in Jakarta live in poverty, and are more exposed to climate change impacts, and more sensitive to them.

Through the collection of case studies, interesting examples of planned and unplanned adaptation were observed. These included building second storeys on houses, or raising the floor level, selecting plastic furniture (which is easily cleaned after a flood), and storing clothing and other items on high shelving, in plastic bags. Collective community actions such as cleaning the rubbish from canals before the monsoon season to widen the channel for water were also documented. However, examples of where adaptive capacity was reduced were also revealed, including: lack of properly planned and enforced land use and urban planning (which allows building on highly exposed areas such as riverbanks, over natural drainage areas, upstream intensive urban development along river ways); the clearing of mangroves and forests; poor provision of basic services such as water supply, sanitation services and waste collection services; poor maintenance of sanitation and water services, and poor disaster risk reduction planning.

At the national and also local city level in both Mumbai and Jakarta, there is an increasing recognition of the importance of climate change, and several policies are highlighting this.

[3] (IPCC 2001, 89) This is the framework first presented by the IPCC in 2001, in Section 1.4.1 of WG2, TAR, then refined further by several authors.
[4] (Municipal Corporation of Greater Mumbai 2009)
[5] (Firman, et al. 2010)

However, while many of these policies appear to be gaining some traction, and have implementation in place, there is still a perceived lack of engagement with the urban poor who may be affected by these policies, which therefore affects how well they will be received and implemented.

Many of the actions that could be taken to improve the cities' response to climate change, and adapting to its impacts are less on the policy formation level, and more on the strategy and implementation level. Many of these actions are not only for city level authorities and agents to undertake, but also at the national and international level. These include undertaking more urban field-based studies to inform the development of appropriate policy and strategies, improving city-level climate modelling, developing better climate change communication approaches and language and capturing and sharing the experiences of communities adapting to climate change. There is a role to better integrate climate change into current NGO agendas and to encourage community-led initiatives. Further strategies include facilitating the improved understanding of climate change by both the community and local government staff and elected representatives, improving the capacity of the community to engage in local government processes, and of the local government representatives to engage the community in planning processes. For emergency events in particular, the improvement of early warning systems would be of value. Broader local government issues of addressing short-term, non-integrated planning and improving governance will have positive implications beyond the climate change agenda. Finally, facilitating understanding by donor agencies of the unique challenges and concepts of urban resilience to climate change is an important strategy to be undertaken.

As concentrators of wealth and innovation, cities are uniquely placed to address the challenges of climate change, and to be supported to achieve positive outcomes for their communities. Asian cities are faced with particular challenges, and need to be encouraged to take urgent action. It is hoped this report will assist agencies and development professionals to target appropriate action to facilitate improved resilience of people in Asian cities to climate change impacts.

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1. INTRODUCTION

This report aims to analyse the importance of cities and urbanisation in the context of addressing climate change and promoting human development for people in Asia.

Additionally, it aims to synthesise the understanding in two urban mega-cities in Asia of:

- Local challenges to climate change impacts
- Vulnerabilities to climate change
- Existing local adaptation strategies of urban communities
- Existing local mitigation strategies of urban communities
- Impact of the policy framework on vulnerabilities

Finally, it will identify opportunities to promote pro-poor policies and strategies to reduce vulnerabilities to be considered by development professionals and local government representatives in developing countries.

No primary research was undertaken for this report. It relied on published materials and field-study reports conducted by others. ICLEI Oceania engaged research assistants in India and Indonesia to assist with sourcing field studies, and conducting the policy review for each city. This process is outlined in Section 2, Methodology.

The world is becoming more urbanised, with more than half the world's population now living in cities[6], and with anticipated future world population growth occurring almost exclusively in urban areas[7]. These urban centres are focal points of economic growth, job creation, culture, creativity and innovation, but as they rapidly expand, they also exhibit extremes in living standards across their communities, income inequity, and differential access to services. Section 3 considers the process of urbanisation generally, its drivers, benefits and challenges. It then considers the interaction of urbanisation and climate change, including the role cities play in contributing to climate change. With an estimated 71%[8] of global greenhouse gas emissions directly or indirectly attributed to cities globally, they have an important role to play in reducing global emissions.

Local governments, along with national governments, business, industry and individuals are implementing measures to limit greenhouse gas emission growth, however emissions continue to grow and the impacts of climate change are now believed to be inevitable.[9] It is merely the scale of impacts under question. Even with immediate, strong action to decrease emissions, cities will still be impacted. Section 4 outlines some of these impacts, and the inter-related nature of further direct and indirect impacts on urban systems and poor populations. It then considers how some of the challenges of urbanisation will exacerbate some of these impacts.

Cities in Asia are rapidly growing during a time when the causes and impacts of climate change are known. Section 5.1 considers what contribution Asian cities are making to global emissions, and what initiatives are being implemented to mitigate them.

Across Asia, impacts of climate change have already been observed, including changes in mean temperature, deviations in precipitation levels and in precipitation patterns, in the frequency and

[6] (UN-HABITAT 2008, 13)
[7] (UN-HABITAT 2008, 5)
[8] (IEA 2008)
[9] (IPCC 2007a)

intensity of storm and cyclone events, and sea level rise.[10] It has been proposed that a city's vulnerability to climate change can be seen as a function of its exposure to a specific (or range) of impacts plus its sensitivity to that impact, and the inverse of its adaptive capacity. This can be represented by:

Vulnerability = f (Exposure, Sensitivity, 1/Adaptive Capacity)[11]

Applying the above concept of vulnerability, cities in Asia are projected to be among the most vulnerable to the impacts of climate change particularly the coastal cities of Asia.[12] Section 5.2 highlights Asian cities' exposure to climate changes and their sensitivity. It considers the impacts already felt by many cities, and how these are projected to worsen in the future.

Two Asian mega-cities, Mumbai in India and Jakarta in Indonesia, have been identified as having high levels of exposure to multiple risks, such as drought, sea-level rise and flooding. They are also economic hubs for their respective countries, with large populations in excess of 10 million people and growing, so exhibit high levels of sensitivity. These two cities will form the basis of this report's further analysis of the vulnerability of people in cities to climate change. This analysis presents some key statistics about each city (Section 6) and includes a review of policies impacting the two cities at the national, regional and city level (Section 7). It also briefly considers some of the drivers in the two cities that increase greenhouse emissions (Section 8). Field-studies from each of the cities focusing on the impacts of flooding and sea-level rise, particularly for the poor, are analysed for both current and future vulnerabilities in Section 9.

Section 10 brings these thoughts together to consider recommendations for policy makers and development workers in developing countries.

The climate change field, in particular the adaptation area, is a multi-disciplinary and emerging field. A standard terminology is still to be accepted across all disciplines, so definitions for the key terms used in the report are presented in Section 12, Glossary Key Terms.

2. METHODOLOGY

The geographic scope of the research is predominantly the Asia region, focusing on two mega-cities chosen from this region; one city in South Asia (Mumbai) and one city in Southeast Asia (Jakarta).

This report aims to synthesise some of the information currently circulating about climate change and cities in Asia. For this reason, no primary research was undertaken.

A literature review was undertaken to consolidate key terms and definitions in use in the field of climate change mitigation and adaptation. The literature review also considered the growth of urbanisation, particularly in Asia, and what the links were between urbanisation and climate change. The role played by cities in increasing greenhouse gas emissions was explored, and how they could be a significant player in reducing global emissions.

Across Asia, many research projects and networks are being established to determine the likely impacts of climate change on urban communities, who will be most vulnerable, and what can be

[10] (Cruz, et al. 2007)
[11] (IPCC 2001, p89) This is the framework first presented by the IPCC in 2001, in Section 1.4.1 of WG2, TAR, then refined further by several authors.
[12] (WWF 2010), (Yusuf and Francisco 2009)

done to minimise the impacts and build resilience. These networks and initiatives include the Asian Cities Climate Change Resilience Network (ACCCRN), the Asia-Pacific Network for Global Change Research (APN), UN-HABITAT's Sustainable Urban Development Network (SUD-Net) Cities in Climate Change Initiative amongst many others. This paper drew on the work of these networks and initiatives to consider the likely impact of climate change on urban centres in Asia, although few of these initiatives focus on megacities.

For the selected cities of Mumbai and Jakarta, a policy review was undertaken to consider if climate change considerations were being integrated into national, regional and local policy, and if so, how. A literature review was undertaken to investigate the areas of production and consumption that most impacted on greenhouse gas emissions for the two cities. Finally, field-based studies were identified for Mumbai and Jakarta and interrogated to draw out the local challenges to climate change impacts; the particular vulnerabilities identified; the existing local adaptation and mitigation strategies of urban communities and the impact of the prevailing policy framework on these vulnerabilities.

The research was undertaken in five stages:

Stage 1 – City Selection and Description
The selection of the two cities was based on a range of criteria, including their exposure to multiple climate change impacts, the population living in informal settlements, the access and availability of information relating to their vulnerability to climate changes, and the access to local knowledge of the policy and city situation. The first stage of the research developed the criteria for city selection and then investigated these criteria across potential cities.

The intention was to then narrow the focus of the research to particular research groups. However, due to the limited number of field-based studies undertaken in mega-cities to date, the study was forced to limit the research groups to those chosen in the few available studies.

Research assistants were engaged in Australia, India and Indonesia to assist with this investigation.

Stage 2 – Urbanisation, Climate Risk and Vulnerability
This stage of the research focused on gathering and synthesising information relating to urbanisation, its benefits and negative aspects, and some of the perceived causes of the negative aspects. It then went on to review the literature about how cities were contributing to climate change, and importantly, how they could potentially abate their greenhouse gas emissions. It specifically tried to identify the links between the causes of the negative aspects of urbanisation and how these may exacerbate climate change, thereby identifying common areas of future effort to improve development outcomes, and reduce global climate change impact.

As the IPCC have now stated that climate change is inevitable,[13] the climate risk and vulnerability research gathered information relating to the impacts of climate change in Asia more broadly, but then narrowed its focus to the two countries, and the two cities in question. In particular, the impacts were framed in human development terms; that is, in what way will the anticipated climate change impacts affect health, income generation and other key determinants of human development.

[13] (IPCC 2007)

Stage 3 – Policy Review
As the adaptive capacity and sensitivity of cities to climate change is greatly influenced by policies at the national, regional and local levels, the research gathered and analysed the policies most relevant for impacting on the vulnerability of the chosen two cities. These policies covered a range of infrastructure, housing, energy and transport considerations, as well as poverty reduction and specific climate change related policies. The analysis investigated whether the policy included climate change considerations, specifically if it addressed climate adaptation or mitigation issues or both. It then considered what impact the policy would have on the city's exposure, sensitivity or adaptive capacity to a range of relevant climate impacts.

Stage 4 – Review of Field-Based Studies
Based on collected field-based studies, this stage investigated the types of climate change related impacts urban communities are currently experiencing, the challenges experienced by the poor and vulnerable communities, and the factors responsible for aggravating vulnerability. Additionally, it investigated what coping strategies were in place at the local level, and identified both planned and unplanned adaptation experiences and opportunities to further support these.

Stage 5 – Recommendations
This stage focused on recommendations for potential policy and strategy interventions that can help promote greater resilience, and low emissions development for vulnerable groups. There is a particular focus on the role of cities to reduce vulnerability, promote resilience and low carbon futures.

2.1 Limitations of this Research

As with all studies, there are limitations to this research. The two most pressing limitations were 1) the access to available, relevant field studies and 2) the breadth of focus on mitigation and adaptation restricted the depth of the study into either particular area.

Firstly, extensive research (in the time permitted), revealed that local-level field based studies on the impacts and vulnerability to climate change are being undertaken in secondary cities, but not as yet in mega-cities. Most studies relate to a particular event or impact, rather than research to glean an understanding of local perceptions and challenges to climate change more generally. This meant that the studies selected for the field-based review were narrow in focus, and did not capture the breadth of possible climate change impacts. Additionally, the researchers were restricted to working in English, Hindi or Bahasa Indonesia, so smaller studies undertaken and reported in other languages were not accessible.

Secondly, the scope of this study aimed to cover both mitigation and adaptation issues, which is very relevant and reasonable. However, the constraints on time and size of the report meant that neither issue could be explored in great depth, so for that reason it is quite a high-level synthesis report.

3. URBANISATION AND IMPACT ON CLIMATE CHANGE

The relationship between urbanisation and climate change is a complex one. Increasing urbanisation is frequently cited as a contributor to increased greenhouse gas emissions, although some challenge this causal assumption. As cities continue to concentrate the world's economic and social systems, they will exhibit increased vulnerability to the impacts of a changing climate, but perhaps also be the centres of action and innovation to mitigate greenhouse gas emissions in the future. As many of the aspects of increased urbanisation play a role in either exacerbating or reducing the impacts of climate change, it is important to understand these aspects. Additionally,

some of the drivers for urbanisation are themselves influenced by climate change (such as rural to urban migration due to drought, salinity, precipitation change and so forth), creating a reinforcing feedback relationship.

3.1 Urbanisation – The Positives and the Negatives

Globally, urban populations are growing, with more than half the world's population now living in cities.[14] The *State of the Worlds' Cities Report 2010/11* notes that by 2050, "urban dwellers will likely account for 86% of the population in the more developed countries, and 67% in less developed regions".[15] In previous decades, the rate of global population growth of both rural and urban communities was comparable, however, in the next 30 years, it is estimated that most of the world's population growth will actually occur in cities,[16] with a significant proportion of this urban growth occurring in developing countries.[17] Some of this growth is contributing to the emergence of urban agglomerations such as mega-regions, urban corridors and mega-cities, that is, cities that have in excess of 10 million people.[18] (Refer Appendix 1)

This phenomenon is particularly evident in Asia, where by 2050, urban populations are expected to reach 64.6 per cent, from a current urbanisation proportion of 42.2 per cent.[19] This region is also where the growth in mega-cities will be most apparent, with mega-cities already existing, and continuing to emerge in India, China, Indonesia, Bangladesh and the Philippines. The Asia-Pacific region already hosts 12 of the 21 global Mega-Cities.[20] These connected economic and social agglomerations are defining how we work, live and relate to each other not only at the local level, but also at the global level.

Cities can provide positive social and economic benefits for city inhabitants, the cities themselves and for their countries. There is an undeniable link between a country's GDP growth and its degree of urbanisation, with many cities representing significant contributions to their country's GDP. In several OECD countries, one single metropolitan area accounts for between 33% and 50% of the nation's total GDP, for example Auckland, Tokyo or Brussels.[21] There is a natural link between the economic development of the country, and the relative wealth and health of its' citizens.[22] On the individual economic level, studies consistently show that the incidence of urban poverty is less than that of rural poverty for most countries[23]. At the city level, Jeb Brugmann notes that cities and enterprises benefit through economies of density, scale, association and extension[24]. This includes the proximity of multiple buyers and sellers, the reduction in transaction costs and the knowledge and finance availability that comes with proximity. As well as economic centres, cities are frequently centres of culture, creativity and learning, aided by the same principles of proximity and concentration of resources and exchange.

Aggregated statistics and "averages", however, do not reveal the disparity within cities, and the negative effects of urbanisation. Many urban centres in developing countries, have a proportion of

[14] (UN Dept of Economic and Social Affairs, Population Division 2009)
[15] (UN-HABITAT 2008, 5)
[16] (UN-HABITAT 2008, 5)
[17] (Sanchez-Rodriquez, et al. 2005, 10), (UN Dept of Economic and Social Affairs, Population Division 2009)
[18] (Sanchez-Rodriquez, et al. 2005, 10), (OECD, 2010, 39)
[19] (UN Dept of Economic and Social Affairs, Population Division 2009)
[20] (UN-HABITAT 2010)
[21] (OECD 2010)
[22] (UN-HABITAT 2008)
[23] (UN-HABITAT 2008)
[24] (Brugmann 2009)

their population living in slums, or informal settlements,[25] and there is vast and growing income inequality, which leads to huge disparity in standards of health and wellbeing. As cities grow, there are growing environmental and social pressures within the urban boundary, in the hinterland that supports it, and globally. Some of these environmental pressures include pressure on resources such as land and water. These pressures lead to inequality of ownership and access, and the related health impacts of poor access to good quality water and sanitation. Social conflicts can arise over access to land and water within the urban boundary, and the hinterland (or peri-urban) areas. Pressure is placed on agricultural food systems, as more land is removed from agricultural production, and engulfed by the expanding urban area. Biodiversity is invariably affected as more habitat is removed to make way for displaced agriculture, and for urban growth. There is also the pressing concern of urban waste and pollution, from solid waste and wastewater, through to particulate air pollution and greenhouse gas pollution. This has a direct impact on the environmental condition, and the health and wellbeing of city dwellers, those in surrounding areas, and in the case of greenhouse gas pollution, globally.

There is a large range of inter-related causes of these negative consequences of urbanisation, particularly in developing countries. Key causes that have been identified include:

- **Short-term municipal planning:** The existence of short-term planning, including short-term development/land-use/spatial planning is evident, where the needs of a rapidly growing city in 10, 20 or 50 years are not adequately built into planning decisions. Planning decisions extend past the tenure of elected officials, and also the employment life of staff. Urban systems such as transport, water and sanitation are long-lived infrastructure systems, and require consideration of capacities and needs at least 50 years into the future. Not only does the planning need to be long-term, but to be integrated across different disciplines, which is a challenge for both developed and developing country cities.
- **Lack of capacity:** Elected public officials and staff lack the knowledge, skill and required organisational systems and resources to undertake and effectively implement long term planning. Additionally, there is a lack of capacity of citizens to actively engage with long-term considerations, and be involved in planning.
- **Poor governance:** In many developing countries, there is clear evidence of poor governance, whereby decisions are made in a non-accountable, non-transparent and non-participatory manner, and can be seen to serve vested interests. In some developing countries, such as Viet Nam, the local priorities for urban growth and development are not directly included in the planning process, as these decisions are made at the state or national level.[26]
- **Competing priorities:** As local governments seek to fund their infrastructure development, the funds for development often partially come from the sale of peri-urban land to private developers that may have competing interests. However, the local government must house a growing population, and requires funds for infrastructure development.[27] These pressures, combined with short-term planning, lack of capacity and poor governance, lead to expanding urban sprawl in many developing cities.
- **Decentralisation and Devolution of Responsibility:** Globally, there is evidence of increasing responsibility being delegated to local authorities; to be responsible for the local environment, infrastructure, economic and social wellbeing of its citizens. This may be a formal process of decentralisation, as is occurring in India and Indonesia, or a less formal

[25] (UN-HABITAT 2008), UN-HABITAT defines a slum as a settlement in an urban area in which more than half of the inhabitants live in inadequate housing and lack basic services. Refer to the Glossary of this paper for an extended definition.
[26] (Tyler, et al. 2010)
[27] (Moench 2011)

devolving of responsibility. However, this increased responsibility is rarely matched with increased resources and funding to effectively carry out these growing responsibilities.[28] This links very closely with the lack of capacity and poor governance, as the staff in local governments do not have the experience and capacity to take on the new areas of responsibility, and to engage effectively with their citizens on key long-term planning issues.

3.2 Greenhouse Gas Emissions in Cities

The above-listed urbanisation benefits, negative aspects and their causes have a bearing on the contribution cities make to climate change, and how significantly they and their citizens are likely to be impacted by the effects of climate change. Satterthwaite[29] notes it is not urbanisation per se, and the numbers of people in cities that automatically lead to greenhouse gas pollution and climate change, it is more a relationship with how these urban dwellers produce and consume goods and services. The International Energy Agency (IEA) concurs, noting it is the growing comparative wealth of inhabitants in Asian cities such as those in China, as well as access to energy services, contributing to above national average energy consumption.[30]

Globally, the IEA estimates that cities will account for more than 73% of the world's energy use by 2030.[31] However, as there is no globally regulated method and framework for collecting and analysing greenhouse gas emission data from cities, this estimate is by no means precise.[32] In growing urban areas, greenhouse gas emissions growth (using traditional point of production accounting methods) stems primarily from[33]:

- **Energy Supply:** Energy is generally provided to cities by burning fossil fuels (such as brown coal), for electricity generation, heating, cooling, cooking, transportation and industrial production. This often occurs outside the municipal boundary (in large centralised electricity plants), but also at the distributed local level, through burning kerosene and diesel. As urbanisation increases, particularly in developing countries (where rural-to-urban migration is a key feature), a shift is evident from burning biomass and waste for energy production, to the more greenhouse intensive fossil fuel sources.[34]

  The greenhouse intensity of the energy supply is related to the energy system supplying energy to the city, and the energy supply mix, that is, the percentage supplied by fossil fuels compared with less greenhouse gas intensive sources such as nuclear power, hydro power, solar or wind power.

- **Transport:** Public and private transport systems grow as the city itself grows, and these are generally fuelled by fossil fuels. The proportion of journeys made by public transport, versus private motorised vehicle is a key determinant in emissions from this sector.

[28] (Nurhadi 2009)
[29] (Satterthwaite 2009)
[30] (IEA 2008)
[31] (IEA 2008, 12)
[32] ICLEI – Local Governments for Sustainability developed a framework to guide the calculation of greenhouse gas inventories for cities – *International Local Government GHG Emissions Analysis Protocol*, www.iclei.org; UNEP, UN-HABITAT and The World Bank have developed the *International Standard for Determining Greenhouse Gas Emissions for Cities.* www.citiesalliance.org
[33] (Satterthwaite 2009), (ICLEI 2009)
[34] (OECD 2010)

While increasing urban density can reduce distances travelled, (as well as impacting mode of travel) and therefore reduce total transport emissions, urban sprawl (where the city boundary continues to expand rapidly outward, generally in a poorly planned manner) can exponentially increase this sector of emissions growth. A reliance on road transport to reach urban sprawl areas increases the need for private motorised vehicles, further increasing greenhouse gas emissions.

As the wealth of inhabitants in developing cities increases, there is a corresponding increase in the proportion of private car use.[35]

- **Buildings:** Residential and commercial buildings contribute to greenhouse emissions, through the power used in lighting, to heat and cool them, and to run the appliances and office machines within them. Emissions are therefore a factor of the greenhouse intensity of the power supply, the energy efficiency of the appliances and systems used, and of the behaviour of building occupants.

