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URBAN DEVELOPMENT SERIES
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Climate-resilient, Climate-friendly World Heritage Cities

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Climate-resilient, Climate-friendly World Heritage Cities

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Urban Development Series

Produced by the World Bank's Urban Development and Resilience Unit of the Sustainable Development Network, the Urban Development Series discusses the challenge of urbanization and what it will mean for developing countries in the decades ahead. The Series aims to explore and delve more substantively into the core issues framed by the World Bank's 2009 Urban Strategy Systems of Cities: Harnessing Urbanization for Growth and Poverty Alleviation. Across the five domains of the Urban Strategy, the Series provides a focal point for publications that seek to foster a better understanding of (i) the core elements of the city system, (ii) pro-poor policies, (iii) city economies, (iv) urban land and housing markets, (v) sustainable urban environment, and other urban issues germane to the urban development agenda for sustainable cities and communities.

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Table of Contents

Figures

Tables

Foreword

Historic downtowns have great potential to contribute to city economies, are pillars of human culture and a testament to the evolution of civilization. Whether they are hubs of commerce and local trade or magnets for tourists, they often generate significant economic activity, benefitting the private sector and Micro, Small and Medium Enterprises.

Yet, while the negative impacts of climate change on urban areas are well-known and widely discussed, its implicit impacts on historic downtowns have not been studied as extensively. This includes World Heritage Cities, which are inscribed by the United Nations Educational, Scientific and Cultural Organization (UNESCO) due to their "Outstanding Universal Value"; they are considered collective heritage of human beings, shared across different cultures and civilizations.

What if a historic downtown is washed away in a flood or destroyed by a major landslide? How would that impact job opportunities and livelihoods for their local communities? And how would future generations learn about history if significant cultural sites are wrecked in earthquakes? What are the major risks threatening our shared cultural heritage and its potential to develop local economies, and how can we mitigate these risks? This paper aims to lay out a framework to answer some of these questions.

In recent years, cultural heritage conservation and valorization have increasingly become drivers of local economic development. Many projects supported by the World Bank in this field help leverage cultural heritage for economic development while developing infrastructure and services for residents and enhancing the livability of cities. The World Bank has also been very active in addressing climate change risks and increasing resiliency of urban areas. This paper is also an effort to merge these two critical agendas.

The paper investigates the impacts of climate change on 237 World Heritage Cities and provides an overview of the geographic distribution of these cities around the globe. It then discusses the importance of historic downtowns and provides various options available to the governments of these cities to address risk mitigation and adaptation to climate change. Further, it provides examples of World Heritage Cities which have taken action to address vulnerability to the adverse impacts of climate change. We hope this paper will serve as a guide to help cities around the world as they seek potential courses of action.

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The report was originally prepared by the World Bank team at the invitation of the Organization of World Heritage Cities (OWHC), and was circulated in support to the keynote presentation made by Anthony Gad Bigio at its 11th Congress in Sintra, Portugal, November 22-25, 2011.

The authors wish to thank the General Secretariat of the OWHC and the Municipality of Sintra for the opportunity to share with the Congress some of the World Bank's on-going research in the field of World Heritage Cities and climate change adaptation and mitigation, urban development and project financing. They hope that this will facilitate further World Bank engagement with World Heritage Cities.

Acronyms

AMF	Autofreie Mustersiedlung Floridsdorf
ANC	The Control and Reduction of Unaccounted Water
BRT	Bus Rapid Transit
CDM	Clean Development Mechanism
CH	Community Heating
CHP	Combined Heat and Power
CMI	Marseille Center for Mediterranean Integration
DAC	Development Assistance Committee
DE	Decentralized Energy
ETS	Emissions Trading System
GEF	Global Environment Facility
GHG	Greenhouse Gas
ITDP	Institute for Transportation and Development Policy
JESSICA	Joint European Support for Sustainable Investment in City Areas
MCMA	Mexico City Metropolitan Area
MDB	Multilater Development Bank
OECD	Organisation for Economic Co-operation and Development
OGC	Open Geospatial Consortium
OWHC	Organization of World Heritage Cities
PPCR	Pilot Program for Climate Resilience
QCCS	Quito's Climate Change Strategy
SDI	Spatial Data Infrastructures
UNEP	United Nations Environment Program
UNESCO	United Nations Education and Scientific Cultural Organization
UNISDR	United Nations International Strategy for Disaster Reduction
WHC	World Heritage Cities
WMO	World Meteorological Organization

Executive Summary

This report is organized in five sections. Section 1 presents an overview of World Heritage Cities (WHC), their geographic distribution and the growth of the urban agglomerations to which they belong. Section 2 presents the natural hazard risks and climate change impacts facing WHC, their location on the coastline or interior, and their rank in terms of level of vulnerability. Section 3 outlines the characteristics that historic cities have in terms of carbon emissions and potential for climate change mitigation. Section 4 discusses the sources of financing which WHC may turn to in order to address climate change mitigation and adaptation. Section 5 presents the climate change adaptation and mitigation action plans being implemented in the WHC of Paris, Tunis, Edinburgh, Mexico City, Hué, and Quito.

