responses of cities to climate-related hazards. This addresses the important question of real-versus-perceived needs. Finally, how such information contributes to urban vulnerability assessments, quantification of the range of potential impacts, and formulation of practical, user-relevant adaptation strategies is explored.

4.1 Buenos Aires

Buenos Aires is the third largest city in Latin America, and is the political and financial capital of Argentina. The city is composed of several sub-jurisdictions that were added as the city expanded since its inception in the fifteenth century as a Spanish port. The Greater Buenos Aires Agglomeration (AGBA) is the largest in Argentina, with over 12 million inhabitants (National Population Census, 2001), with 77 percent of the population living in the surrounding provincial boroughs, and 23 percent in the central urban core of Buenos Aires City (Instituto Nacional de Estadística y Censos [INDEC], 2003). Table 8 summarizes the population, area, and density of the city and its administrative units (Figure 22). Buenos Aires City (CABA) is administered by an autonomous government elected directly by its citizens. With less than 10 percent of the Argentinean population, the CABA produces around 24 percent of the GDP. The Geographic Gross Product of the city in 2006 was about US $50 billion (Directorate for Statistics and Census, 2007). Service sectors account for 80 percent of the local economy.

Hazards

Increases in sea and river levels, rising temperature and precipitation, along with increased frequency of extreme events like flooding caused by heavy (convective) rains and storm surges, as well as droughts are the primary climate-induced hazards for Buenos Aires. The city has a humid subtropical climate with long hot summers, and winters with low precipitation caused by the central semi-permanent high pressure center in the South Atlantic. This pressure system can cause strong south-southeast winds in the autumn and summer causing floods along the shores (Camillioni & Barros, 2008). For an overview of the seasons and basic climate parameters of the city see Tables 9 and 10 (Servicio Meteorológico Nacional, 2008).

Since the 1900s, the mean temperature has steadily increased on average by 0.2°C per decade. Likewise, over the last century, the precipitation in Buenos Aires has increased on average by 22.8 millimeter per decade. For details on observed and projected temperature and precipitation trends for Buenos Aires see Figures 2, 6, 12 and 16. In regard to extreme events, there is an increase in frequency of extreme precipitation and associated city floods, see Table 11. Further, occurrences of precipitation events of more than 100 millimeters within 24 hours have nearly doubled—from 19 times between 1911 and 1970 to 32 times between 1980 and 2000. Such observed increases in the quantity and frequency of extreme precipitation not only adversely affects urban infrastructure, but also damages private property and disrupts the economic and social functioning of the city.

Moreover, floods have become more frequent in the low-lying coastal zones since 1960 when the south Atlantic anticyclone was displaced southward bringing an increased frequency of easterly winds over the La Plata River. Storms with southeasterly winds, locally known as *sudestadas*, cause the River to swell, and result in the flooding of coastal zones that lie up to 2.8–5 meters above mean sea level, see Table 12.

Additionally contributing to flood proneness, over the last century the average water level of the La Plata River has increased by 1.7 millimeters per year. If this trend continues, the coastal areas in and around the metropolitan agglomeration will experience more frequent flood frequency as well as erosion along the coast (Camillioni & Barros, 2008). A less likely, yet catastrophic climate-associated hazard is the salinization of the inner waters of the La Plata River, and the consequent contamination of the aquifers (Menéndez, 2005).

Box 1. Coast of the La Plata River

The La Plata River, an estuary, widens gradually from 50 kilometers at its source to 200 kilometers at its mouth; the river also increases salinity along its exterior boundary towards the Atlantic Ocean. The riverbed has a gradual gradient (0.01 meter per kilometer), which favors maritime-type dynamics, with both lunar and wind-induced tides from the ocean. The "sudestadas" are local storms that can last from a few hours up to two or three days with strong winds from the southeast that push waters towards the interior of the river and cause floods along the low Argentinean bank.

Source: Assessment of Impacts and Adaptation to Climate Change, 2005

Droughts caused by long dry spells in the La Plata River basin occasionally occur. However, these droughts affect cities located in the centre and northwestern areas of the Basin more than Buenos Aires. This is because the section of the river along Buenos Aires has an average annual flow rate of 22,000 meter cube per second. Therefore, droughts were not considered a hazard for the city until 2008 when a surprising environmental problem with dry conditions emerged. In autumn, smoke from forest fires covered the city with soot for several weeks, posing a health hazard for the people of Buenos Aires.

Vulnerabilities

The city is located along the shores of the La Plata River and spreads over the *pampa*, a wide fertile plain, and adjoining the Paraná river delta. As a result the entire metropolitan area is less than 30 meters above mean sea level. As the city grew, several rivulets that formed the natural drainage system were replaced with a system of underground storm water drains (Falczuk, 2008).