  The increasing wealth of some city inhabitants, and better access to energy services, leads to higher appliance ownership, and proportionately higher energy use[36]. In domestic buildings, such things which become commonplace as wealth increases include multiple flat-screen TV's in each household, computers, mobile phones, game consoles, electronic kitchen appliances, electronic toys and so on.

  Additionally, there is a trend towards smaller households in urban areas[37], leading to higher per capita emissions to deliver the same services.

- **Waste and Wastewater:** The increasing consumption of goods, currently leads to growing waste, and a growing population leads to increased wastewater. It was noted that the generation of waste over-rides population growth in some Indian cities.[38] Emissions from this sector are related to not only the increasing volume of waste, but how the waste is managed. The types of systems to treat/dispose of waste and wastewater directly impact a city's greenhouse gas emissions profile. Paradoxically, it is the more affluent cities that have the resources to invest in better waste management systems. This is a particular area of interest for municipal governments in developing countries, due to the multiple benefits of effective waste management.

- **Industry:** Growing levels of production and manufacturing of goods, and the greenhouse gas intensity of these industries, contributes to urban greenhouse gas emissions. Even though these goods may not be consumed in the local urban area, their physical production location is often in the economic hub of a city.[39]

  More developed countries are moving to tertiary industries, such as finance, entertainment and tourism, with the result that developing countries are carrying the burden of the manufacturing industries greenhouse emissions.

How cities address each of the above sectors as they grow directly impacts their greenhouse emissions profile. Many of these areas can be tackled independently of regional or national

[35] (UN-HABITAT 2011)
[36] (IEA 2008, Ch.8)
[37] (UN-HABITAT 2011)
[38] (Indian Network for Climate Change Assessment 2010)
[39] (ICLEI 2007), (Satterthwaite 2009)

government policy, making cities very important in the climate change mitigation arena. Through concentrated and aggregated resources and proximity to target groups, cities have the potential to significantly mitigate their greenhouse gas emissions. This can be done through activating many of the levers at hand for city governments, such as planning, regulation, purchasing power, network facilitation, education and their civic leadership role.

Box 1: Cities Connected to International Negotiations
Since the early 1990's, Cities have been actively connected to global climate change negotiations through involvement in such organisations as ICLEI – Local Governments for Sustainability. ICLEI represents local governments at the United Nations (UN) Commission on Sustainable Development, the UN Framework Convention on Climate Change and co-operates with the UN Environment Programme and UN-HABITAT.

ICLEI actively advocates for local government to be formally recognised for the role they can play in mitigating climate change, and for financial mechanisms to be open to cities to participate in their own right.

Over 1200 local governments are members of ICLEI worldwide.

Source: www.iclei.org

The area of focus needs to be determined on a city-by-city basis. To determine the area of focus, cities must undertake a process of developing a robust baseline greenhouse gas inventory, establishing their emissions profile, and putting in place rigorous monitoring and reporting systems to assess the results of any initiatives. Cities engaged in programs such as ICLEI's *Cities for Climate Protection* program, or the Clinton Initiative' *C40* program have been systematically tackling greenhouse gas mitigation for many years (see Box 1). However, participants in these programs attest that city energy data is difficult to find and often incomplete.

The area of **energy supply** is one that is strongly related to national level policy levers. National policies that put a price on carbon, and favour alternative energy production provide a framework for cities to plan for renewable energy to supply their energy needs as they grow instead of fossil fuel use. This significantly alters the greenhouse gas emission profile for the city. Cities in China, for example, need to respond directly to the central government's targets relating to reduced energy intensity, thus facilitating the penetration of clean energy technologies. Also, the small town of Hepburn Shire in Australia, for example, has worked with its community to develop a local wind farm to supply a percentage of the city's energy needs.[40] In this instance, the city is activating its civic leadership role in partnering with the community on a significant investment project.

The sector of **industrial** emissions is one that is not under the direct control of city government's, but can be influenced by regulation and other activities. As cities rapidly expand and develop, particularly in developing countries, many aim to actively seek out and attract more businesses to their area, to propel future employment growth and ongoing development. Strategically planning to attract lower energy intensity industries like service industries, or other "green industries", rather than high-intensity manufacturing industries will impact the industrial emissions output for a city. Mumbai in India for example, has transitioned itself from a significant textile manufacturing centre, to a predominantly serviced-based city,[41] and cities in China are also actively facilitating structural change towards an enlarged tertiary sector.[42]

[40] (Hepburn Wind 2011)
[41] (Municipal Corporation of Greater Mumbai 2009)
[42] (IEA 2008)

One of the major areas that impacts greenhouse gas emissions in cities is **transport** – particularly transport from private vehicles. It has been shown that the high population density of a city can positively impact greenhouse emissions through more people choosing public transport, or low energy modes of transport rather than private cars.[43] To achieve effective transport emissions reductions, cities can plan to develop integrated transport systems that allow for significant public transport, walking and cycling use over private car use. Regulatory powers can be employed to encourage sustainable behaviour, such as London's Congestion tax to reduce car use in central London, and a greater reliance on walking and public transport.

Cities are potentially able to impact the emissions from **buildings** in their municipality, by activating their regulatory powers and mandating minimum energy efficiency standards for new buildings as part of building codes and standards. As a leadership function, they can ensure, as a minimum, that all municipal buildings are demonstrating high levels of energy efficiency; this is a common practice for city governments globally. The City of Port Phillip in Australia for example is undertaking an extensive building retrofit program, over three years, that aims to ensure all government buildings demonstrate high energy efficiency features.[44] An innovative example of where large scale, low-energy housing is being provided includes Dongtan Eco-City in China, near Shanghai. In Thailand, low environmental impact housing is being combined with low cost by providing homes through the re-use of shipping containers.[45]

A final area of influence and control for cities is that of **waste**. Effective waste separation and treatment processes can enable the reduction of highly potent greenhouse gasses such as methane, and significantly reduce a city's emissions. Proactive cities are going one step further, and capturing the methane gas produced by waste landfill sites and converting this to energy to power their municipalities, thus helping to address their energy supply mix, while also reducing their emissions.

An alternative greenhouse accounting method for cities has been proposed, which is based on consumption of goods and services in the city, rather than point of source emissions.[46] This is to correctly reflect the differing impact of wealthy city consumption patterns, compared with those in developing countries. With this method, there is a more direct correlation between the *wealth* of cities and the growth in their greenhouse gas emissions than population growth and greenhouse gas emission growth.[47] For example, the greenhouse gas emissions per capita for people in wealthy developed countries of Europe, North America and Australasia are far in excess of the urban per-capita emissions of Asian cities. Targeting the way a city and its people consume goods and services provides another possible leverage point for reducing greenhouse emissions.

To be undertaken effectively and efficiently, the climate change mitigation areas outlined above require long-term planning, municipal staff capacity and capacity of local private sector experts, strong governance, clear prioritisation of emissions reduction as an important area of activity, and financial and other resources to implement initiatives. However, as was outlined previously, the causes of many of the negative impacts of urbanisation in general also suggest that this will be a significant challenge for cities in developing countries.

[43] (OECD 2010)
[44] (City of Port Phillip 2010)
[45] (SWITCH-Asia Network Facility, Burcu and Patrick 2009)
[46] (Satterthwaite 2009)
[47] (Satterthwaite 2009, 51)

Although the above review suggests general areas that cities may be able to target and influence, it needs to be recognised that as with many aggregated statistics, inequality is hidden in general, aggregated greenhouse gas profiles for cities. Increasing populations in some cities in developing countries have not had a significant contribution to climate change, because their way of life and method of consumption does not require high energy input.[48] Within cities like Mumbai, it is the growth in energy-intensive consumption patterns of the wealthy, rather than the growth in numbers of city dwellers per se that contributes to greenhouse gas emissions growth. It is therefore the patterns of consumption of its wealthier citizens that cities also need to target and influence, as well as improving city systems under the municipality's control, if cities are to meaningfully contribute to mitigating greenhouse gas emissions.

4. THE IMPACT OF CLIMATE CHANGE ON CITIES

Irrespective of what an individual city's contribution may be to climate change, most urban areas, particularly those in developing countries, will be impacted by a changing climate. The impacts felt by cities will directly or indirectly relate to variations in climatic conditions such as temperature change, precipitation change, frequency and intensity of severe storm events, and sea level rise.

4.1 Vulnerability, Exposure, Sensitivity and Adaptive Capacity

The field of climate change adaptation is a multi-disciplinary field drawing on fields of expertise such as social sciences, geography, climate science, hydrology, engineering, development and disaster risk reduction specialties, to name a few. Various frameworks have been proposed to conceptualise and assist to address vulnerability and urban resilience, each with a slightly different emphasis and interpretation of key components. One framework which has been proposed to assess a city's vulnerability to climate change impacts is one that considers the city's exposure to climatic change, its sensitivity to (or the degree to which it is affected by) that climatic change and its associated impacts, and the level of adaptive capacity it has built into its systems and people to prepare for, mitigate and cope with the impacts of the climatic change. This may be represented by the formula:

$$\text{Vulnerability} = f\,(\text{Sensitivity} * \text{Exposure} * 1/\text{Adaptive Capacity})$$[49]

This is not a static framework, as vulnerability varies over space and time, depending on the range of variables and inputs. Therefore, a city's vulnerability is also not static.

Considering this framework, the geographic location of many cities predisposes them to significant **exposure** to a range of climate change impacts. A high proportion of cities, particularly mega-cities, are located along coastlines, near river floodplains or deltas,[50] which according to the IPCC Fourth Assessment Report is likely to increase their exposure to a range of risks, including coastal erosion, sea level rise and more frequent intense storm activity. Climate observations have established that there has been an increase in intensity of tropical cyclones, and that global average sea level has risen.[51] IPCC projections suggest tropical cyclones will become more intense, and sea-levels will continue to rise in the coming decades.[52] As cities develop and alter the natural workings of river ways and coastlines – through removal of coral reefs,

[48] (Satterthwaite 2009)
[49] (IPCC 2001, 89) This is the framework first presented by the IPCC in 2001, in Section 1.4.1 of WG2, TAR, then refined further by several authors.
[50] (IPCC 2007a), (OECD 2010)
[51] (IPCC 2007a)
[52] (IPCC 2007a)

mangroves, alteration of coastlines and river banks, and decreasing areas of permeable surfaces, the exposure to these risks is exacerbated.

The nature of cities is that they concentrate people and systems, making them more **sensitive** to any given impact, that is, they are likely to be impacted to a higher degree. The high density of the built environment and infrastructure in cities makes it likely to be impacted to a higher degree by extreme events such as storms, flooding and heat waves. Additionally, the large number of people concentrated in cities means that for any given impact, a higher number of individuals are likely to be affected than for less populous areas. In mega-cities in particular, where economic resources are highly concentrated, the disruption of "business as usual" can have a significant financial impact not only on the city, but on the country more broadly.

Cities' **adaptive capacity** relates to their knowledge, resources and ability to mitigate potential damages, take advantage of opportunities or cope with climate change challenges. Knowledge in this case relates to knowledge and understanding of city officials, the private sector, NGOs and citizens. It is the knowledge and understanding of these groups of what strategies to pre-emptively put in place to cope with climate change impacts, and what knowledge is drawn upon during extreme events or even during daily planning and activities. Resources relates to financial resources, appropriately skilled labour and materials. While ability can relate to the broad political system that either allows or inhibits action, the existing geography, infrastructure and culture of the city can also either allow or inhibit action.

By functioning through a network of inter-related, interdependent systems, such as transport, communication, power, water and sanitation systems, cities can potentially be reducing their adaptive capacity to climate risk. If there is a failure in one system then there is the risk of subsequent failures in related systems. For example, a failure in the power system may lead to interruptions in transport, communications and water pumping. For interruptions/failure to be avoided, there needs to be the knowledge, resources and ability to design and build systems with the adaptive capacity to resort to "back-up" support systems, so they can work independently, or with alternative dependence if required.

City infrastructure, which provides the basic services that allow people to earn an income and maintain health, including the drainage infrastructure, road and transport infrastructure, communications and building infrastructure is designed generally with certain climate patterns in mind (often based on past weather experience). Planning for the development and building of infrastructure to meet uncertain future climate needs requires long-term planning, and the capacity to integrate future climate uncertainty into planning decisions. Much of the existing infrastructure has not been built with future climate uncertainty in mind, and as climate adaptation planning is a relatively new field, infrastructure planning decisions are being made now without a solid consideration of future climate variability. Additionally, to upgrade or adapt existing infrastructure is costly, and as the benefits of this expense are not immediately perceived, then competing priorities for finance and resourcing can easily take precedence. In developing countries in particular, where urbanised areas are challenged by poor long-term planning, a lack of capacity and limited resources, this situation is compounded. Poorly informed design decisions now are building in future potential vulnerability to the impacts of climate change.

For most cities around the globe, poor populations of men and women (see Box 2) within cities are considered to be the most vulnerable.[53] This is in part due to a **lack of resources and**

[53] (IPCC 2007a), (OECD 2010)

capacity to respond to climate changes (whether they be immediate disasters, or more gradual change), and in part due to their **amplified exposure** and **sensitivity** to the impacts.

Box 2: Gender and Climate Change in Urban Areas
Globally, very few studies have been conducted to disaggregate the ***contribution made*** to climate change based on gender, or the ***differentiated impacts*** from climate change based on gender. Some of the broader considerations include:

Mitigation
Energy Use: Women have a higher responsibility for unpaid "home" care activities, including cooking, cleaning and washing. They are more directly responsible for energy use in the home, and therefore, can be more effectively targeted to reduce home-based energy emissions, through choice of appliances and behaviour change.
Mobility: With a lower participation rate in the formal economy, women's travel needs are less oriented to radial commuting in cities than men's. They may be making more frequent, local trips, which can be targeted in mobility planning to be less energy intensive.
Waste: In developed countries, it may be the "men who take out the garbage", but women are still more responsible for household purchasing and consumption. Their choice of goods, and the levels of packaging influences waste volumes.
Adaptation
The capacity to respond to climate change impacts is a factor of knowledge (education) and resources to avoid/cope with impacts. In developing country cities, women still have lower literacy and education levels, and are employed in the lower wage informal sector, so have less resources to draw on. Policies and strategies need to directly target the gender dimensions of poverty to assist with adaptation strategies.

Source: "Gender, Cities and Climate Change", Gotelind Alber, 2010

Poor settlements, whether they are informal or formal, have a higher exposure to many climate change impacts, as they are often located on lower level land that is already more prone to flooding, and is likely to be at higher risk from either sea level rise or storm events, such as the Dharavi slums in Mumbai,[54] or the newer slum areas along the canals of Kolkata. The urban poor do not have the luxury of choice for where they site their homes, so are more vulnerable than those who theoretically could choose to live in a less exposed part of the city.

The housing materials of the poor in cities are often less robust, therefore they are less likely to withstand extreme weather events and associated impacts. This increases the sensitivity of the poor, as the level of impact is proportionately higher than for those in more robust houses that may only receive a small amount of damage during extreme events. The provision of services, particularly to informal settlements, such as electricity/power, sanitation and fresh water are frequently inadequate compared with wealthier populations in the same cities. These services contribute to the adaptive capacity and level of sensitivity of the poor areas.

The working poor in many cities are more likely to be engaged in activities that are outside, predominantly unprotected from the weather, which greatly increases their exposure to temperature changes, and such events as heat waves. For example, street vendors and rickshaw drivers in cities such as Mumbai, Bangkok and Phnom Penh must continue to work unprotected during extreme temperature days, in order to earn their livelihood. Alternatively, for some workers, their workplace is situated close to their home, and is itself severely impacted by any extreme event, for example, local markets or informal factories. Should these workplaces be closed for any period of time, then this directly affects the income and livelihood of the poor. If their workplace is on the other side of the city, they must rely on transport that may be impacted

[54] (de Sherbinin, Schiller and Pulsipher 2009), (OECD 2010)

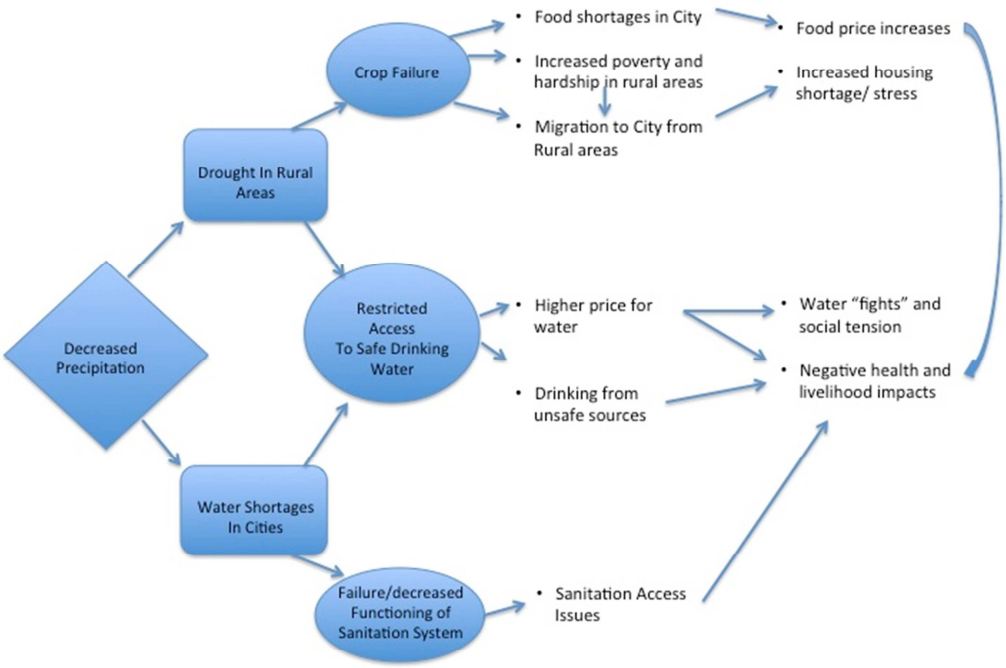
by extreme climate events – again, potentially threatening their income and livelihood. Thus for a variety of situations, the poor are more sensitive to potential climate change impacts, as any change may affect their income and livelihood.

4.2 Inter-related Impacts

Changes in particular physical climate stimuli such as precipitation change, temperature change, storm intensity and frequency and sea level rise have been observed to different degrees around the world, and the trend in these changes is expected to continue.[55] Cities' exposure, sensitivity and adaptive capacity to these stimuli is also varied, but there are some consistent underlying vulnerabilities. The interconnected range of impacts from climate stimuli affects natural systems, built infrastructure systems, socio-economic systems within cities, and the support systems such as agricultural systems outside cities. Together, these affect the development, health and wellbeing of cities and their inhabitants.

Exposure to precipitation changes varies across the globe. Some areas, such as northern Europe and parts of northern and central Asia have observed increased precipitation in recent decades, and are likely to receive further increased precipitation in coming decades, while parts of Africa and southern Asia are likely to see a decrease in total precipitation.[56] The impact of altered precipitation regimes on cities may result in an alteration in fresh water availability, indirectly impacting the functioning of sanitation systems and the health of city populations. Precipitation levels impact the agricultural areas providing food to cities, therefore an alteration in precipitation will indirectly affect city dwellers through its impact on the local food system, and potentially higher levels of rural-urban migration. Figure 1 illustrates a small portion of the inter-related impacts that may flow from decreased precipitation.

Figure 1: Decreased Precipitation – inter-related impacts



Source: Author, 2011

[55] (IPCC 2007a)
[56] (IPCC 2007a)

Through intensive storm activity, sea level rise or precipitation change, cities are increasingly vulnerable to flooding.[57] As well as their increased exposure to these events, many city infrastructure and drainage systems do not have the capacity to adapt to the altered demands placed on them. They are generally long-lived, and many systems are already decades old. Particularly in developing countries, they may be poorly maintained, and are not designed to cope with the increased demands – not only from the climatic changes but also from the increased population needs they must service. Recent floods in Mumbai (2005), Jakarta (2007) and (the developed country) Brisbane (2010-11) have demonstrated this. The inability of water transport systems in particular to operate effectively, can lead to contamination of water storage and potable water systems by run-off, sewage and debris. This leads to the spread of pathogens, directly impacting the health of city-dwellers.

Observed changes in temperature indicate the number of hot days and hot nights has increased, and future climate modelling suggests that this trend is likely to continue in the future, and that the frequency of heat waves will increase.[58] Cities will be particularly impacted by increasing temperature, as they tend to have higher air and surface temperatures than rural areas. This is known as the urban heat island effect.[59] This is caused by a variety of things, including the increased area of roadways, buildings and concrete surfaces that absorb sunlight and re-radiate heat, decreased vegetation cover which provides shade and the concentrated operation of heat-generating equipment such as air conditioners, cars and other mechanised transport. Measurements suggest that urban areas can be between 3.5 - 4°C warmer than surrounding rural areas. This increases to as much as 10°C for mega-cities and large urban agglomerations.[60] Increased temperature has an impact on the correct functioning of infrastructure, and a detrimental impact on health, particularly of the poor, elderly and very young.[61] The early 2009 heat wave in Melbourne disrupted train services, power supply and saw a dramatic increase in the number of people, particularly the elderly, treated for heat stroke and other heat related conditions. [62]

The following table collates some of the key impacts and vulnerabilities of urban centres to climate change, as discussed above.