CLIMATE CHANGE RISKS FOR WORLD HERITAGE CITIES

WHC are at significant risk of deterioration. Climate change and natural disasters will exacerbate those already complex challenges, and specific geographic locations—such as coastal areas—and spatial development patterns may cause additional vulnerability to WHC. Human-created hazards such as unsustainable tourism, uncontrolled urbanization, and poor management already constitute serious threats for some WHC. Compounding risks due to climate change and natural disasters into the equation will make the conservation needs even more challenging in the future, especially for those located in developing countries, where policies and resources to conserve and rehabilitate are often insufficient.

Sea level rise and storm surges, coastal erosion, extreme precipitation events, heat waves and heat island effect, water scarcity, and worsening air quality are the most relevant climate related hazards in urban areas, with impacts on public health and the environment. Geophysical and hydro-meteorological events are affecting heritage cities and are becoming more intense and more frequent. Natural disasters can result in high economic losses, humanitarian tragedies and environmental catastrophes. The damages are happening mostly in developing countries, and direct damages from extreme events are rising. The paper presents maps, where all World Heritage Cities are geo-referenced and overlaid with climate change and natural disaster risks, which allows for the ranking of the WHC most at risk.

CARBON EMISSIONS FROM WORLD HERITAGE CITIES

Carbon emissions, the primary cause of climate change, are proportional to the quantity of energy that is consumed in its various forms by end-users. While more than seventy percent of energy worldwide is consumed in the urban areas, the per capita carbon emissions of each city varies greatly, depending on urban form, density, economic activities, and transportation systems. Many general characteristics of historic cores of WHC make them more energy efficient with lower carbon emissions than newer cities. They tend to have a more intensive and narrower road network as well as smaller-size blocks and buildings. These factors favor the use of more limited space and energy per capita. WHC also favor mixed land-uses, which minimize the distance from residential to productive or commercial areas.

The compact structure of WHC also allows for pedestrian and non-motorized mobility and for the use of public transit as the preferential transportation mode, as opposed to the use of private motorcars, in view of the size of the road network and limited parking opportunities. In the absence of abundant energy sources to heat or cool, historic buildings have generally been designed and built with passive systems and materials providing thermal inertia and therefore are highly adapted to local climatic conditions while emitting relatively low amounts of carbon. Such comparative advantages of historic city cores can be harnessed by governments in further improving energy efficiency and abating carbon emissions, confirming the role of WHC as highly livable urban environments, providing models of climate-friendly urban development.

FINANCING CLIMATE ACTION IN WORLD HERITAGE CITIES

Financial resources for the conservation and rehabilitation of World Heritage Cities mostly come from local government budgets, national government budgets, and investments made by the resident population and businesses. Integrating climate resilience and carbon emissions reduction objectives into the conservation and rehabilitation programs creates opportunities to access additional funding. Wherever the national or supranational policy context establishes clear goals for carbon emissions reduction, WHC can argue that investments in their urban fabrics generate positive results and climate co-benefits.

International financing for climate change adaptation and mitigation and for urban development by the World Bank can also promote historic city rehabilitation objectives. The World Bank has invested over $1.8 billion in sector operations in and around WHC in the past four decades. These projects have directly and indirectly benefited the conservation and enhancement of WHC. Finally, concessional financing for climate change adaptation and mitigation, while currently targeted at national level, will increasingly find its way to sub-national governments, including WHC. The report reviews some of the financial mechanisms currently in place, as well as the limitations of concessional financing for urban adaptation.

WORLD HERITAGE CITIES ENGAGING IN CLIMATE RESILIENCE AND MITIGATION

Many World Heritage Cities are already engaging in action plans and implementation programs to increase their climate change adaptation and mitigation of their carbon emissions. The triggers for adaptation are generally the increased understanding of vulnerability and risks and the need to build resilience in time. The trigger for mitigation may consist of national or supra-national policies, financial incentives, or the grass-root movements in favor of greener city living. The paper reviews a number of cases of World Heritage Cities already investing in climate change adaptation and mitigation action plans: Paris, Tunis, Edinburgh, Mexico City, Hué, and Quito.