Spatial Distribution of Poor Versus Non-poor: Over the 1990s the city has experienced sprawl with developers building gated communities on the periphery of the metropolitan area, extending the city over an area one and a half times the size of the CABA (Pírez, 2002). With disparity on the rise and migration of the non-poor from the city center to the periphery, the city has been further spatially segregated by income groups. This condition was further intensified with the economic crisis of 2001, which created the 'new poor' consisting of the middle class that now lacked incomes.

The precise distribution and enumeration of the slums is complicated by two additional factors. First is the process of 'urban invasions' whereby squatter settlements crop up sporadically across the city. Second, like all other urban data for AGBA, information on the poor is parsed into 30 administrative units. For this research, data for slums and other dilapidated housing in the CABA were derived from an Ombudsman survey in 2006 (see Table 13 for quantification of low-income housing), which found that about 20 percent of all households in the urban core of the AGBA live in poor housing conditions.

Additionally, the survey identified 24 new settlements with 13,000 inhabitants located under bridges or simply 'under the sky' (Defensoría del Pueblo de la Ciudad de Buenos Aires, 2006). However, unlike developing-country slums, most households have land tenure and property rights related to their homes due to a well-established public housing program in Argentina. Mapping the spatial distribution of differential vulnerability of the poor and non-poor to floods and other hazards is critical to crafting a climate-risk assessment of Buenos Aires (see Figures 23 and 24).

Low elevation urban areas: In its present configuration, a quarter of the metropolitan area is susceptible to floods (Clichevsky, 2002; Menéndez, 2005). Urban expansion continues over the basins of the Matanza-Riachuelo, Reconquista, and Luján rivers, as well as the estuary of the La Plata River (see Figure 25). These areas consist of a combination of new gated communities, real estate speculation sites, as well as illegal plots in the flood plain targeted toward the housing needs of the poor. With a lack of regulation governing such urban development and the creation of unprotected infrastructure in the flood plain, the vulnerability of this part of the city is increasing (Ríos & González, 2005).

To assess the vulnerability of the low-elevation areas of the city a review of past urban floods was undertaken. As reported in newspapers and official assessments, floods impaired all modes of public and private transportation, including domestic flights, road, and rail; disrupted energy supplies, telephone lines and traffic lights; flooded buildings; and created an overall disruption of city life. Streets and cellars were waterlogged and people living in low-elevation neighborhoods in the suburbs were evacuated (González, 2005). In sum, the economic costs were high. Unlike urban disasters in other developing countries, the death toll in Buenos Aires related to flooding disasters tends to be low. The primary costs are the disruption of the economic activity of the city and damage to public and private property.

As the metropolitan area has been expanding into the flood plains, a simulation to quantify the population vulnerable to sea level rise was conducted. Barros et al. (2008) observed that "Assuming little change in population density and distribution, under the scenario of maximum sea-level rise during the 2070 decade (…) the number of people living in areas at flood risk with a return period of 100 years is expected to be about 900,000, almost double the present at-risk population". The potential damage to public and private assets can be assessed from a recent survey that estimated that 125 public offices, 17 social security offices, 205 health centers, 928 educational buildings, 306 recreational areas and 1,046 private industrial complexes are currently at risk to floods.

A conservative estimate by Barros et al. (2008) states that at present the damage to real estate from floods is about US$30 million per year. Assuming a business-as–usual scenario, which includes a 1.5 percent annual growth in infrastructure and construction and no adoption of flood-protection measures, the projected annual cost of damages is US$80 and US$300 million by 2030 and 2070 respectively. These estimates do not include the losses to gated communities of the non-poor being built in the coastal area, largely located less than 4.4 meters above mean sea-level. Nor does this account for the loss in productivity of the labor force, which can be significant given the size of the population likely to be affected. Thus, the costs of not responding to climate change in the course of urban development are projected to be significant and disruptive.

Adaptive Capacity

The Argentinean government's response to global climate change has been dominated by mitigation efforts related to policies and programs to reduce greenhouse gas emissions (Pochat et al., 2006), with relatively little attention to adaptation. The lead national agency to address climate issues is the Secretariat for Environmental and Sustainable Development.

In 1993 Argentina became a signatory to the United Nations Framework Convention on Climate Change. In response, the federal government established the office for Joint Implementation, but in 1998 this was renamed the Office for Clean Development Mechanisms. Further, in 1999 Argentina adopted the objectives of the Greenhouse Gases Reduction Programme, and in 2001 signed on to the Kyoto Protocol. To institutionalize the response to climate change, in 2003 a Climate Change Unit was established within the Secretariat for Environmental and Sustainable Development. In 2007, this evolved into the Climate Change Office. In addition, the government has been supporting a range of research programmes, such as the National Programme on Climate Scenarios, which was initated in 2005. Through these institutional arrangements, first and second national reports were prepared in 1997 and 2006 respectively. The third version is under preparation (Pochat et al., 2006).