Table 1: Inter-related Impacts of Climate Change

Change	Impact on natural systems, agriculture, water	Impact on urban areas	Impact on health and household coping
Temperature: Warm spells and heat waves frequency up on most land areas	Reduced crop yields in warmer regions; Wildfire risk increased; Wider range for disease vectors	Heat islands with higher temperatures, often large concentrations of vulnerable people; Air pollution worse	Increased risk of heat-related mortality and morbidity; More vector-borne disease; Impacts for those doing strenuous labour; Increased respiratory disease where air pollution worsens; Food shortages
Precipitation: Heavy precipitation events frequency	Damage to crops; Soil erosion; Water-logging; Water quality problems	Floods and landslide risks up; Disruption to livelihoods and city economies;	Deaths, injuries, increased food-borne, water-borne and water-washed diseases; More malaria from standing water;

[57] (Tyler, et al. 2010), (WWF 2010)
[58] (IPCC 2007a)
[59] (OECD 2010)
[60] (OECD 2010)
[61] (IPCC 2007a)
[62] (Houston and Reilly 2009)

increased over many areas		Damage to homes, possessions, businesses and to transport and infra-structure; Loss of income and assets; Large displacements of population, with risks to social networks and assets	decreased mobility with implications for livelihoods; Dislocations; Food shortages; Risks to mental health, especially associated with displacement
Intense Storms: Intense tropical cyclone activity increases	Damage to crops, trees and coral reefs; Disruption to water supplies		
Precipitation and Temperature combined: Increased area affected by **drought**	Land degradation; Lower crop yields; Livestock deaths, wildfire risks and water stress up	Water shortages; Distress migration into urban centres; Hydro-electric constraints; Lower rural demand for goods/services; Higher food prices	Increased food and water shortages; Malnutrition and food- and water-borne diseases up; Risk of mental health problems up; Respiratory problems from wildfires
Sea Level Rise: Increased incidence of **extreme high sea level**	Salinisation of water sources; Coastal erosion.	Loss of property and enterprises; Damage to tourism; Damage to buildings from rising water table	Coastal flooding, increasing risk of death and injuries; Loss of livelihoods; Health problems from salinated water

Source: Adapted from Bartlett, 2008

5. CLIMATE CHANGE IN URBAN ASIA

Urban Asia is growing more rapidly than other parts of the world[63], so it is appropriate to consider what its likely impact will be on climate change, and conversely, what the impacts of climate change are likely to be on urban Asia.

5.1 Production and Consumption in Asian Cities: Its Impact on Climate Change

Dhakal notes the difficulty in comparing greenhouse emissions of cities, due to different accounting methods, the scope of greenhouse gases accounted for, emission source and even urban definition.[64] From a greenhouse accounting perspective, using point of source accounting methods (currently the main greenhouse gas accounting method, as it aligns with international protocols), the sectors contributing to greenhouse gas emissions growth in Asian cities are: Energy supply, Transport, Buildings, Industry and Waste.

An alternative approach to greenhouse emissions calculations for cities is the consumption approach, which relates a product's emissions to where it is consumed, rather than where it is produced. The following section discusses point of source emissions for Asian cities, however, also notes the disparity within cities, relating to consumption patterns of the wealthy, compared with those of the poor. The insights of both approaches can help policy makers target appropriate greenhouse gas reduction strategies, within their sphere of influence and control.

Energy

Energy consumption in Asia has grown over recent decades, closely mirroring its economic development. Since the 1990's, the energy consumption across Asia has increased significantly, aligned with substantial increases in electricity generation capacity. The primary source of this energy is fossil fuels (with coal being the primary source), in fact over 80%. Nuclear, hydropower and traditional fuels such as wood and animal dung make up the remaining 19.75%, with renewable energy accounting for only 0.25%.[65]

[63] (UN-HABITAT 2008)
[64] (Dhakal 2010)
[65] (UN-HABITAT 2010, 20)

Access to reliable energy supplies is a precursor for development, whether this is to power large factories, or small, self-employed enterprises. There are disparities across the region in regards to access, but urban populations are generally better served than rural. The main issues/barriers to providing electricity to slum areas in Asia relate to: irregular tenure, shared spaces, ill-defined responsibilities for payment and low consumption.[66] Electricity supply to poorer areas is not as reliable as it is to wealthier urban areas. In some cities, therefore, the poor are forced to pay high prices for relatively poor kerosene based lighting, or low quality biomass cooking fuels.[67]

In an attempt to reduce the greenhouse gas intensity of their energy supply, some Asian cities are turning to alternative energy sources (see Box 3). China, for example, had a 20% energy-intensity reduction target by 2010 in its 11th Five-Year Plan. This target was delegated to provincial level (and consequently city level in some cases) to meet specific targets. To help meet the target, cities encouraged the greater penetration of lower emission natural gas to replace the use of coal in commercial and household sectors.[68] The city of Rizhao, also in China has a focused drive on renewable energy, including electricity generation from methane gas from wastewater treatment, livestock dung and straw, solar powered street-lights, solar water heating and cooking devices.[69]

Box 3: A Medium-Sized City Setting the Standard

Nagpur, a medium-sized city of around 2.5 million people in India's Maharashtra state is actively pursuing greenhouse gas reduction initiatives across many fronts, and is seen as a pioneer city in this space. As a member of ICLEI – Local Governments for Sustainability, Nagpur is a signatory city to the carBonn Cities Climate Registry. Through this registry, Nagpur has committed to report its GHG reduction commitments, GHG emissions inventories and climate mitigation/adaptation actions.

Local Renewables

Nagpur was selected as one of the original Indian model communities under the Local Renewables project of ICLEI. Actions under taken in Nagpur under the project:

1. Preparation of a city energy report 2005-06 - The collection of energy consumption data in Nagpur enabled the city to plot trends in their usage of energy. The percentages of various sectors and various fuels used in the city were identified. This identification of energy consumption in different sectors of the city helped Nagpur formulate a course of action to reduce future consumption and meet targets.
2. Development of a Renewable Energy and Energy Efficiency policy document for Nagpur city. This policy was followed by the formation of a five-year action plan, which outlined ways in which Nagpur could achieve the targets set out in the city level RE-EE policy within the defined time span of five years.
3. In addition to this general policy, Nagpur also formulated a specific policy mandating the use of solar water heaters in residential and commercial construction and offering a 10% property tax rebate as an incentive for building owners to install solar water heaters. This amendment to Nagpur's byelaws became operational in January 2008.
4. Establishment of a Nagpur Renewable Energy and Energy Efficiency Resource Center (REEERC)
5. Short term projects in Nagpur - Energy audit of the NMC building complex in 2007, Solar Water Heater in a public hospital in Nagpur in 2007, Solar PV in the Nagpur Resource Center in 2008, Solar powered lights in the NMC premises in 2008, EE lighting in an NMC girls' school in 2010, and awareness raising activities. Apart from this many long term projects have also been undertaken.

Solar city

The Indian Solar Cities program was launched in 2008 by the Ministry of New and Renewable Energy,

[66] (UN-HABITAT 2010, 152)
[67] (UN-HABITAT 2010, 16)
[68] (IEA 2008, 192)
[69] (UN-HABITAT 2010, 191)

Government of India. Nagpur is one of the first cities chosen to be a Solar City to establish and implement plans for energy saving, energy efficiency and using renewable energy. Nagpur was selected by the Government of India in 2009 in the initial stages of the Solar Cities program to be developed as a '**Model Solar City'**, where the recommendations in the master plan will be implemented in order to serve as a best practice example for other cities to emulate. The target to be achieved under this project is 10% reduction in conventional energy consumption through adoption of renewable energy and energy efficiency measures.

Source: www.iclei.org

Transport

The World Bank estimates that in urban metropolitan areas, transportation accounts for one third of greenhouse gas emissions.[70] It is also a major contributor to urban air pollution, which is a significant problem in many Asian cities such as Phnom Penh, Bangkok and Jakarta. Emissions stem from increasing road freight transport, fossil-fuel powered public transport systems, rapidly increasing numbers of motor vehicles, old, poorly maintained vehicles, and in some cities, old style "two-stroke" cycles. The issue is likely to be further exacerbated in developing Asia, as there is a strong association between rising income and car use in developing countries.[71] In New Delhi, vehicle registrations increased at an average annual rate of 6.7% between 1991 and 2001, and in Chiang Mai, the number of registered passenger vehicles increased 20-fold between 1970 and 2000, but the population only doubled.[72] Across many Asian cities, as their overall wealth grows, there is a growing share of individual motorisation (whether by car or by motorcycles/mopeds), when compared with public transport use (which leads to higher greenhouse gas emissions).

Some cities in Asia have well functioning bus, skytrain and underground systems, such as Bangkok's skytrain and Hong Kong's MTR, with adequate capacity. Many Asian cities, however, rely on older bus services for public transport, that don't meet the capacity needs of the growing population. These are often poorly maintained, older-style diesel buses that contribute significantly to both greenhouse gas emissions, and urban air pollution.

The area of transport emissions is one where there is an obvious disparity between the emissions generated by the poor, and those generated by the wealthy within a city. The growing middle classes in Asian cities are opting for privatised road transport, adding significantly to greenhouse gas emissions, and congestion troubles in cities (that interrupt the functioning of public bus systems). Access to well functioning rail and modern rapid bus transit systems is often too expensive for the poor, and even the cost of a commute on an older style bus system to and from work across the city substantially eats into the daily income earned. Municipal governments in Asian cities to date have not placed a high priority on pedestrian or cycle transport (the least-cost option for the poor), preferring to focus on motorised road transport instead. Those cities, such as Ho Chi Minh, that used to have high cycle use and cycle lanes (freely accessible to the poor), are slowly being transformed into motorised vehicle roads. Many paved roads in Indonesian cities don't even have footpaths.[73]

As congestion increases on the roads, it also takes longer for goods to be transported to destinations within and across the city. This adds further to the greenhouse gas emission profile from transport, as trucks idle in traffic, as well as adding to the cost of goods, further impacting on the poor.

[70] (The World Bank 2006, 4)
[71] (UN-HABITAT 2011)
[72] (Lebel, et al. 2007, 64)
[73] (UN-HABITAT 2010)

Some Asian cities are tackling their transport emissions, however. In China, cities like Chengdu and Suzhou have encouraged the use of electric bicycles. These low energy forms of transport are replacing traditional motorcycles and mopeds, with reduced greenhouse emissions and reduced tailpipe exhaust emissions. Delhi in India, identified that significant transport emissions in the city were due to old diesel buses. These have now undertaken a process of conversion to compressed natural gas, significantly reducing not only greenhouse emissions, but tailpipe polluting emissions as well. Further, they have introduced hybrid rickshaws, which are powered by solar-generated electricity, produced at a dedicated facility within Delhi[74]. To limit the number of cars on its roads, Singapore instituted the Certificate of Entitlement in the early 1990's. Essentially, residents must bid for the right to own a motor vehicle.[75]

Buildings

Buildings contribute to greenhouse gas emissions in two ways: in their construction (through the embodied energy in construction materials), and through their lifetime use. It is estimated that 80% of a buildings' emissions are related to its lifetime use, which relates to its design, and the behaviour of its inhabitants. This is why the International Energy Agency believes that energy-efficiency standards in buildings could reduce greenhouse gas emissions across the globe by as much as 11%, when compared with a business as usual scenario.[76]

A significant construction material for commercial and residential buildings across most of Asia is concrete (it is durable, does not warp or rot in the humidity, and is relatively inexpensive), except in informal settlements, where construction materials are more varied. Concrete has high embodied energy, due to the manufacturing process. Increasing construction of high-rise commercial and residential buildings within Asian cities is anticipated to continue, and with it, the continued use of concrete.

The design of domestic and commercial buildings, to suit the particular climate and environment, can influence emissions during the life of the building related to heating, cooling and lighting. For example, buildings with large numbers of uncovered windows facing the sun during the hottest part of the day add to air-conditioning requirements, and greenhouse gas emissions. The affluent in Asia's hotter cities are adding to emissions by installing air-conditioning. In China's urban areas for example, most housing units have their own air-conditioning units.[77] In Indonesia, air-conditioner sales tripled between 1988 and 2000.[78]

Within buildings, greenhouse gas use relates to heating, cooling, lighting, appliance and office equipment use. As Asian city residents become more affluent, they are purchasing more energy-using equipment including TVs (multiple TV's sometimes), microwaves, mobile phones, computers, kitchen appliances, electronic games and toys and so forth. In Japan, TV ownership has increased from just over an average of 1 per household in 1970, to just under 2.5 per household in 2004.[79] While in China, rural China averages 0.75 TV's per household, while the urban areas average 1.33 TV's per household.[80]

The emissions from the use of these products can be reduced by a) changing the energy supply mix to less greenhouse intensive sources, b) introducing efficiency labelling and standards, and

[74] (UN-HABITAT 2010)
[75] (The World Bank 2000)
[76] (UN-HABITAT 2010, 21)
[77] (UN-HABITAT 2010)
[78] (Egan 1999)
[79] (Harrington, Jones and Harrison 2006, 3)
[80] (Harrington, Jones and Harrison 2006, 4)

perhaps most importantly, c) targeting consumer behaviour. In Malaysia and parts of India, central governments have placed varying forms of bans or phase-outs of incandescent light bulbs, to favour more energy-conserving LEDs and compact fluorescent lights.[81] Both the Philippines and Thailand have energy-efficiency labelling and standards programs in place for domestic appliances.[82]

Industry

Asia and its cities are currently referred to as the "the factory of the world", as they represent the world's manufacturing centre.[83] As developed countries move to tertiary industries, developing countries in Asia pick up the manufacturing mantel. Direct investment from foreign multi-nationals has allowed for the relatively inexpensive expansion of production facilities in Asian cities. For example, Bangkok in Thailand has become an auto production and export hub, emerging in 2005 as the largest hub for automobile production in South East Asia.[84] From a greenhouse accounting perspective, using point of source accounting methods, this manufacturing and production focus exponentially increases the greenhouse gas emissions associated with Asian cities, as many industrial processes are energy-intensive.

From food processing and electronic components to footwear and textiles, cities across Asia are consuming vast amounts of energy, and emitting greenhouse gases to facilitate economic development for their regions. Cities have a role to play in regulating for environmental standards in industrial production, in attracting "green" industries, and encouraging energy efficiency and reduced energy-intensity production. The United Nations Environment Programme Geriap Project using the "Energy Efficiency Guide for Industry in Asia" has worked with numerous industries across Thailand, the Philippines, Indonesia, China, Viet Nam and Sri Lanka to reduce their greenhouse emissions.[85]

Waste

Greenhouse emissions from waste stem from the volume of waste, and the waste management method employed. In Asian cities, waste volumes are increasing with increasing affluence of cities' middle classes. Generally speaking however, the urban poor in Asia generate less waste. This is due to consuming fewer "non-food" items, and the tendency to re-use and recycle a greater percentage of their waste.

Municipal authorities are generally responsible for waste collection and management (even if this is contracted out to private entities), so can strongly influence the waste management component of greenhouse emissions. Unfortunately, the predominant disposal method for waste in Asian cities is still open dumping,[86] and in cities such as Jakarta, open burning of domestic and industrial waste is common.[87] Additionally, the slum areas of cities are poorly supplied with waste collection services, thus the rubbish is left to gather in canals, along roadways and in open ditches.

The urban poor can however, play a significant role in waste management in many Asian cities. Extremely poor families sift through rubbish and retrieve reusable and recyclable items such as bottles and cans, and sell them to recycling facilities. In some cities, NGOs and community organisations have established profitable recycling groups, such as the Linis Grande (clean and beautiful) project in metropolitan Manila. In Hanoi, waste pickers collected and sold 18 to 22% of

[81] (Greenpeace International 2009, Malaysian National News Agency 2011)
[82] (Egan 1999)
[83] (UN-HABITAT 2010)
[84] (UN-HABITAT 2010, 83)
[85] (UNEP 2006)
[86] (UN-HABITAT 2010, 20)
[87] (Gawler 2011)

solid waste, while in Delhi, the figure is about 12 – 15%.[88] This significantly reduces the volume of waste to landfill, directly reducing greenhouse gas emissions.

A further management option for Asian cities is to capture methane from landfill, and convert this to energy. Quezon City in the Philippines used Clean Development Mechanism financing to help establish a waste to energy facility.[89]

A strong element of any urban waste management strategy is behaviour change: teaching the community to "reduce", "reuse" and "recycle", then ensuring there are facilities in place to deal correctly with different streams of waste.

As can be seen, quoting average figures for greenhouse gas per capita in Asian cities hides the disparity between the wealthy and the poor, as the consumption patterns of the wealthy are adding to a city's emissions at a much higher rate than the consumption patterns of the poor. By targeting the energy supply mix, building stock and operation, transport, production processes of industry and waste sectors, as well as targeting the behaviour of affluent consumers in cities, policy makers at both the national and local level can significantly mitigate greenhouse gas emissions from urban areas.

5.2 Impacts and Vulnerability

Studies suggest[90] urban Asia is highly vulnerable to the impacts of climate change. Changes in local climate have already been observed, including increased intensity of storm and cyclone activity, more frequent rainfall events, but with the number of rainy days and volume of precipitation decreasing, and longer duration of heat waves in many countries.[91] For example, China has experienced a gradual warming over the past 50 years, and while the North-East and North of the country have seen a decline in precipitation in the last decade, there has been an increase in the West and along the South-East coast. Bangladesh has experienced an increase in temperature of about 1°C in May and 0.5°C in November for the period 1985 – 1998; Sri Lanka has seen an increasing trend in February precipitation, but a decrease in June precipitation, while the Philippines has observed an increase in annual average rainfall in the last three decades.[92]

Asia has a significant proportion of its urban population located in coastal areas, more vulnerable to a range of climate change impacts.[93] Generally, they are cities that are growing at a significant rate[94] and experience many of the challenges of rapidly urbanising centres. That is, they have a large proportion of informal settlements, the provision of municipal services, such as water supply, sanitation and waste services is stretched, and their planning structures are more oriented to short-term priorities rather than long-term considerations. While the capacity of municipal staff to consider long-range planning and integrating climate change into their planning is improving, it is currently limited, they lack resources, and governance in some cities needs to be strengthened.

Regional Climate Models, using IPCC generated scenarios, with a variety of additional regional data and socio-economic conditions included, have projected significant climatic changes, and the consequential impacts for many cities in Asia. While the IPCC scenarios and projections, and the methodology of downscaling global and regional climate data to cities produces very imprecise

[88] (UN-HABITAT 2010, 150)
[89] (Sabater 2009)
[90] (WWF 2010), (Yusuf and Francisco 2009)
[91] (Cruz, et al. 2007)
[92] (Cruz, et al. 2007)
[93] (McGranahan, Balk and Anderson 2007)
[94] (UN Dept of Economic and Social Affairs, Population Division 2009)

information, it can suggest trends to be considered, if not predictive thresholds. Coastal cities such as Dhaka in Bangladesh, Jakarta in Indonesia, Manila in the Philippines and Kolkata in India are particularly vulnerable. This is due to a combined function of their exposure to multiple impacts such as sea level rise, river flooding and tropical storms (all already experience severe flooding), the degree of impact predominantly due to the significant size of the cities, and their relatively low perceived adaptive capacity.[95] For many cities in Asia, their perceived urgent climate adaptation need relates to flooding (whether this be caused by sea level rise, storm events or increased precipitation), and weather related disaster preparedness, as this is something they are already experiencing.[96] However, other impacts are expected, including drought and heat waves. Each of these impacts has an interconnected range of impacts on health and livelihoods in Asian cities. The following section highlights some of the impacts identified for selected mega-cities in Asia.

Flooding – from Increased Precipitation, Storm Surges and Severe Weather Events
Cities participating in the Asian Cities Climate Change Resilience Network (ACCCRN), and also the Asia-Pacific Network for Global Change Research (APN) have overwhelmingly identified flooding and associated water related issues as their priority area for adaptive action in the short term.[97] For many, this is predominantly related to their recent and ongoing exposure to significant flooding events, for example, Mumbai (2005), Jakarta (2007), Can Tho (2010), Bangkok (2010), Ho Chi Minh City (annually) and Manila (2009).

One of the direct contributors to vulnerability to flooding is related to the cities' actual location: that is, on the coast, riverbanks and river deltas, or a combination of these.[98] Cities such as Kolkata (India), Dhaka (Bangladesh), Bangkok (Thailand), Ho Chi Minh City (Viet Nam) are all highly exposed to flooding due to this combination. Dhaka for example, is situated not far from the coast, a river delta, and between four flood-prone rivers[99]. For some, this exposure is further compounded by subsidence, with cities such as Bangkok, Shanghai, Kolkata and Manila all exhibiting extensive subsidence[100] in recent decades.[101] Exposure to flooding is further exacerbated by man-made alterations to the environment, such as increasing the coverage of impervious surfaces, which reduces the ability of the water to be naturally absorbed by the earth and flow to natural absorption areas and also increases the peak level and speed of water flows. Impervious surfaces also assist with funnelling water to low lying areas, further compounding flooding in these areas. Removal of mangroves and filling in and building over wetlands reduces the city's protection from tidal floods, and increases exposure. For some cities, upstream extraction of ground water is affecting the issue of subsidence as in Bangkok, and the alteration of river flows due to upstream dams also reduces silt loads, again contributing to the problem of subsidence,[102] thus adding to their exposure to floods, particularly related to sea level rise.

Those living in the informal settlements of Asian cities prone to flooding are particularly exposed, as these settlements are generally on marginal, lower-lying land. They have poor infrastructure to quickly drain excess water, so are therefore prone to water logging lasting for several days, even weeks following significant rain events and storms. The slum areas of Dhaka, for example, are

[95] (WWF 2010)
[96] (Moench 2011), (Tyler, et al. 2010)
[97] (Tyler, et al. 2010), (Snidvongs 2009)
[98] (McGranahan, Balk and Anderson 2007)
[99] (UN-HABITAT 2008), (WWF 2010)
[100] Subsidence relates to the gradual "sinking" of cities' infrastructure, which can be caused by withdrawal of ground water (both within and outside the boundaries of the city), the weight of development, and sea level rise altering water table levels. Refer to the Glossary for further information.
[101] (WWF 2010)
[102] (Snidvongs 2009), (WWF 2010)

located on low-lying land, prone to frequent flooding, with poor infrastructure provision.[103] The rubbish build-up in slum areas adds to the inability of water to drain out of flood-affected areas efficiently.

Many of the mega-cities of Asia are the economic hubs of their countries, Ho Chi Minh City (accounting for 20% of Viet Nam's GDP in 2005), Bangkok (representing 44% of Thailand's GDP), Manila (32% of GDP for the Philippines in 2007) and also global economic hubs, such as Shanghai, which is rabidly becoming a global financial capital, as well as being the world's largest cargo port.[104] As economic hubs, they attract and concentrate a significant population. Manila's average population density is 18,000 persons per sq km,[105] while Shanghai's is 74,600 per sq km.[106] These two factors combined increase a city's sensitivity to the impacts of climate change, as an interruption to the economic activity of the city has significant impacts on the country as a whole, and the number of people potentially impacted by a localised event is increased. For example, the tropical storm Bilis that impacted Shanghai in 2006 caused 3.4million people to be relocated, and damaged or destroyed over 900,000 homes.[107]

The incidence of flooding in Asian cities has immediate impacts on infrastructure, city systems and people, as well as delayed and indirect impacts. There can be immediate destruction of and damage to buildings, particularly those in poor or slum areas that are built of inferior materials, damage to road and rail networks, and damage to drainage, sanitation and water supply infrastructure. Energy and communications systems can also be directly impacted. Previous flash floods in Ho Chi Minh City for example, have destroyed entire sections of the city, and the Dhaka floods of 1988 inundated 85% of the city, impacting livelihoods, air travel and communications for several weeks[108].