These climate change action plans vary as to the kind of impacts the cities are facing: from flooding to marine inundation, glacier melt and related water scarcity, and heat waves. Not all of these cities are high emitters of GHG, therefore only some of the action plans include mitigation measures. In all cases, the action plans combine where possible adaptation and mitigation responses and integrate the proposed actions with urban development planning and investment programs. Municipalities are in the lead for their implementation and the mainstreaming of climate change in the management of WHC worldwide.

1 World Heritage Cities: A Special Set of Urban Centers

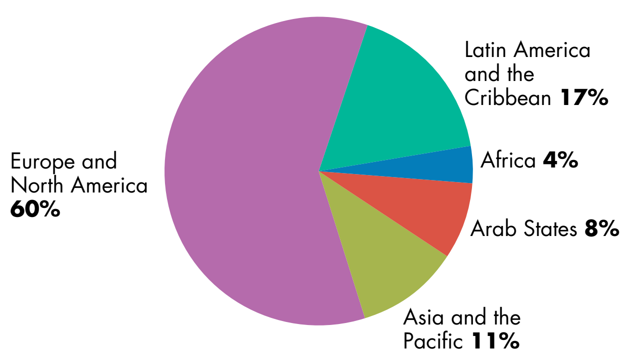
The 237[1] World Heritage Cities (WHC) represent a special set of urban centers across the world. They are identified by their placement on the UNESCO World Heritage List, where they were progressively inscribed in the course of nearly forty years since the establishment of the World Heritage Convention. The inscription process starts with the request of the national governments and is finalized with the approval of the UNESCO Committee, the custodian of the list. They represent about one fourth of all World Heritage Sites, which include natural as well as cultural ones. The reasons for their inscription are related to the unique character of the urban fabric and of the historic buildings that compose them.

Figure 1 presents the distribution of WHC by regions of the world, as defined by UNESCO. Europe and North America host the largest number of WHC with 143, followed by Latin America and the Caribbean with 39, Asia and the Pacific with 25, Arab States with 20, and Africa with 10. The geographic distribution of WHC reflects perhaps as much the commitment of their national governments to promote their recognition, conservation, and future management, as the richness of the various regions of the world in urban heritage. In this respect, it is important to underline that WHC are a subset of "historic cities" worldwide, which are defined in a variety of ways but which clearly include a much larger number of urban centers across the globe, of which WHC are certainly the best known.

WHC are to be found in industrialized countries, emerging economies, and developing countries alike. When classified according to the list of countries which are World Bank clients, i.e., recipients of international development aid financing, WHC are equally represented, with 125, or 53 percent, to be found in industrialized countries, and 112, or 47 percent, to be found in emerging economies and developing countries. The two groups of WHC do not benefit from the same level of recognition, institutional support, conservation, and rehabilitation resources. With greater international support, more historic cities from emerging economies and developing countries could eventually be included in the World Heritage List by UNESCO, thus changing the current regional distribution.

The original historic cores of WHC have become generally part of much larger urban agglomerations. These are at times limited to a few hundred thousand inhabitants and are at times reaching many million. This radical transformation of the global urban landscape has profoundly modified the role and reduced the relative importance of the historic cores in the overall functioning of the agglomerations to which they belong, but not necessarily their symbolic, cultural, spiritual, and artistic values.