However, the roles and responsibilities of governmental agencies in regard to climate change remain fragmented, while adaptation responses, specifically at the city level, remain to be addressed. In addition, four Ministries with a dozen departments and institutions are involved in flood monitoring and broader disaster management systems (Natenzon & Viand, 2008). Gradually, lower levels of government such as the states and local authorities are taking an interest in addressing climate change mitigation and adaptation, and a range of stakeholders such as NGOs, the media, and citizen groups are participating.

Emerging Issues

Conflicting plans and multiple jurisdictions reduce the efficacy of climate change response plans at the city level as well (Murgida & González, 2005). For example, in 2007 an office for Climatic Protection and Energy Efficiency was established within the Ministry for Environment of Buenos Aires City. With the arrival of a new administration in December 2007 this ministry was restructured into the Ministry of Environment and Public Space, with a new Environmental Protection Agency. The Office of Climate Protection and Energy Efficiency was dismantled despite the fact that previously initiated programs and projects like "Clean Production" and "Air Quality" continue to be implemented (Murgida, 2007).

The primary obstacles to institutional action at the metropolitan level are lack of actionable climate information, as well as vertical and horizontal fragmentation of jurisdictions with divergent interests and responses. Administrative units within the AGBA address flood management but lack an integrated strategy. For example, within Buenos Aires City two different plans—the Urban Environmental Plan and the Buenos Aires 2015 Strategic Plan—are being implemented simultaneously but with a lack of effective coordination. Further, in practice there are two critical legislative instruments to regulate urban development in the city—namely the Building Code enacted in 1944 and the Urban Planning Code enacted in 1977. These are complemented by additional measures like the Flood Control Plan, and post-2001 flood tax rebates for affected communities. However, these plans, codes and norms are inconsistent. For instance, the Urban Planning Code incentivizes the occupation of vulnerable low-lying areas within the city contradicting the flood prevention plans (González 2005).

Moreover, constantly changing organizational roles and responsibilities of government agencies tasked to address climate change pose a challenge. For instance, in 2005, the Buenos Aires State Government created a unit to address climate change within the provincial Ministry for Environmental Policy. This office continues to be operational under the new local government that was elected in 2007, but the unit has been moved to the Ministry of Social Development and has a reduced mandate. This lack of action orientation is compounded by a general lack of public awareness of the risks associated with climate change (Assessment of Impacts and Adaptation to Climate Change, 2005).

Additionally, there is a mismatch in terms and scales. While the climate adaptation strategies like flood prevention and management need to take a long-term view and plan for the metropolitan region as a whole, most planning interventions address short-term needs and do not take a city-wide view (Murgida & Natenzon, 2007). "By analyzing who participated in the planning process and in which areas they did so, it becomes evident that the vast majority of interventions were partial, some were very specific, and a few encompass different areas and spheres" (Pírez, 2008). These issues become further complicated for the metropolitan region due to the overlap and aggregation of administrative units that lack a central governing authority.

The community of scientists and researchers has taken on an unusual task of coordinating climate-related programs and policies. A leading example of this effort was the launch of the Global Climate Change Research Program at Buenos Aires University (PIUBACC) in May 2007. The objective of this program is to map and link all research as well as city development projects within the metropolitan area so as to provide the government, civil society, and more-specifically interested groups directly involved in climate change programs a holistic and scientific assessment of climate change risks. Additionally, the scientists are drawing transferable lessons from community knowledge on flood management along the La Plata River coast with a dual focus on the vulnerability of the poor and on adaptation to storm-surge floods (Barros et al., 2005).

4.2 Delhi[13]

Delhi has a population of 16 million inhabitants, and is rapidly urbanizing with a 3.85 percent annual growth rate over the 1990s amounting to half a million migrants each year. In 1901 Delhi had 400,000 inhabitants. Furthermore, rising per capita incomes are increasing energy consumption, and over-stretching its infrastructure. Delhi is a city of contrasts—in 2000, 1.15 million people were living below the National Poverty line. On the other hand, Delhi's Gross State Domestic Product at current prices was about US $27 billion during 2007 (Department of Planning, 2008). At its widest dimensions, Delhi stretches 50 kilometers and occupies an area of 1,400 square kilometers. To compound

[13] This response is primarily based on feedback and documents provided by the Department of Environment, Government of National Capital Territory of Delhi, India. In particular, summarized here are some pivotal actions taken by the government of Delhi under the leadership of the Chief Minister of Delhi including issues raised during her participation at the C40 Large City Climate Summit in New York in 2007.