The inability to access work and earn a daily income during such events is a significant impact on urban populations, especially poorer populations. For the poor, their place of work may be in close proximity to their home (local trading, or small factory worker). In this case, their place of employment is likely to be disrupted by the flooding inundating the slum area. Alternatively, if the workers have to commute long distances to their place of work, then disruptions to transport routes also make attending work difficult. As these workers generally rely on a daily income, loss of a single day can have significant impact on their income and livelihood. In addition, there is the immediate loss of life and injury to people caught in flood waters, or in the path of crumbling infrastructure.

Delayed or indirect impacts can be compounded by many factors, such as the ability of the affected systems to return to normal functioning quickly, and the capacity of city officials and the population to avoid or adapt to impact areas. The health impacts on urban populations are significant, and generally unequally distributed, with poorer populations drastically more affected.[109] Flooding of urban areas can compromise city water supply systems, through contamination by sewerage and debris, or by salt-water inundation if the flooding event was the result of a storm surge. This can lead to a range of water-borne diseases, increasing urban population mortality and morbidity rates following a flood event. Low and middle-income countries have reported an increase in such diseases as cholera and typhoid fever following flood

[103] (UN-HABITAT 2008), (WWF 2010)
[104] (WWF 2010)
[105] (WWF 2010)
[106] (de Sherbinin, Schiller and Pulsipher 2009)
[107] (WWF 2010)
[108] (Alam and Rabbani 2009)
[109] (Bartlett 2008), (Kovats and Akhtar 2009)

events,[110] and Bartlett notes that diarrhoeal illnesses caused by the contamination of piped water supplies and breakdown of sanitation systems can lead to a greater loss of life than the initial event.[111] After the Mumbai flood of 2005, the prevalence of leptospirosis[112] increased 8-fold[113]. As flood water pools and stagnates, particularly in those Asian cities where temperatures are generally high, the ongoing health impacts of vector-borne diseases such as malaria are increased[114]. For the poor, these health impacts are magnified, due to living in close-proximity to open drain and sewer systems, in areas that are likely to remain water-logged for longer, and being comparatively less well-serviced by health care.

If flooding extends to the agricultural land surrounding a city, impacts are extended through disruptions to the food supply to the city, and potential transfer of contaminants into water storage and transmission systems. Urban centres in Asia generally rely on the peri-urban and hinterland, as well as imports from other countries for food. They do not produce food themselves (except for some small urban gardens). Any disruption to food supplies in the area (through flood, drought or other event), can lead to food shortages, and rises in prices. For the poor in Asian cities, this is a significant impact. The share of food expenditure (out of total expenditure) for many urban poor can represent a significant proportion of their household expenditure, for example, 53% for urban Indonesians in 2002[115].

Adaptive capacity to flooding across Asian cities is varied, but many urbanisation actions already undertaken by some cities are actually limiting their future adaptive capacity, or leading to "maladaptation" to floods. Such actions include removal of (or lack of protection of) mangroves and infilling of wetlands and delta floodplain land for development (as in Dhaka, Bangkok, Manila and Kolkata[116]). Unplanned development and expansion into adjacent agricultural land (or sprawl) that does not take account of future flood risks and requirements when considering drainage and other systems contributes to the further vulnerability of cities. Even where the development is part of an overall master plan, if this has not considered climate change risks (as in the case of Ho Chi Minh City and Manila[117]), then there is a high likelihood of maladaptation (see Box 4).

Box 4: Bangkok Flood Protection System – Adaptation for Some, Maladaptation for Others

The concept of maladaptation is an important one to consider when planning adaptation initiatives. The UNDP defines maladaptation as: An action or process that increases vulnerability to climate change-related hazards. Maladaptive actions and processes often include planned development policies and measures that deliver short-term gains or economic benefits but lead to exacerbated vulnerability in the medium to long-term. An action that reduces the vulnerability for one group, may increase the vulnerability of another. Or, poorly planned adaptive measures may provide a short-term decrease in vulnerability, but over the long-term, lead to increased vulnerability.

It has been suggested that the flood protection measures put in place to protect Bangkok, may actually be an example of "maladaptation". Large-scale engineering measures have been constructed in the Thai capital that include a flood embankment surrounding the city, and pumped drainage systems. However, during peak flooding events (as were experienced in 2006, and again in 2010), these systems reduced the

[110] (Kovats and Akhtar 2009)
[111] (Bartlett 2008)
[112] *Leptospirosis: is a bacterial zoonotic disease, commonly transmitted to humans by allowing water that has been contaminated with animal urine to come into contact with breaks in the skin, eyes and mucus membranes (http://www.health.gov.au/internet/main/publishing.nsf/Content/cda-phlncd-leptospirosis.htm)*
[113] (Kovats and Akhtar 2009)
[114] (Kovats and Akhtar 2009)
[115] (Dept. of Agriculture and Fisheries and Forestry 2004, 5)
[116] (WWF 2010)
[117] (Snidvongs 2009)

severity of the impact on Bangkok by allowing agricultural lands outside the embankment and north of the city to flood. It has also been acknowledged, that in the future, the lands outside the embankment are likely to experience significantly worse flooding, partly as a result of the Bangkok flood protection system.

Complicated bureaucracy and vested interests seem to be exacerbating the problem of finding a solution to ongoing flooding that considers all stakeholders' wellbeing – both inside and outside the city boundaries.

Source: World Bank, Climate Risk and Adaptation in Asian Coastal Megacities, Ch3; and Janchitfah, S., Flood Control Planning Awash in Bureaucracy, Bangkok Post, 14/11/2010.

To compound this situation, the capacity of city officials in many Asian cities to undertake the integration of climate change considerations is currently limited,[118] although several initiatives are underway to improve the understanding of the linkages between development planning and climate change. Ho Chi Minh city is building its capacity to understand climate change and its impacts through participation in the ACCCRN project, the APN for Global Change Research and as a member of the C40 Cities initiative. Other Asian cities of Bangkok, Beijing, Delhi, Dhaka, Hanoi, Hong Kong, Jakarta, Mumbai, Shanghai and Tokyo[119] are also members of the C40 Cities initiative, and Jakarta, Bangkok, Shanghai and Mumbai also participate in the APN for Global Change Research.[120]

Access to financial resources is a key indicator of adaptive capacity, and cities such as Dhaka, and Kolkata have limited financial resources, compared with powerhouse cities such as Shanghai, Hong Kong and Singapore.[121] In Bangkok, the Bangkok Metropolitan Administration has planned for ongoing flooding in the city, and has been able to access resources to implement technical measures to mitigate these impacts. Recent infrastructure planning has included the installation of higher banks and pumping stations in the city to assist regulate canals, and water gates have been installed to prevent salt-water intrusion. Additionally, there are plans to grow mangroves to improve coastal storm surge protection, and to mitigate coastal erosion.[122]

An additional consideration of adaptive capacity is the community level understanding of climate change and its impacts. After recent storm events, residents of Manila have a higher understanding of the connection between climate change and city flooding,[123] and Bangkok has implemented community-based emergency response training.[124] However, overall community understanding of broader climate change science and issues is perceived to be quite low.[125]

Drought

Exposure to increasing temperatures across Asia combined with variable and decreased precipitation, particularly when combined with increasing populations, has already led to cities experiencing drought and water shortages, and this trend is projected to continue.[126] The IPCC estimates that minimum monthly flows in the Mekong delta will decrease by 26 – 29%,[127] exposing cities such as Ho Chi Minh City to reduced water access. Cities' exposure to the impacts of drought is made worse by uncontrolled groundwater extraction, increasing use of water by

[118] (Tyler, et al. 2010)
[119] (C40 Cities 2010)
[120] (Snidvongs 2009)
[121] (WWF 2010)
[122] (Panya Consultants Co Ltd 2009), (WWF 2010)
[123] (Snidvongs 2009)
[124] (WWF 2010)
[125] (Tyler, et al. 2010)
[126] (Cruz, et al. 2007)
[127] (Cruz, et al. 2007)

growing industries, contamination of supplies, and in the case of cities in Thailand, Laos, Cambodia and Viet Nam, the altered flow impacts of upstream dams and power schemes in other countries.

The poor in Asian cities are particularly vulnerable, as clean water supply to informal settlements and slums is frequently fragmented, and poorly maintained. With increasing water scarcity during droughts, the price of water increases, and access becomes more challenging, thus increasing the sensitivity of the poor to this issue. The health impacts not only relate to scarce water supply, but also water quality, as extreme low flows can lead to increased chemical and microbiological loads.[128] Additionally, as water supplies decline, the functioning of the sanitation system is also compromised, increasing the risk of water-borne disease impacts, further increasing the hardship for the poor communities.

Drought doesn't only affect the water supply for a city, it also impacts the energy supply for cities dependent on hydroelectric power, such as Manila, and the food security of the city if surrounding agricultural land is also impacted by drought. This then has serious health impacts, particularly relating to malnutrition, and livelihood impacts, as well as the potential vulnerability of the poor to food price increases. Additionally, as successive droughts put pressure on rural communities, rural-to-urban migration increases, thereby further stressing urban systems.

Many of the urbanisation and development initiatives underway in Asian cities will place a further strain on water supplies, thereby leading to potentially more severe or frequent droughts. As urban sanitation and water supply systems are improved, there will be an increase in potable water use, however, few cities combine this development with better localised capture, treatment and re-use of rainwater and storm water. Effective maintenance of water supply pipes and systems is required to reduce leakage and water lost from the system, but many cities do not have the resources to implement significant maintenance schedules.

Heat Waves and Urban Heat Island Effect

Cities across Asia have observed a trend of increasing temperature over the last decade, which is projected to continue.[129] Cities in South Asia and South East Asia particularly are already exposed to high daytime temperatures. The built environment of concrete, heat-absorbing surfaces, heat generating equipment such as cars and machinery all contribute to the urban heat island effect, where cities can be as much as 10°C warmer than their rural surrounds.[130]

Kovats notes "heat is an environmental and occupational hazard."[131] Although individuals in Asian cities may be more physiologically, behaviourally and culturally acclimatised to hotter temperatures than individuals in northern Europe or America, their tolerance for extremes is limited. The elderly, very young, or ill are particularly sensitive to these extremes. The poor who work in occupations that require them to be outside, such as labourers, rickshaw drivers or street vendors are unable to shield themselves from heat waves. Their adaptation mechanism may be to work slower, or take more frequent breaks. This can in turn affect their income generation and livelihood.

A further health consideration is that increased temperatures shorten the development period for malaria and dengue fever carrying mosquitoes, significantly increasing the risk of increased

[128] (Kovats and Akhtar 2009)
[129] (Cruz, et al. 2007)
[130] (OECD 2010)
[131] (Kovats and Akhtar 2009, 165)

exposure for humans.[132] The poor who cannot seal their homes against mosquitoes or afford the luxury of personal repellent or mosquito nets are particularly exposed.

Extended periods of extreme heat can affect other systems such as power transmission lines, transport systems, communications and water supply systems and put a further strain on health services. In cities such as Melbourne and Sydney (Australia), where there is a growing reliance on air-conditioners in private homes during summer, extended periods of hot weather induce spikes in the electricity demand, which can cause blackouts across the city. An interruption to the power supply can then have flow on, indirect impacts to a multitude of other interconnected systems across the city.

The urban heat island effect also contributes to poor air quality, a significant issue in Bangkok, Jakarta, Mumbai and many other Asian mega-cities. This includes particulate matter and pollutant concentration, as well as the distribution of allergens. The urban poor are particularly exposed, as they cannot retreat to sealed, air-conditioned offices and homes, where pollutant exposure is reduced. Urban street traders, rickshaw drivers and construction workers are continually exposed to poor air quality.

Many Asian cities have recognised the risk of heat waves and urban heat islands, and have developed initiatives to counter these. Jakarta has a strategy to increase green-spaces across the city, including the planting and regeneration of mangroves in the North of the city; Bangkok similarly has a program of mangrove regeneration underway, and Shanghai is trialling a heat/health warning system.[133] A community level response to increasing urban heat islands, is to install more air conditioners. This is often cited as a common “maladaptive” measure, as while it decreases the vulnerability of some to the impacts of climate change, over time, the cumulative effect is to increase greenhouse gas emissions, and increase the effects of global warming.

The combined effect of increasing urbanisation and climate change are likely to exacerbate many existing challenges in urban Asia. The following sections consider some of these challenges in relation to two mega-cites in Asia; Mumbai and Jakarta.

6. FOCUS: MUMBAI AND JAKARTA

Two Asian mega-cities that are likely to experience significant impacts of climate change are Mumbai in India, and Jakarta in Indonesia. Yusuf and Francisco[134] list Jakarta as the most vulnerable region in Southeast Asia. The criteria for selection of cities for the focus of this section of the report were: their exposure to multiple impacts, the population living in informal settlements, the access and availability of information relating to their vulnerability to climate changes, and the access to local knowledge of the policy and city situation.

Both Mumbai and Jakarta are exposed to serious flooding, severe storms, drought, urban heat island effect and heat waves, along with the associated direct and indirect impacts of these conditions on city service provision, health and livelihood. Each city has a significant population living in poverty, in informal or slum settlements. For Mumbai, approximately 6.9 million[135] people are believed to live in slums. For Jakarta, official census figures suggest 700,000 people

[132] (Kovats and Akhtar 2009)
[133] (Kovats and Akhtar 2009)
[134] (Yusuf and Francisco 2009)
[135] (Municipal Corporation of Greater Mumbai 2009)

are poor, or "near poor"[136], while unofficial figures suggest that the coastal slum areas of North Jakarta have a slum population of 1.2m[137, 138]

Studies for Asian mega-cities relating directly to a variety of climate change impacts are scarce. Some studies are in the process of being finalised (such as a World Bank study looking at the vulnerability of people to climate change in Kolkata), and technical studies concentrating on the range of potential future impacts, incorporating downscaled modelling and some hydrological analysis have been undertaken. However, studies that actually spoke to urban populations have not been undertaken. We found all studies were related to an existing problem or issue, with the future nature of that issue being considered in relation to future climate change. Predictably, the most pressing issues that were then researched related to disaster risk reduction; specifically flooding. In the case of both Jakarta and Mumbai, the cities experience annual flooding, but serious flooding incidents in 2007 for Jakarta, and 2005 for Mumbai, compelled follow-up research to be undertaken (see Appendix 3 for list of Jakarta and Mumbai studies reviewed).

Finally, ICLEI – Local Governments for Sustainability has a South Asian office based in Delhi that could facilitate local research and policy access and review in India, which narrowed the field of candidate cities. Additionally, recent work by ICLEI Oceania in Indonesia enabled local researchers to be engaged to assist with locating and analysing field-based research papers (many in Bahasa Indonesia), and reviewing the local policy situation.

Thus, the final cities chosen to investigate through field-based studies were Mumbai and Jakarta. The following tables outline the geographic, environmental, socio-economic and political situation of each of the cities. Section 7 presents a review of key national, regional and local city policies relevant to climate change, Section 8 investigates the two cities' contribution to climate change, while Section 9 considers the specific impacts of climate change that the two cities are likely to face, particular vulnerabilities and their adaptive capacities, based on field studies undertaken in each of the cities.

Table 2: Attributes of Mumbai

Attributes	Mumbai
Geography	Situated on the West coast of India, at the mouth of the Ulhas River, a low lying promontory called Salsette Island, formed from connecting 11 islands, with an area of approximately 437.7 square km. Bordered on three sides by water: The Arabian Sea to the West and South, the Harbour Bay and Thane Creek in the East. Greater Mumbai is represented by the Mumbai City District – 67.7sq km, and the Mumbai Suburban district – 370 sq km.[139] (the area under the control of the Municipal Corporation of Greater Mumbai). An additional 4,355 sq km make up the Mumbai Municipal Region (MMR). Much of the city is close to sea level; It consists of coastal mud flats, swamps and mangroves; A natural harbour and salt pans in the East, hills and beaches in the West. Three lakes are within the city limits, and three small rivers run through the city.

[136] (Firman, et al. 2010)
[137] (WWF 2010, 14)
[138] The poverty line in Jakarta is a combination of Food Poverty and Non-Food poverty. For 2010, the combined monthly poverty line was 331,169Rp per capita. (BPS: Statistics Indonesia, 2010)
The poverty line in Mumbai in 2009 was Rs. 594 per capita per month (Mumbai Human Development Report, Municipal Corporation of Greater Mumbai, 2009)
[139] (Pacific Disaster Centre 2005, 8), (Municipal Corporation of Greater Mumbai 2009, 7)

Population	The 2001 census counted the population of Greater Mumbai as 11.9 million, it is now estimated to be 13.9, and 20[140] to 21 million for the Mumbai Metropolitan Region;[141]	
Population Density	At the 2001 census, estimated to be 27,200 people per square km. (with a variance of some wards having a population density of 9,400 people per sq km, and some having over 110,000 people per sq km.[142]	
% Living in Informal Settlements	The 2001 census indicated 6.9 million, or approximately 57% living in slums. [143]	
Water & Sanitation Coverage	92% of **non-slum** population have piped water to homes; 5.3% have individual access in slums, and with the remaining slum population having a variety of shared and/or public access points.[144] There is a network of Storm Water Drains that drain into rivers and the Arabian sea. This network is between 70 to 100 years old, and is only capable of handling 24 mm per hour at low tide. In practice, this system often carries sewage and septic tank overflow. The Municipal Corporation operates an underground sewage network for the city, with a system of Sewerage Treatment plants.	
Public Transportation	The Mumbai Suburban Railway comprises three separate networks covering Mumbai city to the suburbs. An extensive bus system run by an autonomous authority of the Municipal Corporation. Taxis and rickshaws are common.	
Economic Significance of the City	Mumbai represents: 33% of income tax collection in India, 60% of Customs Duty, 40% of Foreign Trade. [145] In 2005, the GDP of the city represented approximately USD 126 billion[146]	
Main Economic Activity	The services sector generates 74% of income – including finance/banking, electronic servicing/IT/software, entertainment (including TVs and movies). A high percentage of employment is in either City, State or Federal government departments. Only 37% of the population are employed in the "formal" sector.	
Political Structure	India is a democratic republic, with a federal structure, divided into 28 states, 6 union territories and the National Capital Territory of Delhi. Land use, regulation and development fall within the jurisdiction of both city administrations and state governments. The Municipal Corporation of Greater Mumbai governs the area of greater Mumbai. Locally elected municipal councillors, across 6 administrative zones and 24 wards.	
City Service Responsibility	Medical services Education Transport Electricity Supply Water Supply	Fire Services Garbage Disposal Markets Gardens Engineering projects – i.e.: drainage, roads, street lights
Current Weather and Variability	Tropical climate with high humidity; two main seasons – dry season between November and February, with moderate levels of humidity; and the wet or humid season between March to October, with monsoon rains heaviest between June to	

[140] (UN Dept of Economic and Social Affairs, Population Division 2009)
[141] (City Mayors 2010)
[142] (Municipal Corporation of Greater Mumbai 2009, 32)
[143] (Municipal Corporation of Greater Mumbai 2009, 174)
[144] (Municipal Corporation of Greater Mumbai 2009, 71)
[145] (Municipal Corporation of Greater Mumbai 2009, 41)
[146] (City Mayors 2007)

	September, high humidity and temperatures over 30 °C. Temperatures range from high of 38 °C to 11 °C at night.
Selected Social Indicators	Mumbai has a high percentage of migrants entering the city, predominantly from the rural areas of India, but also some migration from other urban centres. It accounted for over 43% of population growth between 1991 – 2001.[147] Literacy rates in 2001 were 82% for men and 72% for women, however, there was variance across the wards of the city of as low as 58% for women and 69% for men.[148] The maternal mortality rate is lower in Mumbai than the national average for India, but has seen an increase in recent years, from 0.06 in 2001 to 0.63 in 2006.[149] Life Expectancy – for Mumbai, this has been calculated as the "average age at death", which in 2007 was 52.6 years for males, and 58.1 years for females.[150] This is below the national average for India.

Table 3: Attributes of Jakarta

Attributes	Jakarta
Geography	Sits at the mouth of the Ciliwung River, on Jakarta Bay, an inlet of the Java Sea, with an area of 661.52km^2. 13 rivers flow through Jakarta, which sits in a comparatively low, flat basin. Approximately 40% of Jakarta is currently below sea–level[151], particularly the northern areas, while the south is comparatively hilly, but with lake and swamp land.[152] Approximately 85% of the area has been constructed upon.[153]
Population	Approx. 9.2 million[154] to 9.6 million[155] for the Jakarta Special Administrative Region (DKI) area. 24 million [156] to 28 million[157] for broader Jakarta Metropolitan Region Additionally, approximately 2.5 million people commute daily to the city.[158]
Population Density	Estimated 14,400[159] in 2010. Some areas density is estimated to be 20,000 – 30,000 people per sq km.[160]
% Living in Informal Settlements	Estimated 1.2million people in coastal slum communities.[161], yet BPS estimate approximately 312,000 are poor, or below the poverty line.[162] Slum populations equivalent to 416 RW[163], where RW are the Rukun Warga, or local neighbourhoods. The poor are generally located in the North and Eastern areas of Jakarta.[164]
Water & Sanitation	Approximately 60% of the population rely on ground water supplies, due to the

[147] (Municipal Corporation of Greater Mumbai 2009, 35)
[148] (Municipal Corporation of Greater Mumbai 2009, 137)
[149] (Municipal Corporation of Greater Mumbai 2009, 15)
[150] (Municipal Corporation of Greater Mumbai 2009, 115)
[151] (Firman, et al. 2010)
[152] (Asian Disaster Preparedness Center 2010)
[153] (Marschiavelli 2008)
[154] (UN Dept of Economic and Social Affairs, Population Division 2009)
[155] (BPS: Statistics Indonesia 2010)
[156] (City Mayors 2007), (WWF 2010, 13)
[157] (Kusumuwati 2011)
[158] (Firman, et al. 2010)
[159] (BPS: Statistics Indonesia 2010)
[160] (Asian Disaster Preparedness Center 2010), (Kusumuwati 2011)
[161] (WWF 2010)
[162] (BPS: Statistics Indonesia 2010)
[163] (Kusumuwati 2011)
[164] (Firman, et al. 2010)

Coverage	limitations of piped water. [165] However, 50% - 65% of the city's population is reached by the formal water supply system. [166]			
Public Transportation	Public transportation is predominantly by bus, along 10 (of 15) corridors. An underground Mass Rapid Transit (MRT) system is being planned. Taxis and ojeks (motorbikes) are common.			
Economic Significance of the City	In 2005, the GDP of the city represented approximately USD 98billion[167] Financial services contributed approximately 28.6%% of the country's GDP in 2008[168].			
Main Economic Activity	The manufacturing sector is significant, including automotive, electronics, chemicals, mechanical engineering and biomedical sciences. These are located predominantly in the North and East of Jakarta.[169] Trading and tourism also significant.[170] Informal employment in Jakarta Metropolitan Region is approximately 68%.[171]			
Political Structure	Jakarta Special Administrative Region (DKI) consists of 5 municipalities, 44 districts, and 267 sub-districts. (The larger Jakarta Metropolitan Region, or Greater Jakarta adds the West Java and Banten provinces.) Since 2001, Indonesia has been experiencing a process of rapid decentralisation.			
City Service Responsibility	Education Health Environment Public Works Spatial Planning Development Planning Culture	Housing Youth and Sport Investment Cooperation & SME Demography & Population Admin. Statistics	Work Force Food Security Women Empowerment & Child Protection Family Planning & Welfare Library	Transportation Communication Agrarian National Unity Community & Village Development Social Archives [172]
Current Weather and Variability	Jakarta has a tropical climate, with year-round rainfall and high humidity. The heaviest rainfall is from January to February.			
Social Indicators (e.g.: % migration etc)	Key social indicators include life expectation of 75.9 (in 2008), and the human development index of 76.6.[173] In 2005, over 22% of children under five suffered severe malnutrition and under nourishment, which was better than the Indonesian average of 28%.[174] Infant mortality rate in 2005 for Jakarta was 18 deaths per 1000 live births.[175]			

7. THE POLICY CONTEXT

India and Indonesia both operate within a recently decentralised framework of government, where theoretically national level policies and strategies inform regional policies, which then inform and shape local city government policies. It has been noted that policies are often well crafted, but the challenge is in the implementation and enforcement of the policies.

[165] (Government of Republic of Indonesia 2007, 41)
[166] (Bakker, et al. 2006), (Kusumuwati 2011), (National Development Planning Agency, GoI 2007, Annex)
[167] (City Mayors 2007)
[168] (Kusumuwati 2011)
[169] (Asian Disaster Preparedness Center 2010)
[170] (WWF 2010)
[171] (Mulyana 2010)
[172] (Nurhadi 2009)
[173] (Statistics Jakarta 2008)
[174] (National Development Planning Agency, GoI 2007, 19)
[175] (National Development Planning Agency, GoI 2007, 46)

A policy review was undertaken for both India and Indonesia, analysing key policies at the national, regional (where relevant) and local city level. At the national level, policies covered such areas as climate change, water, sanitation, transport, energy, education, poverty reduction, health, environment, forestry, trade, disaster management, air quality, housing and settlements, spatial planning, waste management and drought management. A complete list is included in Appendix 2.

The regional and local level policies reviewed included such areas as green building, energy saving, air pollution, development and greenhouse gas reduction plans, investment and infrastructure, population, tourism, biotechnology, disaster management, water, forest, solar power policies and disaster management plans.

The approach to analysis investigated whether the policy included climate change considerations, specifically if it addressed adaptation or mitigation issues or both. The analysis then went on to consider whether the policy would have a positive, negative or neutral impact on the city's exposure, sensitivity or adaptive capacity to a range of climate change impacts, including sea level rise, flooding, severe storms/cyclones, drought, increased precipitation and heat stress. Overlaid with this was the particular impact on key human development considerations of livelihood, education, health and basic services.

7.1 Indonesia and Jakarta

For Indonesia, several national level policies have been developed that specifically address climate change. These include the *National Action Plan on Climate Change 2007, Indonesia Climate Change Sectoral Roadmap 2009, National Strategy and Action Plan on Urban Air Quality Improvement 2006, Energy Saving Policy 2005, National Energy Policy 2006 and the Spatial Planning Law 2007.* This demonstrates that climate change has definitely become a National agenda item for Indonesia.

Of particular interest, the *National Action Plan on Climate Change* addresses both mitigation and adaptation efforts. It considers areas such as coral reef and mangrove protection and water conservation. Additionally it identifies efforts to reduce greenhouse gas emissions through strengthening the regulatory framework on energy efficiency, air pollution control, and capacity building to encourage Clean Development Mechanism (CDM) projects. Consideration of specific impacts such as sea-level rise is addressed through mangrove preservation, flooding through capacity building for an early warning system, and drought through the establishment of a school for farmers.

The *Indonesia Climate Change Sectoral Roadmap 2009* is an important piece of work, as it establishes a roadmap for mainstreaming climate change issues into national development planning. It establishes goals for both adaptation and mitigation activities for the next 20 years, covering areas such as waste, transportation, industry and water resources.

Other policies, particularly older policies, do not specifically address climate change. These include the *Poverty Reduction Strategy 2004* and the *National Policy and Strategy on Housing and Settlements 2002.* As these strategies are reviewed, Indonesia needs to ensure that climate change considerations will be integrated into them, so that they do not compete with, or contradict the aims of the newly developed climate policies.

Policies such as the *Community Based Water Supply and Environmental Sanitation Policy 2003* do not mention climate change specifically, however, their ultimate impact will be to reduce vulnerability by promoting the active role of the community in all water supply and sanitation

projects, while also encouraging water conservation and solid waste management (thereby reducing emissions).

At the local city level, DKI Jakarta policies reviewed were *Medium Term Development Plan 2007-2012, Spatial Planning Policy 2030 (DRAFT), GHG Emission Reduction (low carbon city) DRAFT 2010, Green Building Policy (DRAFT), Control on Air Pollution (Local Regulation No. 2/2005), Electricity Saving (Governorial Decree No. 73/2008).* All policies specifically addressed climate change, predominantly with the focus on greenhouse gas reduction. The *Green Building Policy* includes a pilot project of retrofitting city hall as a green building.

The new draft *Spatial Planning Policy*, which is still in development includes adaptation measures for flood control, such as a large sea-wall construction and mangrove rehabilitation. On the combined mitigation/adaptation side, it promotes the extension of open green space in the city (which has a current target of 30% green space by 2020). Implementation of this last action will be particularly problematic, as Jakarta currently has less than 10% open space – and it is uncertain where the remaining 20% will be sourced. It is suggested that the majority will be plantings along roadsides, on small plots of vacant government land, and potentially private gardens in new developments. Attendees at the *Climate Resilient Cities Identifying ASEAN Best Practices: Workshop and Exchange, Jakarta, January 2011* thought the Policy was unachievable, and had several concerns with the amount of large infrastructure (such as the proposed sea wall) and further development that was planned on reclaimed land in North Jakarta, which would increase water demand, and concern over relocation of the resident slum population.[176]

While the National and Local level policies appear solid and well crafted, with a growing understanding and integration of climate change, there is concern that the strategies to implement the policies are not being developed, and that enforcement is weak. This review did not analyse the implementation efficacy of each of the policies identified.

Recent work by the Asian Cities Climate Change Resilience Network suggests that the capacity of both city staff in Indonesia, and also the urban poor, to engage in climate change policy issues is not strong. Furthermore, interaction between city officials and NGOs (representing civil society) is not a regular occurrence. For policies to adequately and effectively address the needs of these groups, effective interaction needs to occur.[177]

7.2 India and Mumbai

At the National level in India, several policies have been developed that will potentially have a positive impact on climate change adaptation and mitigation at the city level. These policies include, *National Urban Sanitation Policy, Water Policy 2002, National Urban Transport Policy, National Urban Housing and Habitat Policy/Energy Conservation Building Codes, Energy Policy, National Environment Policy 2006, National Forest Policy, Foreign Trade Policy (2009 – 2014), National Policy on Disaster Management, National Disaster Management Guidelines – Management of Floods, Cyclone Management Guidelines, Drought Management Guidelines, National Agriculture Policy, National Biofuel Policy* but most importantly, the *National Action Plan on Climate Change.*

The National Action Plan on Climate Change (NAPCC) is a significant piece of policy, including eight "missions". These missions, or directions, cover solar energy, energy efficiency, sustainable habitat, water, sustaining the Himalayan ecosystem, "green" India (focus on forests), sustainable

[176](Gawler 2011)
[177](Tyler, et al. 2010)

agriculture and strategic knowledge for climate change. The National Mission on Sustainable Habitat is of particular relevance to cities. It aims to address the need of adapting to future climate change by improving the resilience of infrastructure, building community-based disaster management, and improving awareness of climate change and its impacts. On the mitigation side, it promotes energy efficiency, a modal shift to public transport and recycling of waste. The National Mission on Strategic Knowledge for Climate Change would establish a Climate Science Research Fund, but importantly, aims to analyse the status of socio economic (health, demography, migration patterns, livelihood) impacts of climate change. Cities are currently aligning their programs and budgets with actions under the NAPCC, and accessing both national and international funding to deliver against the outcomes of the missions.

The *National Policy on Disaster Management* and the *Cyclone Management Guidelines* aim to increase the resilience of communities to disasters. Importantly, the *National Policy on Disaster Management* seeks to mainstream disaster management in development planning at all levels of government, drawing on technology, traditional wisdom and environmental sustainability principles.

In India, city level governance can be heavily influenced by state level policies. As the capital of Maharashtra state, Mumbai does have a higher level of autonomy than some cities, but the state policies do still have an impact. The *State Population Policy,* for example, does not mention climate change specifically, but will help to improve the adaptive capacity of slum populations in urban areas by increasing the availability of health services to these areas. A contrary policy, the *Industrial, Investment and Infrastructure Policy 2006* seeks to encourage employment and improve infrastructure. However, it does not discuss the need for infrastructure to be climate resilient, and it focuses on industrialisation to improve employment, which can have a multitude of negative environmental and social impacts if not pursued cautiously.

The state level *Housing Policy* addresses a number of issues that could improve the adaptive capacity of those living in urban slums, by improving infrastructure such as roads, water supply, sanitation, transport and even slum redevelopment. While it does refer to the promotion of environmentally sustainable cities and townships, it does not refer to climate change specifically, which could have negative long-term infrastructure ramifications if not considered.

Given that some of the climate change impacts for Mumbai are related to disasters such as floods and severe storms/cyclones, the *State Disaster Management Plan,* is an important document. It proposes to affect livelihoods by providing early warning systems, improve health and basic services by improving infrastructure, emergency evacuation procedures and providing cyclone shelters as well as improving community preparedness through community education. This management plan is linked to by the *Mumbai Disaster Management Plan.* As well as seeking to improve transport facilities and housing, it applies some very practical considerations by ensuring there are well-trained emergency response personnel, and that there is improved public communication and information systems during the entire disaster management planning cycle

While many of these policies appear to be gaining some traction, and have implementation in place, there is still a perceived lack of engagement with the urban poor who may be affected by these policies, which therefore affects how well they will be received and implemented. Some groups are still marginalized, and are not able to participate in the process, whether this be due to cultural, or educational reasons.

8. PRODUCTION AND CONSUMPTION IN MUMBAI AND JAKARTA

As seen in previous sections, cities can help directly and indirectly shape greenhouse emissions by how they influence consumption in their cities, and production processes. The following section outlines some of the drivers for consumption and production related to greenhouse gas emissions for Mumbai and Jakarta. The two key areas considered are energy supply and transport, as these are both the most significant contributors to greenhouse gas emissions in the cities.

Energy Access and Provision

To encourage development, both India and Jakarta have undergone a process of building energy capacity to be able to provide reliable and efficient access to energy. In Maharashtra state (where Mumbai is located), approximately 95% of households use electricity for lighting in urban areas (which is an indicator of electricity coverage for the area), compared with only 65% for rural areas.[178] Yedla notes that household energy consumption shift, relevant to income, follows the trend of "cheapest and conventional (biomass) → cheaper and efficiency (kerosene) → most costly and efficient (LPG and electricity)". At the household level, the key determinants of energy demand are prices of fuels and appliances, the disposable income of the households, availability of fuels and appliances, cultural and particular requirements.[179]

Nationally, India still relies very heavily on fossil fuels for energy production, with 2005/06 estimates suggesting 53% of total commercial energy supply is derived from coal, and 35% from oil.[180] However, India's National Action Plan on Climate Change is seeking to change this, and increase the percentage of solar energy in the mix. A solar cities program is being conducted across many cities of India, but is targeting cities with populations under 5 million, so excludes Mumbai at this time (refer Box 3). The national Energy Policy also has a focus on lower-emission technologies, such as "clean coal", nuclear and hydro-electricity and renewable energies. How these national strategies are implemented in Maharashtra state will effect the greenhouse gas intensity of electricity supply in Mumbai.

Across Indonesia, electricity usage has grown significantly in the last decade, with 71.7 million MW being supplied by the state energy company in 1999, compared with 134.6 million MW supplied in 2009. In this time, household electricity use has doubled (27.5 million MW to 54.9 million MW), commercial/business use has nearly tripled (9.1 million MW to 24.8 million MW), while industrial emissions have only increased by 50% (31.4 million MW to 46.2 million MW).[181] The primary energy supply for Jakarta (in 2001) was oil, representing 82.2%, while coal represented less than 1% and natural gas approached 17%.[182] National level policies on climate change and the National Energy Policy encourage energy switching through activating the Clean Development Mechanism, and energy diversification, with targets set to achieve less energy intensity in the energy mix. If implemented, these policies will see a reduction in energy intensity in cities like Jakarta.

Most large scale energy generation and supply projects require the investment of the private sector, as well as the Research and Development and innovative technology the sector brings to the area. Through its NAPCC, and other initiatives, India in particular is encouraging the private sector to be engaged in changing India's energy mix.

[178] (Yedla 2010, 35)
[179] (Yedla 2010, 14)
[180] (Kumar , et al. 2009, 4)
[181] (BPS: Statistics Indonesia 2009)
[182] (Marpaung 2008)

Urban Form and Transport

One of the conundrums for urban planners in cities such as Mumbai and Jakarta involves issues of urban density. Well-planned, dense agglomerations can reduce a city's greenhouse gas emissions through effective household energy supply (see above) and compact mass transport systems.[183] However, both Mumbai and Jakarta have the double conundrum of extremely dense inner-city areas, combined with urban sprawl. Average density for Jakarta is 14,400 people per sq km,[184] while Mumbai's population density is over 27,200 people per sq km.[185] Partially as a response to such high densities, workers in both cities are increasingly moving to "suburban" areas, where housing prices are more affordable, but continue to work in the city centre. In Jakarta, 30% of people who are working in Jakarta live in the surrounding suburban areas.[186] This has significant implications for transport systems, and the associated greenhouse gas emissions in these cities.

Neither Jakarta nor Mumbai have adequately planned for rapid urban expansion in terms of transport planning, with both municipalities focusing transport planning efforts on providing newer, wider, faster roads. This emphasis leads to a modal shift towards private, motorised transport, and road freight as opposed to rail freight. Both Jakarta and Mumbai have witnessed significant private vehicle growth rates (See Tables 4 and 5). The shift to private motorised transport favours the affluent in these cities, who can afford to purchase and run a vehicle, and adversely affects the poor. Increased preference for car use on roads in Jakarta for example, has made it extremely difficult and dangerous to get around by cycle or walking (some parts of Jakarta do not even have footpaths). In Mumbai, ongoing road widening "eats into" footpaths, and like Jakarta, these are lined with obstacles such as vendors, potholes etc.

Mumbai and Jakarta are both serviced by mass transport systems, incorporating both rail and bus services. A World Bank survey conducted in 2004 in Mumbai estimated that 22% of trips to work were undertaken by train, 16% by bus, and a significant 47% by foot or bicycle and 11% by private motorised vehicle. For those below a household level Rs5000 (approximately USD89 at May 24 2012 exchange rate) per month poverty line, 61% walked or cycled to work, 16% caught the train, 16% the bus and less than 1% used private motorised transport.[187] This demonstrates the importance of an integrated cycle, walking and mass transport network for Mumbai, to reduce emissions in a pro-poor manner.

Although the Mumbai rail system is known to be fairly punctual, it is dangerously overcrowded (with an estimated 4,000 people dying annually by falling from trains)[188]. New services are added regularly, but they seem to make little difference. Those catching the train in from far suburbs can expect to spend up to four hours on the train commuting each day. Tables 4 and 5 show that the number of registered buses in each city has either remained fairly static (Jakarta) or actually declined (Mumbai), suggesting there has not been an increase in service provision to align with population growth in either city. However, to reduce greenhouse emissions in Mumbai, the bus fleet is being upgraded to run on 10% biodiesel, and compact natural gas, in line with the National Urban Transport Policy.[189]

Jakarta has implemented rapid bus transit corridors, and is investigating a mass rapid transit (MRT) rail line in an attempt to reduce congestion on its roads, improve air quality and reduce

[183] (Dodman, *Urban Form, Greenhouse Gas Emissions and Climate Vulnerability* 2010)
[184] (BPS: Statistics Indonesia 2010)
[185] (Municipal Corporation of Greater Mumbai 2009, 32)
[186] (Lebel, et al. 2007, 66)
[187] (Municipal Corporation of Greater Mumbai 2009, 157)
[188] (Municipal Corporation of Greater Mumbai 2009, 156)
[189] (Municipal Corporation of Greater Mumbai 2009, 155)

emissions. This is in line with the National Climate Change Sectoral Roadmap, but particularly the city's Medium Term Development Plan 2007 – 2012 which encourages the implementation of a rapid, integrated bus system, and development of the MRT system.

Table 4: Number of Registered Motor Vehicles, Jakarta, excl. Army, Police and Diplomatic

Jakarta	2001	2002	2003	2004	2005	2006	2007	2008
Motor cycles	1,813,136	2,257,194	3,316,900	3,940,700	4,647,435	5,310,068	5,974,173	6,765,723
Passenger Vans	1,130,496	1,195,871	1,529,824	1,645,306	1,766,801	1,835,653	1,916,469	2,034,943
Cargo Cars	347,443	366,221	464,748	488,517	499,581	504,727	518,991	538,731
Buses	253,648	254,849	315,652	316,396	316,502	317,050	318,332	308,528
TOTAL	**3,544,723**	**4,074,135**	**5,627,124**	**6,390,919**	**7,230,319**	**7,967,498**	**8,727,965**	**9,647,925**

Source: Statistics Jakarta, http://jakarta.bps.go.id/index_e.html

Table 5: Number of Registered Vehicles in Mumbai

Mumbai	2000	2001	2002	2003	2004	2005	2006	2007
2Wheelers	407,306	440,517	475,352	527,108	584,180	NA	714,209	792,512
3Wheelers	97,565	101,914	104,829	98,527	102,224	NA	104,899	104,862
Cars/jeeps	329,546	344,870	353,417	366,805	384,258	NA	436,213	464,139
Taxis	58,696	62,447	63,679	54,809	56,459	NA	57,383	55,486
Heavy Motor Vehicle/ Buses	82,172	86,837	78,338	79,754	75,567	NA	72,159	77,567
Other	53,980	57,789	55,412	56,130	52,243	NA	8,784	8,879
TOTAL	**1,029,265**	**1,094,374**	**1,131,027**	**1,183,133**	**1,254,931**	**NA**	**1,393,647**	**1,503,445**

Source: Taken from Air Quality Assessment, Emissions Inventory and Source Apportionment Studies: Mumbai Central Pollution Control Board & National Environmental Engineering Research Institute, 2010

9. THE VULNERABILITY OF MUMBAI AND JAKARTA TO THE IMPACTS OF CLIMATE CHANGE

Through reviewing field-based studies[190] undertaken in Mumbai and Jakarta, this section aims to synthesise the understanding of:

- Local challenges to climate change impacts
- Vulnerabilities to climate change
- Existing local adaptation strategies of urban communities
- Impact of the policy framework on vulnerabilities

As with other cities in Asia, the predominant concern of both Mumbai and Jakarta is the risk of flooding, whether by severe storm or cyclone event, sea-level rise or heavy precipitation and river flooding; or even a combination of these. Studies that model future impact of climate change for both cities clearly identify flood as the predominant issue, in the case of Jakarta, this is seen as both a sea-level rise issue, and a river flooding issue; and in Mumbai, it is predominantly concern of future more frequent and intense precipitation events.[191]

[190] Details of field-based studies are recorded in Appendix 3.
[191] (Hallegate, et al. 2010)

Other impacts such as the increasing urban heat island effect and associated heat waves and air quality issues are on the radar for the local governments, but studies have not been undertaken at the community level to investigate attitudes and behaviour in relation to these effects.

The local challenges and vulnerabilities of the research groups will be presented through the lens of their **exposure, sensitivity** and **adaptive capacity** to the impact of flooding. One study from Jakarta explored flooding due to a precipitation event, one looked at flooding due to sea-level rise, and one looked at a range of sea level rise impacts (including flooding) for coastal villages. The three Mumbai studies each explored the 2005 flooding event, but from different perspectives.

For Jakarta, the studies were:
Institute of Essential Services Reform - *Vulnerability Assessment of Jakarta & Java Island (2010)*
Ms. Mone Iye Cornelia Marschiavelii (University of Gadjah Mada, Yogyakarta) - *Vulnerability Assessment and Coping Mechanism related to Floods in Urban Areas: A Community Based Case Study in Kampung Melayu, Jakarta (2008)*
Mr. Awanda Sentosa (University of Indonesia, Jakarta) - *Socio-Economic Aspect of Vulnerability Assessment due to Sea Level Rise in Jakarta (2010)*

For Mumbai, the studies were:
Monalisa Chatterjee - *Resilient Flood Loss Response Systems for Vulnerable Populations in Mumbai: A Neglected Alternative (2010)*
Stephanie Hallegate et al - *Flood Risks, Climate Change Impacts and Adaptation Benefits in Mumbai (2010)*
H. Takano and S. Sammadar - *Floods Risk Reduction in Livelihood Risks: Thoughts and Insights from Mumbai (2010)*

Only one study, the IESR study in Kamal Muara village nominated a target group of fisherman as its focus. The other studies did not nominate particular groups of focus within these areas. That is, they did not particularly study the impact of flooding on women, children, the elderly or a particular ethnic or religious group. Rather, a random selection of households from the geographic location was chosen. Each location, however, **had a significant proportion of poor people living in informal settlements**, so by default this is the demographic focused on.

Further details on each of these studies are presented in **Appendix 3**.

Geographic Exposure of the Research Groups to Flooding
Each of the six study sites was selected by the researchers because of their high level of exposure to flooding, whether caused by sea-level rise or precipitation events. The challenges faced by residents in the study areas included ongoing and projected worsening exposure to flood events from either more intense precipitation events and storms, or sea-level rise. The direct challenge of having to build on low-lying land, often reclaimed land on the banks of water ways added to their exposure. Lack of control over developmental planning decisions that contributed to their exposure such as upstream development along river ways, overdevelopment of natural drainage areas, poor waste management services, which led to rubbish clogging waterways and making exposure to flooding worse, poor drainage planning and maintenance which further compounded impacts of the flooding. As most participants cited being close to their workplace (across the various studies) as a reason for staying in a highly exposed area, inadequate transport systems (requiring residents to be in walking distance of their employment) is another factor that contributes to their exposure, but is out of their direct control. Each of these challenges is explored in relation to the study areas in more detail below.

For Jakarta, the study neighbourhoods are generally in the North, along the coast. The specific villages are, Kamal Muara, (IESR research), Kampung Melayu (Marschiavelli research) and Kamal Muara, Penjaringan and Pluit (Sentosa research). The IESR study modelling estimated that by 2100, sea level rise would likely inundate most of this area, as far as central Jakarta.[192]

For Mumbai, the settlements selected are generally found along the Mithi River. They are the Jari Mari[193] Settlement in L ward, near Chatrapati Shivaji International airport, on the banks of the Mithi River and Prem Nagar in P South ward, next to Malad Creek in Goregaon, (Chatterjee research), settlements in the H East, H West, K East, K West, P South, P North, R South, R North, N, S and T wards in the suburbs of Mumbai (Hallegate research) and three settlements in the Dharavi slum in G North Ward, Prem Nagar, Parsi-chawl and Rajiv Ghandi Nagar (Takano and Sammadar research). Downscaled climate projections are unable to project with any certainty the future exposure change in rainfall events for Mumbai, however there is likely to be an increase in monsoon rains of 10 – 30%, and sea level rise of 1.2mm per annum is likely to continue.[194]

Each of the locations has a relatively low elevation, and is close to a water body, so the population's proximity to the flooding entity increases its vulnerability. Compounding factors, generally of a man-made nature, increase this exposure. The research sites are located in highly built up areas that facilitate the quick run-off of water. In Mumbai for example, Hallegate notes that 40% of the urban storm water previously flowed through open lands, acting as a kind of holding pond. In 2005, only 10% of water flowed through open land. Additionally, all sites nominated the blocking of natural waterways and man-made drains with rubbish as something that exacerbated the rate of flooding during the extreme flood events. Kampung Melayu, for example, noted that there was no longer a rubbish collection service provided by the local government for the area, and that the width of the canal was narrowed significantly.[195]

Some sites were further exposed due to the removal of mangroves and being built on reclaimed land, as is noted in the Chatterjee and Hallegate studies in Mumbai. The studies in Jakarta particularly noted that the encroachment of the houses, right up to the waterway edge also assisted with narrowing the natural drainage system, and compounding the flood effect.[196] It was noted in the Hallegate study, that upstream building along the river catchment increased the speed and volume of water in the river system, therefore compounding the downstream effects.[197]

Leaving these areas and moving to less exposed places was a challenge for many residents. They predominantly selected to live/stay in these areas, because they were in close proximity to their work (or education, or transport to either of these)[198], they had been there a long time (some areas over 20 years) and had a strong social support and connection with the location.[199]

Sensitivity of the Research Groups to Flooding

Sensitivity was not specifically addressed as a separate issue in any of the studies. However, it can be interpreted as the degree the flood affected residents' assets (the impact on their home and belongings), their livelihood (through lost work days and lost income) and their health (through

[192] (Institute of Essential Services Reform 2010)
[193] Note, throughout the Chatterjee research paper, the Jari Mari Settlement is referred to as either Jari Mari, or Jarimari. We have chosen to use the Jari Mari variation for this paper.
[194] (Nair n.d.)
[195] (Marschiavelli 2008)
[196] (Institute of Essential Services Reform 2010), (Marschiavelli 2008)
[197] (Hallegate, et al. 2010)
[198] (Takano and Samaddar 2010), (Hallegate, et al. 2010), (Marschiavelli 2008)
[199] (Takano and Samaddar 2010), (Marschiavelli 2008)

injury and illness). The sensitivity to each of these issues is a factor of several socio-economic conditions. With a higher relative income, residents can reduce their sensitivity to flooding by building multi-level houses, with more sturdy materials such as bricks and concrete, with good storage for possessions. One study suggests insurance may be a preferable option. Multiple sources of income for the household spreads the risk of income loss during flooding events. The challenge of improved health is a combination of factors, such as understanding and awareness of good hygiene practices, and factors outside the residents' control, such as improved waste collection services and water and sanitation services.

In both the Mumbai and Jakarta studies, it was noted that as the areas flooded annually during the monsoon season, there was a fair degree of tolerance for floods, they were "perceived as normal"[200], and they were just "perceived as an inconvenience for the general public."[201] During both the 2005 Mumbai and 2007 Jakarta flood events, however, the impact was higher flood levels combined with longer duration. Houses in the Jari Mari and Prem Nagar settlement in Mumbai were inundated between 6 – 12 ft[202], while the Parsi-Chawl area flooded to approximately a maximum of 9 ft, with the inundation of houses lasting one to one and half days, and Rajiv Ghandi Nagar flood level was higher, (up to 15ft in a small number of cases) and lasted longer.[203] In Kampung Melayu in Jakarta, flood waters reached 5 metres in some places, and lasted up to 15 days.[204]

However, even with such extreme levels of flooding, the residents of Prem Nagar, Parsi-Chawl and Rajiv Ghandi Nagar reported "little" or "no" damage to their houses (39.1%/52.5%, 28.6%/70.9% and 36.5%/57.2% of respondents respectively).[205] Houses in these areas were generally made in the *pucca* style, which is of quite sturdy materials such as brick, concrete and timber, some with multi-levels. Thus, their sensitivity to inundation was less. In Kampung Melayu (Jakarta), there was a significant percentage of residents who had built second levels on their houses, which reduced their sensitivity to flooding.[206]

The Takano study revealed there was a significant loss in durable assets, and in stored food.[207] To replace these, and repair houses, residents either drew on their savings[208] or drew on familial and other networks for finance, which then had to be paid back, or worked off if they were supplied by an employer.[209]

As many slum inhabitants earn a daily wage, any time away from work means no income for that day. In Mumbai, Takano found that an average of between 10 – 30 working days were lost across the three study areas.[210] Similar results were found in Kampung Melayu, where many of the residents worked in the local market that had been inundated, and took several days to be operational again.[211] Fishermen in Kamal Muaru are exposed to high economic losses during

[200] (Marschiavelli 2008, 38)
[201] (Chatterjee 2010, 100)
[202] (Chatterjee 2010)
[203] (Takano and Samaddar 2010)
[204] (Marschiavelli 2008)
[205] (Takano and Samaddar 2010, 113)
[206] (Marschiavelli 2008)
[207] (Takano and Samaddar 2010, 113)
[208] (Hallegate, et al. 2010)
[209] (Chatterjee 2010)
[210] (Takano and Samaddar 2010, 111)
[211] (Marschiavelli 2008)

storm events, when they are unable to go out and fish. To reduce their sensitivity, many are seeking second jobs, as motorbike mechanic for example.[212]

The impact of flood on health and livelihoods can be related to the level of basic services provided to slum areas. Takano's study compared three slum areas in close proximity, with similar average incomes, but each had a significantly different level of service provision. The following Table 6 taken from the study illustrates this. His conclusions were, that the impact on health and livelihoods was less for the residents in Parsi-Chawl, who had a generally higher standard of basic service provision.

Table 6: Service Provision in Dharavi Slum Area

	Prem Nagar	Parsi-Chawl	Rajiv Ghandi Nagar
Water Supply Source			
BMC Supplied water outside the house (shared by 4 to 5 households)	93%	36.9%	78.8%
BMC supplied water inside the house	6.3%	63.1%	20.2%
Buying water supply from outside	1.2%	0%	1%
Total	100%	100%	100%
Sanitation Facility			
Nearby Community Facility	82.3%	20.7%	58.2%
Own Sanitation System	1.7%	79.3%	18.8%
Open Filled Defecation	16.1%	0%	23.1%
TOTAL	100%	100%	100%

Source: Tatano and Sammadar, 2010, p 109.

For the people of Kampung Melayu, in addition to seeing the cause of the flood as heavy rain further upstream, 27% thought garbage was a main contributor to the severity of the flooding[213].

Hallegate's modelling suggests that 1 in 200 year events such as the 2005 Mumbai flood are likely to occur 1 in 90 years under an upper limit climate change scenario, even without the increased urbanisation pressures on the city, and that the frequency of more intense storms in general is likely to increase. This suggests that the vulnerable populations in the study areas of Mumbai will have less time to recover between events, and there will be an accumulated sensitivity of lost assets, work days and savings (as they are ploughed back into more frequent house repairs).

The sensitivity to health impacts is related to injury or death as a direct cause of the flood or extreme storm event, and also illness following the event. To avoid injury or death, residents need to be able to avoid being in the path of the storm or flood. This means having a safe place to go during the event, having early warning of the event, and understanding what is required when an early warning is received. In addition to having early warning, they need to have confidence in the accuracy of that warning. In both Mumbai and Jakarta, residents of the affected areas sought shelter first in their upper house levels, but then with friends and family, or in community provided centres – such as "mosques, schools, government offices and health clinics"[214], as was the case in Kampung Melayu. As floods and storms are a regular occurrence, most areas in both Mumbai and Jakarta have some form of flood warning system. However, it was noted in Kampung Melayu there was mixed levels of confidence in the accuracy of the system.[215] The residents noted also that though they may be given a warning as to the flood level that was

[212] (Institute of Essential Services Reform 2010)
[213] (Marschiavelli 2008, 38)
[214] (Marschiavelli 2008, 39)
[215] (Marschiavelli 2008)

approaching, there was no formalised understanding of what actions should be taken in such an event. It relied on individual's past experience of similar warning levels.[216]

The incidence of disease following an event, particularly water-borne diseases, appears to be high in these studies. This is related to how quickly the water can drain away from the urban area, whether drinking water supplies are contaminated or not, if sanitation and sewage systems were compromised, allowing effluent to flow into streets, houses and water supplies, and the knowledge and understanding of the population of correct health precautions in these situations. The Municipal Corporation of Greater Mumbai was quoted in the Takano Mumbai study, as recording 419 deaths due to flash flooding and landslide, while another 216 were killed due to illness following the flood.[217] Chatterjee quotes Mumbai Metropolitan Region (MMR) authorities as reporting 700 deaths[218], while the Government of Maharashtra reported 447 deaths during the floods, as a result of drowning, landslides, a stampede due to a false tsunami warning, housing collapses and people trapped in vehicles.[219] Chatterjee lists some of the diseases that were reported in the two weeks following the flood, including gastroenteritis, hepatitis, enteric fever, typhoid, malaria, dengue fever and leptospirosis, collectively numbering in the tens of thousands of cases.[220] The IESR study noted there was an outbreak of dengue fever after one flood event in Jakarta in 2008.[221] No studies, however, commented on the adequacy of the health system to treat these cases, or the individual level and understanding of hygiene and health precautions.

Faced with this array of challenges, as a result of their exposure and sensitivity to floods and storm events, residents undertake a selection of measures to shield themselves from the worst impacts. These will be explored in the following section.

Adaptive Capacity

The capacity of residents to adapt to extreme events such as floods and storms is a combination of their own resources, initiatives and socio-cultural networks, as well as the formal structures and processes within which they operate. Things that facilitate adaptive capacity include:

- Education/understanding/knowledge of climate change and future risks;
- Network of support during the event, and recovery after the event;
- Resources to adapt – i.e.: build second storey or move;
- Resources or access to resources to recover from event;
- Formal local government or other frameworks and processes, such as appropriate and well-maintained infrastructure, and effective early warning systems.

One very powerful coping strategy at both the individual and community level is knowledge and understanding. Residents who have lived in the study areas for some time, and have experienced extreme events, are better prepared for future extreme events. They know the hydrology of the floods, which areas will flood worst, what systems will be impacted, therefore how they need to prepare in advance. Sharing these understandings with neighbours, friends and colleagues provides a strong basis for adaptive capacity during events. These studies did not explore in great detail the perception or understanding of the communities to future climate risks in general, other than to glean their perceptions on whether they felt storm events and flooding were becoming more frequent or severe, or what they considered the causes were.

[216] (Marschiavelli 2008)
[217] (Takano and Samaddar 2010, 105)
[218] (Chatterjee 2010, 96)
[219] (Hallegate, et al. 2010, 14)
[220] (Chatterjee 2010, 98)
[221] (Institute of Essential Services Reform 2010)

At the individual level, several measures were undertaken by residents of the study areas to reduce their exposure and sensitivity to extreme events. Many of these were based on the aforementioned knowledge and understanding. Prior to a flood or storm event, residents prepared for the event by altering their physical structures to reduce their exposure and sensitivity to floods such as: building from solid materials such as brick, concrete, timber and so forth; adding extra levels to the house, so that valuable items can be stored upstairs away from flood waters; raising the floor level of existing houses and installing storage at higher levels in the house to remove possessions from harm's way. Residents in one study purchased more durable plastic furniture (rather than timber), as it was easy to move and to clean post a flood event.[222] On the broader community level, residents of Kampung Melayu regularly cleaned the rubbish from the drains and riverbanks prior to the monsoon season to reduce the level of clogging.[223]

Other than the physical structures, residents reduced their sensitivity to impacts by having multiple income sources for the household. This may be through multiple people earning an income, or through one member of the house having a diversified income, for example, as a fisherman and as a motorbike mechanic[224]; or as a recycled factory worker and a small stall operator, or providing a house-cleaning service post the event[225]. Additionally, it was noted by some residents in Kampung Melayu that all children know how to swim from an early age, so if they are caught in flood waters, they have a chance of survival.[226]

During (and in the hours leading up to) the event, behaviour was more specific to the different locations. Sentosa noted that some residents of Kamal Muara, Pluit and Penjaringan increased supplies of food, fuel and water, while others chose to relocate to non-flood prone areas.[227] Other coping strategies included: evacuating early to a community centre (particularly pregnant women, children and the elderly); moving possessions to higher levels of the house, or to neighbours' houses; relocating to family and neighbours on higher ground; placing clothing and other goods in plastic bags. In Kampung Melayu, it was noted that the community facilities were inadequate (poor sanitation and cleanliness), so people preferred to stay in their own houses, or go to family and neighbours.[228] During the Mumbai floods, some workers from the study areas were unable to return home, so stayed at their place of work (in relatively secure, well built buildings), while in Jakarta, pieces of rope were tied along particularly hazardous walkways to reduce the risk of injury to people travelling through fast moving waters.[229] In both Mumbai and Jakarta, residents were however, uncomfortable with leaving their houses and possessions unguarded. They felt they would be robbed or further damaged if they were not there.[230]

Post the flood or storm event, people hired themselves out to clean and repair houses, and communities in Kampung Melayu collectively cleaned the canal and surrounding areas. Chatterjee particularly discusses the financial recovery mechanisms post the Mumbai 2005 flood. This included borrowing from family, friends, neighbours, local banks, self-help associations and employers to finance building repairs and to replace possessions. Chatterjee found that households drew upon an average of five of these mechanisms, whereas Hallegate found participants in their study region mainly used their personal savings to finance repairs and reconstruction.[231]

[222] (Marschiavelli 2008)
[223] (Marschiavelli 2008)
[224] (Sentosa 2010)
[225] (Institute of Essential Services Reform 2010)
[226] (Marschiavelli 2008)
[227] (Sentosa 2010)
[228] (Marschiavelli 2008)
[229] (Marschiavelli 2008)
[230] (Chatterjee 2010), (Marschiavelli 2008)
[231] (Hallegate, et al. 2010)

The capacity to mitigate extreme flood and storm events is not only a function of the individual's capacity, but also of the more formal social and government processes and structures in place. It has already been noted that the local communities perceive many things contribute to the flooding of their areas, which are under the control of government. Thus, adaptive capacity is reduced by: lack of properly planned and enforced land use and urban planning (which allows building on highly exposed areas such as riverbanks, over natural drainage areas, upstream intensive urban development along river ways); the clearing of mangroves and forests; poor provision of basic services such as water supply, sanitation services and waste collection services; poor maintenance of sanitation and water services that may be provided; poor disaster risk reduction planning (i.e. it is not integrated with development planning and does not necessarily take account of rapid urbanisation or climate change).

The local governments in the research areas had undertaken some adaptive measures (although some may be perceived as unpalatable to some of the residents). This included removal of huts along the drains prior to the monsoon season[232], establishment of early warning systems (of varying effectiveness), establishment of public kitchens during events,[233] access to communications (through mobile phones or static lines),[234] and disaster risk reduction strategies in place for some areas. Sentosa noted that the community worked with the government in the Penjaringan sub-district to construct a sea-wall and improve the drainage system.

Chatterjee summarised the adaptive measures taken across Mumbai in response to the 2005 Floods (note these are not necessarily particular to the research areas) in Table 7.

Table 7: Range of Applied Actions in Mumbai

Post Flood Actions				
Immediate			**Recovery and Reconstruction**	
Disaster Preparedness	**Relieve and Rehabilitation**	**Institutional**	**Infrastructure Development**	**Decongesting Mumbai and Restoration of Ecology**
Upgraded rainfall forecast - Weather radar systems and rainwater monitoring Upgraded communication system	Personnel training in fire, police, home guard and other Periodic inventory and restocking Equipment for emergency Identified emergency centers and help lines	Financial autonomy and statutory authority of disaster management department Disaster Management plans for each ward	BRIMSTOWAD (major drainage and water supply infrastructure project) Transportation (focus on mass public transport, rather than individual vehicle) and Communication	Cleaning and clearing of bottlenecks in Mithi river Buffer Zones in Lower Mithi River Area

Source: Chatterjee, 2010, p 111

[232] (Chatterjee 2010)
[233] (Marschiavelli 2008)
[234] (Chatterjee 2010), (Marschiavelli 2008)

Several NGOs operate in the study areas, although their activities were not separated out in studies. They play a role in assisting community education of flood preparedness, emergency management during an event, and post event recovery.

Key barriers that were collectively identified in the studies to adapting to perceived climate change risks included:

- Lack of awareness of the community of future climate change risks;
- Lack of financial support to implement adaptive initiatives;
- Lack of coordinated planning – including coordinated development planning, and coordinated emergency response planning, with integrated climate change considerations;
- Lack of trust in emergency warnings, due to past inaccuracies;
- Poor implementation/enforcement of policy;
- Poor data (or access to data) and future climate change uncertainty.

10. RECOMMENDATIONS

Cities in Asia are becoming aware of the imperative of taking climate change action, and are facilitated in this process by a number of networks and research programs. However, these networks only cover a relatively small percentage of cities, and further work is needed. The following section presents a menu of recommendations that policy and development workers may wish to explore further.

We have broadly divided these recommendations into four categories: Knowledge/Information recommendations, Community Capacity and Local Government Capacity recommendations and International Donor Community recommendations.

a) Knowledge/Information

Urban Field-Based Studies: As highlighted very early in this report, there are very few studies being undertaken in mega-cities that adequately capture community understanding of climate change impacts, and their strategies to cope with these. The experience of local people during extreme events, or as climate impacts gradually affect them is extremely valuable, and is important to be captured and shared. Strategies to encourage broad based field research capturing a diversity of perspectives (not only of the poor) are required to inform appropriate policy and strategy development.

City-Level Climate Modelling: Current approaches to city level modelling rely heavily on downscaling Global Climate Models or Regional Climate Models, and sometimes combining these with local climate data. This approach currently produces widely varying projections, which can make future planning even more uncertain for city officials and the community. Access to local data in Asian cities can be a significant problem, either because it is not available, or inter-departmental bureaucracy makes the process extremely complicated. City climate models also need to incorporate future development projections to adequately capture potential future impacts, which adds another layer of complexity and uncertainty to models. National governments are currently investing quite heavily in Regional Climate Models, and a strategy of further investment in approaches to developing appropriate city-scale data is highly recommended. This information will be able to not only inform pro-poor development strategies, but also pro-poor disaster risk reduction planning.

Communicating Climate: An additional aspect to climate modelling information, is the communication of this information. The language spoken by climate scientists is very different from that understood by city planners and the community. Climate scientists often do not understand exactly what information is required of them, and city planners misinterpret and misuse the information available. National investment in "science communication" fields, that can be trans-boundary in nature would reduce the risk of inappropriate use of scientific information.

b) Community Capacity

Capturing and Sharing Experiences: Although this may fall into the knowledge/information area, it is also relevant to be highlighted here, under Community Capacity. The field studies showed clearly that previous understanding and knowledge of how to act prior to, during and after extreme events built the capacity of members of the local community. Capturing these experiences and sharing them to new arrivals to areas, between areas, even between cities and countries, will reduce the vulnerability of these groups, and may collectively improve the adaptive capacity of communities. There is a clear role for local NGOs and development professionals to facilitate this capturing and sharing of experiences.

Integrating Climate Change into Current NGO Agendas: NGO's have a specific agenda that propels them, be it alleviating the suffering of children in poverty, assisting to empower women, improving environmental conditions or a combination of these (and other) priorities. For these NGOs, who work daily with the urban poor, to provide the best outcomes to their constituents, they need to fully understand the climate change landscape, and how it impacts their agenda. This would require significant resources to be invested in training and skilling local NGO and community development professionals, in what for some may be a whole new field. This relates strongly to the "communicating climate" recommendation above, as incorrectly communicated information confuses the climate change debate, and stifles potential adaptation measures.

Community-led Initiatives: Actions identified and initiated by the community have a strong likelihood of building local level adaptive capacity. Such initiatives as waste reduction are a "no-regrets" policy, as should climate change impacts be more or less than projected, the community is often better off, emissions may be reduced, and adaptive capacity increased. Other initiatives such as locally developed social support networks, micro-finance or emergency management approaches are all worthy of further support, and again may fall into the remit of local NGOs. Strategies to support these initiatives should be encouraged.

Community Understanding of Climate Change: For individuals in the community, the understanding of climate change is strongly linked to the understanding of the most recent climatic event – such as a flood, cyclone, storm surge etc. Facilitating the broader understanding of the community beyond emergency events is important. This recommendation is strongly linked to the Communicating Climate recommendation mentioned previously.

Capacity to Engage: The formal engagement of the local community, particularly marginalised populations, in local government (even regional and national government) processes is particularly poor in developing countries in Asia. However, many NGOs work in the space of building community empowerment, to enhance the community's capacity to engage formally with government processes. Enhancing these processes, and ensuring the integrated understanding of climate change issues is recommended. This strategy links very closely with the strategy of integrating climate change into current NGO agendas.

Early Warning Systems: Early warning systems take many forms across Asia (for tsunamis, floods, heat waves etc). Ensuring that these systems are developed with community input and understanding is important. Communities need to know what is required of them when each particular "alert level" has been reached. The studies suggested this step – which is the step between formal government processes and the community, is weak and needs to be strengthened.

c) Local Government Capacity

Local Government Understanding of Climate Change: Elected representatives and city staff need to have a good understanding of climate change, and how it is likely to impact their area of control, to be able to appreciate the importance of integrating climate change into their planning processes. Several organisations and networks, such as ICLEI – Local Governments for Sustainability, C40 Cities, Asian Cities Climate Change Resilient Network and others work in the region to facilitate improved knowledge and understanding of climate change implications, but being able to extend this reach to even more cities would be an advantage.

Address Short-term, Non-integrated Planning: Cities in Asia are not the only ones that suffer from short-term planning horizons, and non-integrated planning. All cities struggle with these issues. The short-term election cycles of all levels of government complicate this issue, but staff, who are generally engaged past the election dates, can continue to build improvements in this area. Continuing to facilitate the development of tools, techniques and training to build the understanding and skills of local government staff to look longer into the future is a process that can be facilitated by the international community, and governance professionals.

Governance Improvement Strategies: Engaging with communities around local government planning issues, in an open, accessible and transparent manner is a relatively new concept to local government – even in developed countries. For many Asian cities, this is counter to their cultural norms, and may be perceived as undermining the authority of local government. A long-term approach to improving the engagement culture, structures and processes for engagement, as well as the skills to undertake engagement is required, and is a strategy that can be facilitated by the international community and NGOs.

Increase Perceived Importance of Climate Change: Local government priorities are determined by a combination of national priorities, and local realities. To overcome the problem of competing priorities, the perceived importance of climate change needs to be increased. Both India and Indonesia have recognised the importance of climate change at the national level. However, more needs to be done to ensure its relevance to the development agenda is cemented in place, and it is given suitable priority. At the local level, more needs to be done to raise the priority of climate change. This is predominantly a strategy of engaging with local elected members in an ongoing, consistent manner, to continuously identify the local realities of climate change, and to support them to feel that cities can do something about it.

Decentralisation Capacity Improvement: The decentralisation processes underway in India and Indonesia have increased the scope of work, and the level of authority and responsibility for local governments. There is currently a knowledge, skill and competency gap to meet the new work requirements, as well as a financial gap. Local government staff not only need support in understanding how climate change is relevant to their roles, but also, help in building capacity to deliver on the increased range of responsibilities, and implement the policies that have been devised at higher levels. Facilitating training, support and networking in this area is an important strategy at the national level for countries in this position.

Additionally, reviewing the process of funding and resourcing for cities at the national level would be one approach to assist with local financing issues, and potentially reduce the likelihood of local level corruption. At the international level, streamlining some of the frameworks for funding would be another strategy. For example, it is an extremely difficult, lengthy process for cities in Indonesia to access the benefits of CDM projects, as they are predominantly a national government level mechanism.

Standardised Greenhouse Gas Accounting: Guidance is available for cities to undertake an emissions inventory for their own operations, and for their broader municipalities. However, different scope inclusions and accounting processes can lead to inaccurate comparisons across jurisdictions. There is also discussion of how to better allocate consumption methodologies in cities' accounting processes. Further work and consolidation of a standardised greenhouse accounting process for cities, recognised globally, would facilitate further action by cities on climate change mitigation.

d) International Donor Community

Donor Understanding of Importance of Funding City Climate Change Work: International donor funding agencies are only just becoming aware of the importance of cities in the climate change agenda. Facilitating understanding by donor agencies of the unique challenges and concepts of urban resilience to climate change is an important strategy to be undertaken. Additionally, assisting to develop a coordinated approach to ensure maximum, effective impacts is a strategy that agencies such as UNDP could lead.

11. CONCLUSION

In an increasingly urbanised world, as international negotiations continue to falter (or progress slowly at best), the role that cities can play in reducing emissions is becoming more important. By using the levers at their control of planning, regulation, purchasing power, network facilitation, education and civic leadership, local governments can control and influence how energy is produced and consumed within their municipalities. The inherent nature of cities, of how they concentrate people and resources, can challenge this process, but also provides an opportunity.

Even if strong greenhouse gas reductions were to take place immediately, climate change would still occur, and cities are likely to feel significant impacts of these. Many cities in Asia are particularly vulnerable to the impacts of climate change, including Mumbai and Jakarta. There is an opportunity for cities to build their resilience to climate change, by reducing their exposure, decreasing the sensitivity of their communities, particularly their poor and marginalised communities, and improving their adaptive capacity.

There is a role for the international community, national and local governments, as well as NGOs and civil society organisations to reduce the vulnerability of cities to climate change. Further research, better climate communications, improved community, NGO and local government capacity and coordinated international donor efforts are just some of the ways resilience can be improved.

12. GLOSSARY OF KEY TERMS

The area of climate change mitigation and adaptation brings together many facets and areas of research and technical expertise, which each have a different "language" for their area of focus. For this reason, some key terms used in the climate change adaptation space are not clearly and consistently defined. For the purpose of this report, definitions used are generally aligned with the Intergovernmental Panel on Climate Change (IPCC) and United Nations Development Programme (UNDP) definitions.

Adaptation – Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation.[235]

> Anticipatory Adaptation – Adaptation that takes place before impacts of climate change are observed. Also referred to as proactive adaptation.[236]
>
> Autonomous Adaptation – Adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems. Also referred to as spontaneous adaptation.[237]
>
> Planned Adaptation – Adaptation that is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state.[238]

Adaptive Capacity – The ability of a system to adjust to climate change, (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. [239]

Climate Change – Refers to any change in climate over time, whether due to natural variability or as a result of human activities.[240]

Climate Change Impacts – The effects of climate change on natural and human systems.[241]

Climate Variability – Climate variability refers to variations in the mean state and other statistics (such as standard deviations, statistics of extremes, etc) of the climate on all temporal and spatial scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability).[242]

Exposure Unit – Represents the system considered to be at risk, and may be defined in terms of geographical extent, location and distribution of a variety population of receptors at risk.[243]

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[235] (IPCC 2007, 869)
[236] (IPCC 2007, 869)
[237] (IPCC 2007, 869)
[238] (IPCC 2007, 869)
[239] (IPCC 2007, 869)
[240] (IPCC 2007, 871)
[241] (IPCC 2007, 876)
[242] (IPCC 2007, 872)
[243] (UKCIP 2010)

Greenhouse Gas – Those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, atmosphere, and clouds.

Maladaptation – An action or process that increases vulnerability to climate change-related hazards. Maladaptive actions and processes often include planned development policies and measures that deliver short-term gains or economic benefits but lead to exacerbated vulnerability in the medium to long-term.[244]

Mega-City – There are varying definitions for a "mega-city", UN-Habitat defines it as a city with a population of over 20 million people[245] Others, define it as a metropolitan/urban area with a population in excess of 8[246], or 10 million people.[247] For this report, we are using the second figure of 10 million as the basis for defining a mega-city.

Mitigation – An anthropogenic intervention to reduce the anthropogenic forcing of the climate system; it includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks.[248]

Resilience – The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organisation, and the capacity to adapt to stress and change.[249]

Sensitivity – The degree to which a system is affected, either adversely or beneficially, by climate variability or change. The effect may be direct or indirect.[250]

Slums – UN-HABITAT defines a slum as a settlement in an urban area in which more than half of the inhabitants live in inadequate housing and lack basic services. Further detail outlines a slum household as one where a group of individuals live under the same roof in an urban area who lack one or more of the following:

1. Durable housing of a permanent nature that protects against extreme climate conditions, and is built in a non-hazardous area.
2. Sufficient living space, which means not more than three people sharing the same room.
3. Easy access to safe water in sufficient amounts at an affordable price.
4. Access to adequate sanitation in the form of a private or public toilet shared by a reasonable number of people.
5. Security of tenure that prevents forced evictions.[251]

Subsidence – The sudden sinking or gradual downward settling of the Earth's surface with little or no horizontal motion.[252] In the case of subsidence in cities, the term relates to the gradual "sinking" of cities' infrastructure, which can be caused by withdrawal of ground water (both within and outside the boundaries of the city), the weight of development, and sea level rise altering water table levels.

[244] (UNDP 2010)
[245] (UN-HABITAT 2008)
[246] (Davis 2004, 6)
[247] (Sanchez-Rodriquez, et al. 2005, 12), (OECD 2010, 39)
[248] (IPCC 2007, 878)
[249] (IPCC 2007, 880)
[250] (IPCC 2007, 881)
[251] (UN-HABITAT 2006, 21)
[252] (IPCC 2001, 386)

Urban/City – There is no agreed upon definition. The OECD notes they are often based on administrative areas defined by particular countries, but also where there is a density of greater than 150 inhabitants per sq km.[253]

Vulnerability – The degree to which a system is susceptible to, and unable to cope with, adverse affects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity and its adaptive capacity.[254]

[253] (OECD 2010, 40)
[254] (IPCC 2007, 883)

APPENDIX 1: CITIES AND POPULATION RANKING

Global City/Agglomeration Population and Growth Rates

	City (English name)	Country	Population*	Est. Growth Rate (2005-2010)**
1	Tokyo	Japan	34.2m *(inc. Yokohama, Kawasaki, Saitama)*	2.94%
2	Guangzhou	China	24.9m *(inc. Northern Pearl River Delta incl. Dongguan, Foshan, Jiangmen, Zhongshan)* 8.8m *(Guangzhou, Guangdong)*	8.80%
3	Seoul	Republic of Korea	24.5m *(inc. Bucheon, Goyang, Incheon, Seongnam, Suweon)* 9.8m	-0.53%
4	Delhi	India	23.9m *(inc. Faridabad, Ghaziabad)* 22.2m	13.66%
5	Mumbai	India	23.3m *(inc. Bhiwandi, Kalyan, Thane, Ulhasnagar)* 20.0m	10.08%
6	Mexico City	Mexico	22.8m *(inc. Nezahualcóyotl, Ecatepec, Naucalpan)* 19.5m	3.87%
7	New York	United States of America	22.2m *(inc. Newark, Paterson)* 19.4m *(inc. Newark)*	3.73%
8	São Paolo	Brazil	20.8m *(inc. Guarulhos)* 20.2 m	8.66%
9	Manila	Philippines	20.1m *(inc. Kalookan, Quezon City)* 11.6 m	8.06%
10	Shanghai	China	18.8m 16.6m	9.16%
11	Jakarta	Indonesia	18.7 m *(inc. Bekasi, Bogor, Depok, Tangerang, Tangerang Selatan)* 9.2m	4.73%
12	Los Angeles	United States of America	17.9 m *(inc. Riverside, Anaheim)* 12.8m *(inc. Long Beach, Santa Ana)*	3.73%
13	Osaka	Japan	16.8 m *(inc. Kobe, Kyoto)* 11.3 m *(inc. Kobe)*	0.7%
14	Karachi	Pakistan	16.7 m 13.1m	12.97%
15	Kolkata	India	16.6 m *(inc. Haora)* 15.6m	8.88%

* Note: Cities are ranked according to their broader "agglomeration" population figures. These are sourced from http://www.citypopulation.de/world/Agglomerations.html. The smaller population figures listed second generally relate to the city local government boundary only, sourced from UN, Dept of Economic and Social Affairs, Population Division, *World Urbanisation Prospects: 2009 Revision.*

** Growth rate calculations based on figures sourced from UN, Dept of Economic and Social Affairs, Population Division, *World Urbanisation Prospects: 2009 Revision*

Asian City/Agglomeration Population and Growth Rates

	City (English name)	Country	Population*	Est. Growth Rate (2005-2010) **
1	Tokyo	Japan	34.2m *(inc. Yokohama, Kawasaki, Saitama)*	2.94%
2	Guangzhou	China	24.9m *(inc. Northern Pearl River Delta, Dongguan, Foshan, Jiangmen, Zhongshan)* 8.8m *(Guangzhou, Guangdong)*	8.80%
3	Seoul	Republic of Korea	24.5m *(inc. Bucheon, Goyang, Incheon, Seongnam, Suweon)* 9.8m	-0.53%
4	Delhi	India	23.9m *(inc. Faridabad, Ghaziabad)* 22.2m	13.66%
5	Mumbai	India	23.3m *(inc. Bhiwandi, Kalyan, Thane, Ulhasnagar)* 20.0m	10.08%
6	Manila	Philippines	20.1m *(inc. Kalookan, Quezon City)* 11.6 m	8.06%
7	Shanghai	China	18.8m 16.6m	9.16%
8	Jakarta	Indonesia	18.7 m *(inc. Bekasi, Bogor, Depok, Tangerang, Tangerang Selatan)* 9.2m	4.73%
9	Osaka	Japan	16.8 m *(inc. Kobe, Kyoto)* 11.3 m *(inc. Kobe)*	0.7%
10	Karachi	Pakistan	16.7 m 13.1m	12.97%
11	Kolkata	India	16.6 m *(inc. Haora)* 15.6m	8.88%
12	Dhaka	Bangladesh	14 m 14.6 m	16.67%
13	Beijing	China	13.9 m 12.4 m	8.12%
14	Shenzen	China	9.5m	13.55%
15	Bangkok	Thailand	9.4m 6.9m	5.49%

* Note: Cities are ranked according to their broader "agglomeration" population figures. These are sourced from http://www.citypopulation.de/world/Agglomerations.html. The smaller population figures listed generally relate to the city local government boundary only, sourced from UN, Dept of Economic and Social Affairs, Population Division, *World Urbanisation Prospects: 2009 Revision.*
** Growth rate calculations based on figures sourced from UN, Dept of Economic and Social Affairs, Population Division, *World Urbanisation Prospects: 2009 Revision*

APPENDIX 2: POLICIES REVIEWED

a) India

National Policies

Policy Name	CC Adaptation (Not Addressed, Positive, Negative)	CC Mitigation (Not Addressed, Positive, Negative)
NUSP – National Urban Sanitation Policy	Positive. Impacts of climate change are to be considered in planning sanitation for cities. There is no particular stress on the reduction of exposure or sensitivity to different impacts, or any particular means of increasing adaptive capacity for such impacts. However, the policy calls for states and cities to develop their sanitation plans with due consideration to impacts of climate change. It stresses awareness and education through development of suitable standards on effluents, infrastructure design, and promoting recycle and reuse of water. Cities which are vulnerable to natural disasters should include disaster preparedness in the design and O&M of sanitation systems. Public awareness on these issues is part of the policy.	Positive. Policy promotes use of low energy intensive technologies and decentralised waste water systems.
Water Policy 2002	Positive. There is no direct linkage with climate change adaptation. However, management of several impacts of climate change, like flood and drought, is a major part of the policy. There is stress on management of water resources in a manner which provides access to drinking water and provides employment opportunities. Periodical assessment of ground water potential, watershed management and research on hydrometeorology is part of the policy which is closely related to climate change mitigation and adaptation. Coastal land management and development is part of the policy.	Positive. Promotes preservation of forests and increasing forest cover
National Urban Transport Policy	Positive. The policy calls for transport plans for cities suiting the geography of the region as well as the socio-economic patterns in the city. It does not specifically address any particular impact of climate change. It promotes sustainable transport. The policy addresses improvement of health through use of better fuel and proper traffic management, better and sustainable travel facilities.	Positive. The policy encourages use of public transport, non motorised transport, enforcement of norms and promotes technological improvements and use of cleaner fuels, including renewable sources, which largely help in mitigation of climate change.

National Policy on Education 1986, modified in 1992	Not addressed. The policy does not address climate change adaptation or mitigation. However, it calls for environmental education to be part of the school curriculum.	Not Addressed
Health Policy	Not Addressed	Not Addressed
National Urban Housing and Habitat Policy / Energy Conservation Building Codes	Positive. The policy encourages the development of healthy environment in terms of sustainable habitat. Promotion of sustainable habitat is closely linked with reserving a significant proportion of the total Master Plan area as 'green lungs of the city', It will be desirable to pursue a goal of 20-25% recreational land use area (excluding water bodies) which has been prescribed for Metro-cities by the Urban Development Plan Formulation and Implementation Guidelines (UDPFI) in order to enhance the sustainability of human settlements. Recreational land use refers to parks, playfields and other open space such as specified park, amusement park, open field, a multipurpose open space, botanical garden, zoological parks, traffic parks, etc.	Positive. There is an emphasis on energy efficient design and construction of buildings
Energy Policy	Not Addressed	Positive. Emphasis has been given to: - Energy efficiency in all sectors - Emphasis on mass transport - Active policy on renewable energy including bio-fuels and fuel plantations - Accelerated development of nuclear and hydro-electricity - Technology Missions for clean coal technologies - Focussed R&D on many climate friendly technologies

National Environment Policy 2006	Positive. Indirectly considered: the policy seeks to standardise environmental management practices & establish monitoring and compliance mechanisms at the local level to ensure that environmental management plans are adhered to. It also calls for the promotion of environmental awareness, education and information dissemination. The policy also focuses on: (i) conservation of critical environmental resources, (ii) intra and inter generational equity with a focus on the livelihoods of the poor, (iii) integration of environmental concerns in economic and social development, (iv) efficiency in environmental resource use, (v) improved environmental governance, and (vi) enhancement of resources for environmental conservation. Overall, therefore it seeks to reduce the vulnerability of communities, though it is not specifically directed at vulnerability to climate risks posed by particular hazards. However, its proposed actions could reduce the vulnerability, sometimes directly and sometimes indirectly to the hazards listed here.	Positive. Seeks to promote energy efficiency, clean technologies and reduce GHG emissions.
National Forest Policy	Positive. The policy contributes directly as well as indirectly to reducing the vulnerability of local communities. It seeks to secure the livelihoods of communities that are directly dependent on forests. Capacity building of local communities to effectively participate in forest conservation is also a key component of the policy. It also seeks to maintain environmental stability which would benefit the larger community in the region. Overall, the policy, often indirectly, contributes towards reducing vulnerabilities to climate risks at local and regional levels.	Positive. The policy seeks to substantially increase forest/tree cover in the country as well as green belts in urban/industrial areas which would increase the carbon sink potential

Foreign Trade Policy (27th Aug 2009 to 31st March 2014)	Positive. The trade policy seeks to increase employment opportunities by placing a special thrust on employment intensive sectors. Further, its Principles of Restriction include: (i) protection of human, animal or plant life and health; and (ii) conservation of exhaustible natural resources. The trade policy also exempts effluent treatment machinery and equipment from customs duty thereby promoting wastewater treatment, reduction in pollution, and improved resource management. These approaches would contribute towards reducing the vulnerability (by decreasing sensitivity and increasing the adaptive capacity) of local communities, but cannot be attributed to any specific hazard.	Positive. The trade policy encourages the production and export of 'green products' with an initial focus on items related to transportation, and solar and wind power. This approach would reduce emissions.
National Policy on Disaster Management	Positive. The policy promotes prevention, preparedness and resilience at all levels through knowledge, innovation and education. Also seeks to mainstream disaster management approaches and techniques into development planning processes and encourages disaster mitigation measures based on technology, traditional wisdom and environmental sustainability. The policy aims at developing contemporary forecasting and early warning systems.	Not Addressed
Cyclone Management Guidelines	Positive. Focuses on reducing the vulnerability to cyclones. Along with appropriate infrastructural inputs the policy seeks to: (i) establish a state-of-the-art Early Warning System at the local level; (ii) commission an Aircraft Probing of Cyclones (APC) facility for India to fill the critical observational data gaps to improve track and intensity predictions; (iii) commissioning of National Disaster Communication Infrastructure at the sub-national and local levels to facilitate interpretation of data and early warning as well as the effective coordination of disaster response actions; and (iv) expanding the warning dissemination outreach by using Direct to Home (DTH) transmissions.	Not Addressed

Drought Management Guidelines	Positive. Focuses on reducing the vulnerability to droughts. Drought Monitoring Cells to be established at the sub-national level - these cells will prepare drought vulnerability maps. Promotion of the watershed development approach to mitigate impacts of droughts	Not Addressed
National Agriculture Policy	Positive. The policy seeks to promote technically sound, economically viable, environmentally non-degrading and socially acceptable use of country's natural resources - land, water and genetic endowment to promote sustainable development of agriculture. Policy promotes watershed management, rational utilization and conservation of the country's abundant water resources.	Positive. The policy encourages to promote afforestation, that leads to carbon sequestration.
National Biofuel policy	Positive. It considers the scope of increased employment opportunities thereby increasing the adaptive capacity. Support for awareness about potential uses in rural economy has further been discussed.	Positive. The policy talks about mainstreaming biofuels and further adds to it by taking into consideration appropriate financial and fiscal measures, research and development and capacity building for the same. It even talks about research in decentralized approaches to waste to power generation, and international cooperation for joint research, field studies etc. Technology transfer/induction would be facilitated for indigenisation and local manufacturing.
National Disaster Management Guidelines, Management of Floods	Positive. The guidelines highlight river wise studies for the problem of erosion and estimate the area liable to erosion by rivers, identify vulnerable spots and plan remedial measures. The guidelines talk about flood prevention and mitigation projects involving building of embankments, catchment area treatment, flood walls, flood levees, etc.	Not Addressed
NAPCC – National Action Plan on Climate Change		
National Solar Mission	Not Addressed	Positive. The mission highlights an increase in the share of solar energy in the total energy mix while recognizing the need to expand the scope of other renewable and non-fossil options such as nuclear energy, wind energy and biomass. Use of these clean fuels would further lead to decreased GHG emissions. It also

		talks about capacity building and research and development for solar technologies.
National Mission for Enhanced Energy Efficiency	Not Addressed	Positive: the mission lays stress on R&D for energy efficiency. Also four new initiatives will be put in place. These are: • A market based mechanism to enhance cost effectiveness of improvements in energy efficiency in energy-intensive large industries and facilities, through certification of energy savings that could be traded. • Accelerating the shift to energy efficient appliances in designated sectors through innovative measures to make the products more affordable. • Creation of mechanisms that would help finance demand side management programmes in all sectors by capturing future energy savings. • Developing fiscal instruments to promote energy efficiency Mission also talks about enhanced energy efficiency measures, accelerating the shift to energy efficient appliances, and developing fiscal instruments to promote energy efficiency.
National Mission on Sustainable Habitat	Positive. The mission will address the need to adapt to future climate change by improving the resilience of infrastructure, community based disaster management, lack of awareness, etc. Capacity building and addressing livelihoods is an important component of this mission. It also discusses fuel shift for domestic use and at transport level; co-benefits of modal shift to public transport, R&D and recycling of solid waste.	Positive. This mission highlights three major aspects: promote energy efficiency; modal shift to public transport; recycling of waste.
National Water Mission	Positive. National Water Mission will ensure integrated water resource management helping to conserve water, recycling of water, minimize wastage and ensure more equitable distribution both across and within states. The mission will take into account the provisions of the National Water Policy and develop a framework to optimize water use by increasing water use	Not Addressed

	efficiency by 20% through regulatory mechanisms with differential entitlements and pricing.	
National Mission for Sustaining the Himalayan Ecosystem	Positive. The receding of glaciers, caused due to the changing climate, poses a threat on the Himalayan ecosystem. This mission talks about sustaining Himalayan ecosystem and outlines various measures to carry this out. Apart from the various measures it discusses, it also focuses on community based management of the ecosystem. This can in turn also help strengthen the adaptive capacity of the region.	Not Addressed
National Mission for a Green India	Not Addressed	Positive. This mission emphasizes increasing the forest cover of India. Since forests act as carbon sinks hence this would lead to carbon sequestration and therefore reduce the overall carbon emissions.
National Mission for Sustainable Agriculture	Positive: the mission talks about various steps to be taken from an adaptive approach towards agriculture. Namely, strategies to make agriculture more resilient to be devised, research to be oriented to monitor and evaluate climate change and recommend agricultural change accordingly, alternative cropping patterns capable of withstanding extremes of weather, and new credit system and insurance mechanism to be devised. These steps would help in making the agriculture a lot more adaptive to the changing climate and would also help farmers against the floods and droughts etc. which would otherwise destroy the crop and lead to a huge monetary loss to them. The mission also talks capacity building, R&D and use of biotechnology in agriculture	Not Addressed
National Mission on Strategic Knowledge for Climate Change	Positive. The mission talks about identifying challenges of, and responding to, climate change. Also a Climate Science Research Fund would be created under the Mission to support research. This would in turn help strengthen the knowledge bank regarding climate change. The mission looks at analysing the status of socio economic (health, demography, migration patterns, livelihood) impacts of climate change. It also stresses	Positive. The mission talks about identifying challenges of, and responding to, climate change. Also a Climate Science Research Fund would be created under the Mission to support research. This would in turn help strengthen the knowledge bank regarding climate change. The mission looks at analysing the status of socio economic (health, demography, migration patterns, livelihood) and

	enhanced climate modelling, strengthening data networks and enhancing environmental knowledge and training at school, colleges and professional level.	impacts of climate change.

Maharashtra State Policies

Policy Name	**CC Adaptation (Not Addressed, Positive, Negative)**	**CC Mitigation (Not Addressed, Positive, Negative)**
State Population Policy	Positive (indirect). This policy does not address climate change directly. However due to its emphasis on health services it does help in improving the adaptive capacity of certain areas, such as special services to tribal areas, small size villages and urban slum areas, to increase awareness among the community about the available facilities, increasing availability of health services.	Not Addressed
Industrial, Investment and Infrastructure Policy, 2006 & Industrial Policy 2001	Positive. This policy does not address climate change directly. However due to its various measures like increased employment, improved infrastructure and emphasis on economic development it can help in improving the adaptive capacity of the area. Negative: it talks about increased industrialisation which can have various negative impacts on the environment thereby contributing to climate change through increased emissions.	Negative. It talks about increased industrialisation which can contribute to climate change through increased emissions.
Housing Policy	Positive. Although this policy does not refer to climate change, it addresses various measures that could help improve the adaptive capacity of the area - improved infrastructure like water supply, roads, sanitation, sewerage, storm water drainage, transport etc., increase in employment opportunities, slum redevelopment and rehabilitation strategy, enforcement of national building codes. It also emphasizes conservation of ecologically sensitive areas, promotion of environmentally sustainable cities and townships, eco housing, and earth quake resistant construction.	Positive. The policy talks about low energy consuming construction
Biotechnology Policy	Neutral. The policy talks about environmental protection through biotechnology, ecologically friendly fertilizers, increase in fisheries, biodiversity conservation, hybrid seeds, disease resistant seeds, and conversion of hazardous waste into useful products through bioremediation. This may help reduce sensitivity, or build adaptive capacity in the agricultural sector to climate change impacts.	Positive. It also covers the production of biofuels.

Tourism Policy	Positive. This policy does not talk about climate change at all. However through various measures like increase in employment opportunities, sustainable environmental practices, infrastructure development (power, water supply, sanitation facilities, hospitals, roads, etc.) it can help in improving the adaptive capacity of the area.	Not Addressed
State Disaster Management Plan	Positive. The plan highlights improved warning and alert systems, post disaster evaluation, emergency evacuation, increased community awareness and training, decrease in risk of loss of life, injuries, resources, setting up of emergency operations centre, hazard mapping, establishment of centre for disaster management, capacity building of NGOs, land use planning and regulations for sustainable development, adoption of building codes, control measures for epidemics, surveillance and monitoring of epidemics, infrastructure improvement, safe siting in earthquake prone areas, etc.	Not Addressed
Water Policy 2003	Positive. There is no direct linkage with climate change adaptation. However, management of several impacts of climate change, like flood and drought, is a major part of the policy. The Policy stresses the management of water resources in a manner which provides access to drinking water and provides employment opportunities. Periodical assessment of ground water potential, watershed management and research on hydrometeorology is part of the policy which is closely related to climate change mitigation and adaptation.	Positive. Promotes preservation of forests and increasing forest cover.
Solar/ Wave Power Plant Policy	Positive. The policy will contribute to energy security.	Positive. This policy promotes renewable energy options such as electricity generation from solar energy e.g. solar thermal, solar photovoltaic, solar photo-synthesis, wave energy, etc.
State Hydro Power Policy	Positive. The policy will contribute to energy security.	Positive. This policy promotes electricity generation through hydro power stations as a renewable energy option.
Maharashtra State Forest Policy 2008	Positive. The policy intends to levy a green tax to encourage forest development.	Positive. Promotes increase in forest cover.

Mumbai City Policies

Policy Name	**CC Adaptation (Not Addressed, Positive, Negative)**	**CC Mitigation (Not Addressed, Positive, Negative)**
Mumbai Disaster Management Plan	Positive. The city level plan highlights improved transport facilities, housing, roads, rail, special corridors for fire brigade, ambulance, police, expansion of roads and rail, broadening of roads, road over bridges, flyovers, improved sanitation, increase public awareness of disaster risk, reduce the risks of loss of life, injuries, economic costs, and destruction of natural and cultural resources that result from disasters, upgrading emergency services, communication and public information systems for public awareness during the entire cycle of the entire cycle of disaster management, land use policies and planning like safe siting and the formation of a Mumbai Disaster Management Committee.	Not Addressed

b) Indonesia

Central Government Policies

Policy Name	Climate Change Considered (Yes/No)	CC Adaptation (Not Addressed, Positive, Negative)	CC Mitigation (Not Addressed Positive, Negative)
National Action Plan on Climate Change (RAN-PI) - 2007	Yes. RAN-PI to be used as guidance for various institutions in carrying out a coordinated and integrated effort to tackle climate change particularly in priority sectors including energy consumer, trade, forestry, agriculture, fishery/marine, mining and infrastructure.	Positive. The policy identifies adaptation efforts to develop resilience and to tackle the present impact of climate change and weather anomaly and anticipate the future impact including the need of adaptation strategy, adaptation on LULUCF sector (coral reef, mangrove protection and water conservation), and capacity building through establishment climate agricultural field school.	Positive. The policy identifies mitigation efforts to reduce green house gas emissions and energy intensity from economic growth including institutional development of clean development mechanism (CDM), strengthening regulatory framework on energy efficiency, energy saving, air pollution control, emission reduction, forest fire and capacity building to encourage CDM projects.
Indonesia Climate Change Sectoral Roadmap (ICCSR) - 2009	Yes. A roadmap for mainstreaming climate change issues into national development planning has been prepared to elaborate further on the previous national documents on climate change (RAN-PI, etc) and to speed up the implementation by the various relevant sectors. It is prepared to cover a time frame of 20 years (2010-2029). Priority programs of roadmap are outlined in four phases of five years relevant RPJM (medium term development plan). The roadmap sets up three categories of activities in each priority sector: (i) data, information and knowledge management, (ii) planning and policy, regulation and institutional development, (iii) plans and program implementation, control with monitoring and evaluation.	Positive. The roadmap sets several goals and activities with regards to adaptation to climate change to be achieved in the next 20 years which will give comprehensive targets for all relevant sectors such as water resources, marine and fisheries, agriculture and health.	Positive. The roadmap sets several goals and activities with regards to mitigation of climate change to be achieved in the next 20 years which will give comprehensive targets for all relevant sectors such as forestry, energy, industry, transportation and waste.

Poverty Reduction Strategy - 2004	Climate change not addressed: PRSP consists of policy, strategy and systematic steps which need to be taken by government, private sector and community to support national movement on poverty alleviation. The strategy includes: (i) increased access for the development sector, (ii) community institutions empowerment, (iii) capacity building, (iv) social protection and (vi) establishment of a global partnership	Not specifically addressed	Not specifically addressed
Community Based Water Supply and Environmental Sanitation Policy (CB-WSES) - 2003	Yes. CB-WSES is one type of water supply and environmental sanitation management model, which put the community as the ultimate decision maker for all WSES development and establishment. It is aimed to improve people's welfare through sustainable management of water supply and environmental sanitation.	Positive. The policy promotes the active role of community in all water supply and environmental sanitation development starting from preparation, construction, operation and maintenance. Although adaptation not specifically addressed, the mechanism is there to include it.	Positive. The policy encourages community to support water resource conservation and solid waste management, which can align with GHG reduction efforts.
Policy for The Development Institutionally - Based WSES Infrastructure and Facilities (IB-WSES)	Yes. IB-WSES is one type of water supply and environmental sanitation management model provided by the institutions such as water supply company, private sector and non-government organisations. It is also to improve people's welfare through sustainable management of water supply and environmental sanitation.	Positive. The policy supports the capacity building of institutions/ water companies related to its financial conditions, institutional development, water services, water resource management, etc.	Positive. The policy encourages the institutions in close coordination with relevant agencies to be involved in conserving water resources.
National Policy on Water Resource (Law No. 7/2004 and Government Regulation No. 42/2008 on Water Resource Management)	Yes. National policy on water resource provides guidance for relevant sectors in formulating strategic plan and specific policy at central and local level. Water resource management includes water resource conservation, utilization of	Positive. The policy promotes the balanced use of surface water, rainwater and ground water intake.	Positive. The policy promotes water conservation (structural and non structural measures) and controls water pollution through solving increased surface water run-off due to decreased land cover and absorption function. It

	water resource, controlled water 'damage', private and community involvement and provision of data and information.		should be done through stipulation and consistent monitoring on spatial plan.
Community Led Total Sanitation (CLTS) - Ministry of Health 2008	Yes – indirectly. The policy is aimed to improve community awareness on the importance of hygiene and healthy life styles. It covers several aspects including: strengthening the roles of government and stakeholders, awareness raising, provision of sanitation facilities, knowledge management and financing scheme.	Positive. The policy encourages community awareness on the importance of hygiene and healthy life styles that will reduce the risks of climate change impact on the health sector.	Not addressed
National Strategy and Action Plan on Urban Air Quality Improvement (NSAP-UAQi) - 2006	Yes. This is a non-legally binding document as guidance to formulate national and local action plans on urban air quality improvement.	Not addressed	Positive. The policy analyses the factors influencing air pollution and the steps that need to be taken to prevent air pollution based on sources. It is also mentioned the control of emission and air quality monitoring and mitigation efforts as well as the need to strengthen institutional capacity.
Energy Saving Policy - 2005	Yes. This policy was enacted as a Presidential Decree instructed to government institutions, state/local owned-enterprise and private sector to undertake real actions on energy saving namely: efficient use of air conditioning and electricity, electronic devices and motorised-vehicle.	Not addressed	Positive. The policy encourage the institutions to undertake real actions for energy saving.
National Energy Policy - 2006	Yes. The policy aims to secure energy supply and optimum energy mix in 2025.	Positive. The policy indirectly promotes sustainable development through providing incentives for the development of alternative energy and energy conservation, which may function as an adaptive capacity measure.	Positive. The policy encourages energy conservation and efficient use of energy and energy diversification.

National Policy and Strategy on Housing and Settlements - 2002	No. The policy does not address climate change issues.	Not addressed	Not addressed
National Policy and Strategy on Solid Waste Management - 2006	Yes. The policy promotes mind-set changes on solid waste management from disposal to management	Positive. The policy encourages to improve the role of community and private sector in solid waste management.	Positive. The policy promotes to reduce waste from its sources and improve the quality of solid waste management systems in line with the clean development mechanism.
Spatial Planning Law - 2007	Yes. The spatial planning policy considers environmental aspects and climate change impact.	Positive. The policy promotes some adaptation measures such as: the disaster management plan and evacuation plan.	Positive. The policy promotes some mitigation efforts such as the provision of open green spaces (30%), mass rapid transport, and air pollution control.

Jakarta City Policies

Policy Name	Climate Change Considered (Yes/No)	CC Adaptation (Not Addressed, Positive, Negative)	CC Mitigation (Not Addressed, Positive, Negative)
Medium Term Development Plan (MTDP) 2007-2012	Yes. The MTDP provides guidance for all sectors in formulating development programs and activities. It is a legally binding document that integrates political and technocratic process. Climate change becomes the priority issue and is a dedicated program with focus on the implementation of RAN PI, energy sector mitigation, adaptation strategy and climate change impact investigation.	Positive. The policy promotes some adaptation measures to climate change involving various sectors such as: education, health, public works and environment.	Positive. The policy encourages several mitigation efforts particularly on transport and energy sector such as: promoting a bus way system, mass rapid transit development, GHG emission reduction and energy efficiency.
Spatial Planning Policy 2030 (draft)	Yes. The draft of spatial planning policy integrates climate change issues, both adaptation and mitigation measures.	Positive. The draft policy promotes that development should consider natural resources and environmental carrying capacity including adaptation measures on flood control infrastructure development, (giant-sea defence) sea-wall construction and mangrove rehabilitation.	Positive. The draft policy specifically promotes some mitigation measures such as: the extension of open-green space, GHG emission reduction and conservation area control.
GHG Emission Reduction (low carbon city) - draft 2010	Yes. The Provincial Government of Jakarta has declared to decrease 30% of GHG emission by 2030 and this target has been implemented through sectoral mitigation measures.	Not addressed	Positive. The draft policy promotes some mitigation efforts such as: car free day, controlling emission from vehicles, fuel conversion, smart energy program, integrated solid waste management, waste water management facilities, water preservation and supply and green building.
Green Building Policy (draft)	Yes. The draft policy has been prepared to regulate green building in Jakarta. The policy is the operationalisation of Law No. 28/2002 and GR No. 36/2005. As pilot project, the City Hall building retrofit is being developed.	Not addressed	Positive. The draft policy promotes the concept of green building including electricity saving, recycling water and waste water treatment and will be tried in government building, schools, private building and real estate

			development.
Control on Air Pollution (Local Regulation No. 2/2005)	Yes. The policy promotes the efforts on air pollution control and prevention in order to achieve good air quality.	Indirectly. Reducing air pollution may help reduce heat island effect.	Positive. The policy supports air pollution control as part of climate-change mitigation efforts which could be done through: emission reduction, mass rapid transit development, car-free day, etc.
Electricity Saving (Governorial Decree No. 73/2008)	Yes. The policy is implementation of energy saving at local level, which has three main programs: electricity efficiency, energy diversification and renewable energy.	Not addressed	Positive. The policy encourages building owners to be responsible to run electricity saving program in their building, and sets up a task force to supervise the implementation of the energy saving program

APPENDIX 3: FIELD BASED STUDIES

For all studies selected, the groups chosen for study were based on a combination of geographic location, and socio-economic status, rather than by gender, age, religion, employment or other criteria.

a) India

Project/Program Title	**Resilient Flood Loss Response Systems for Vulnerable Populations in Mumbai: A Neglected Alternative**
Organisation/Author	Monalisa Chatterjee
Period	2010
What is Vulnerability Assessment approach undertaken?	As this is a PhD study, the approach taken develops its own framework, drawing on several theoretical approaches. It is based on a combination of quantitative and qualitative data gathering. It has 3 levels: 1) a national level analysis of hazard events and mitigation policy; 2) city level review of flood mitigation strategies; and 3) a household scale assessment of flood risk, vulnerability and coping strategies; Methodology included: Survey of 50 households in the area via a detailed questionnaire; Focus groups conducted in both communities; Key informant interviews; Observations and visits;

Project/Program Title	**Flood Risks, Climate Change Impacts and Adaptation Benefits in Mumbai**
Organisation/Author	Stephane Hallegate, Henriet Fanny, Anand Patwhardan, K. Narayanan, Subimal Ghosh, Subhankar Karmakar, Unmesh Patnaik, Abhijat Abhayankar, Sanjib Pohit, Jan Corfee-Morlot, Celine Herweijer, Nicola Ranger, Sumana Bhattacharya, Murthy Bachu, Satya Priya, K. Dhore, Farhat Rafique, P. Mathur, Nicolas Naville
Period	2010
What is Vulnerability Assessment approach undertaken?	Impacts based adaptation assessment: Characterising current level of vulnerability and potential future sensitivities, quantifying relevant risks, identifying adaptation options. Sample size of surveys about 530 households, approx. 50 households across 11 wards; Interviews with “head of household”, which in over 85% of cases was male.

Project/Program Title	**Floods Risk Reduction in Livelihood Risks: Thoughts and Insights from Mumbai**
Organisation/Author	H. Takano and S. Sammadar
Period	2010
What is Vulnerability Assessment approach undertaken?	Face to face, structured and semi-structured interviews; based on sampling, targeting head of family, but if not available, then other respondents were chosen. Also observation, unstructured interview of field engineers, local political and religious leaders.

b) Indonesia

Project/Program Title	Vulnerability Assessment of Jakarta and Java Island
Organisation/Author	Institute of Essential Services Reform
Period	2010
What is Vulnerability Assessment approach undertaken?	This research combines both top down and bottom up approaches. The top down approach is represented by the climate modeling method using the Meteorological Research Institute (MRI) model of Japan that includes scenario A1B, A2, and B1 which will be used to project the future climate risks of Java Island and DKI Jakarta province. Meanwhile the bottom up approach is done through field research using Participatory Rural Appraisal (PRA) concepts and tools to look at the current climate risks and present adaptation strategies including the challenges at urban coastal community, called Kelurahan Kamal Muara. Findings from these two approaches will be used for triangulation which will improve the validity and reliability of the results.

Project/Program Title	Vulnerability Assessment and Coping Mechanism related to Floods in Urban Areas: A Community Based Case Study in Kampung Melayu, Jakarta
Organisation/Author	Masters Degree Thesis, Ms. Mone Iye Cornelia (University of Gadjah Mada, Yogyakarta)
Period	2008
What is Vulnerability Assessment approach undertaken?	This research tries to explore the vulnerability as well as the capacity for flood management based on local people's perception. There were 83 households interviewed using a questionnaire. Certain elements of risk related with physical and socio-economic aspects were identified. Physical information concerned the building structure and building contents. Several socio-economic were used as key indicators to analyse the vulnerability of people. In addition, information about flood occurrence, and existing coping mechanisms based on people's perception are also discussed in this research.

Project/Program Title	Socio-Economic Aspect of Vulnerability Assessment due to Sea Level Rise in Jakarta
Organisation/Author	Master Degree Thesis, Mr. Awanda Sentosa (University of Indonesia, Jakarta)
Period	2010
What is Vulnerability Assessment approach undertaken?	This research focuses on socio-economic vulnerability assessment and the development of a socio-economic vulnerability index due to sea level rise. The research covers the following components: (i) identification of disaster event (event, predictability, duration, area), (ii) Socio-economic vulnerability index (land use, poverty index, population density, number of people affected by sea flood, the impact of sea level rise), (iii) factors incluencing vulnerability (education level, employment, asset tenureship, income, social and source of information)

	The research was developed based on previous studies on sea level rise impact in North Jakarta and primary surveys to identify socio-economic impact.

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