Figure 1. Distribution of WHC by region



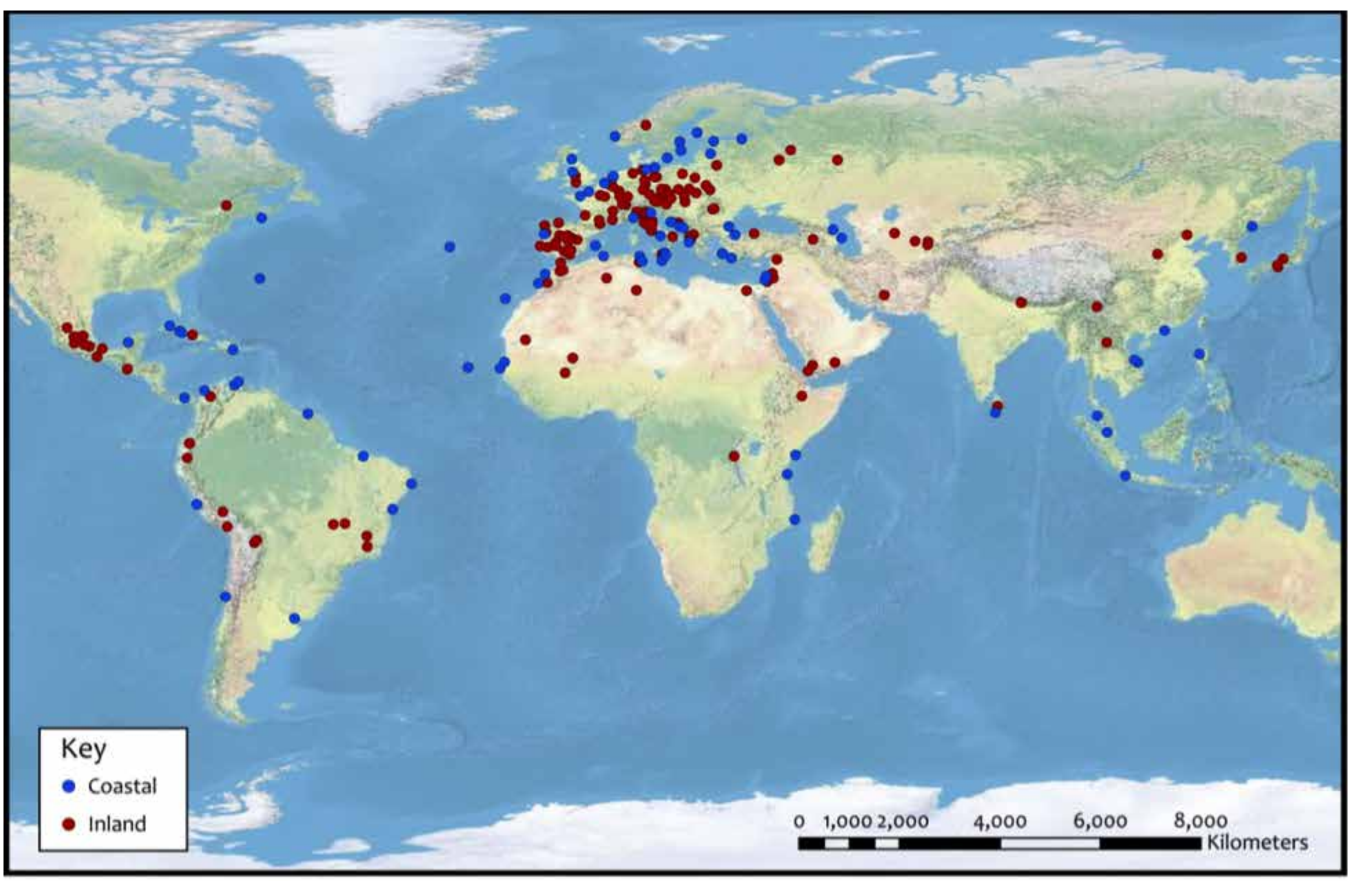
[1] This study was conducted based on the 2010 list of World Heritage cities.

2 Climate Change Risks for World Heritage Cities

Like all cities in the world, WHC are vulnerable to the increasing impacts of climate change, which compounds their exposure to natural hazards. Climate change risks vary very much by location. Coastal cities (e.g., Cartagena), which represent one full third of WHC, are exposed to increasing sea-level rise, storm surges, marine inundation, and coastal erosion risks. Other cities may be exposed to the consequences of glacier melt (e.g., Quito) or of increasing ambient temperatures with impacts on human health via heat waves and increased ambient pollution. Urban flooding and landslides are prevalent risks for many WHC as climate change in many parts of the world induces increased precipitations and extreme weather events. Natural hazards such as earthquakes and tsunamis, while not related to climate change, add to the urban vulnerability of WHC worldwide.

The vulnerability of WHC to natural hazards and climate change is higher than that of modern cities on account of the particular fragility of their urban fabric and of the historic buildings of which they are composed. The vulnerability of a city to climate change and natural hazards is due to its physical characteristics, but it is also due to the ability to respond to its residents and local institutions. In general terms, WHC in Europe and North America are inhabited by higher income residents; real-estate values are high, and regulations and institutions are in place for their protection and conservation. Conversely, in emerging economies and developing countries, WHC are mostly inhabited by poorer populations; real-estate values are low, and resources for conservation are rarely sufficient.

Figure 2. Geographic distribution of WHC based on their location in coastal and inland areas



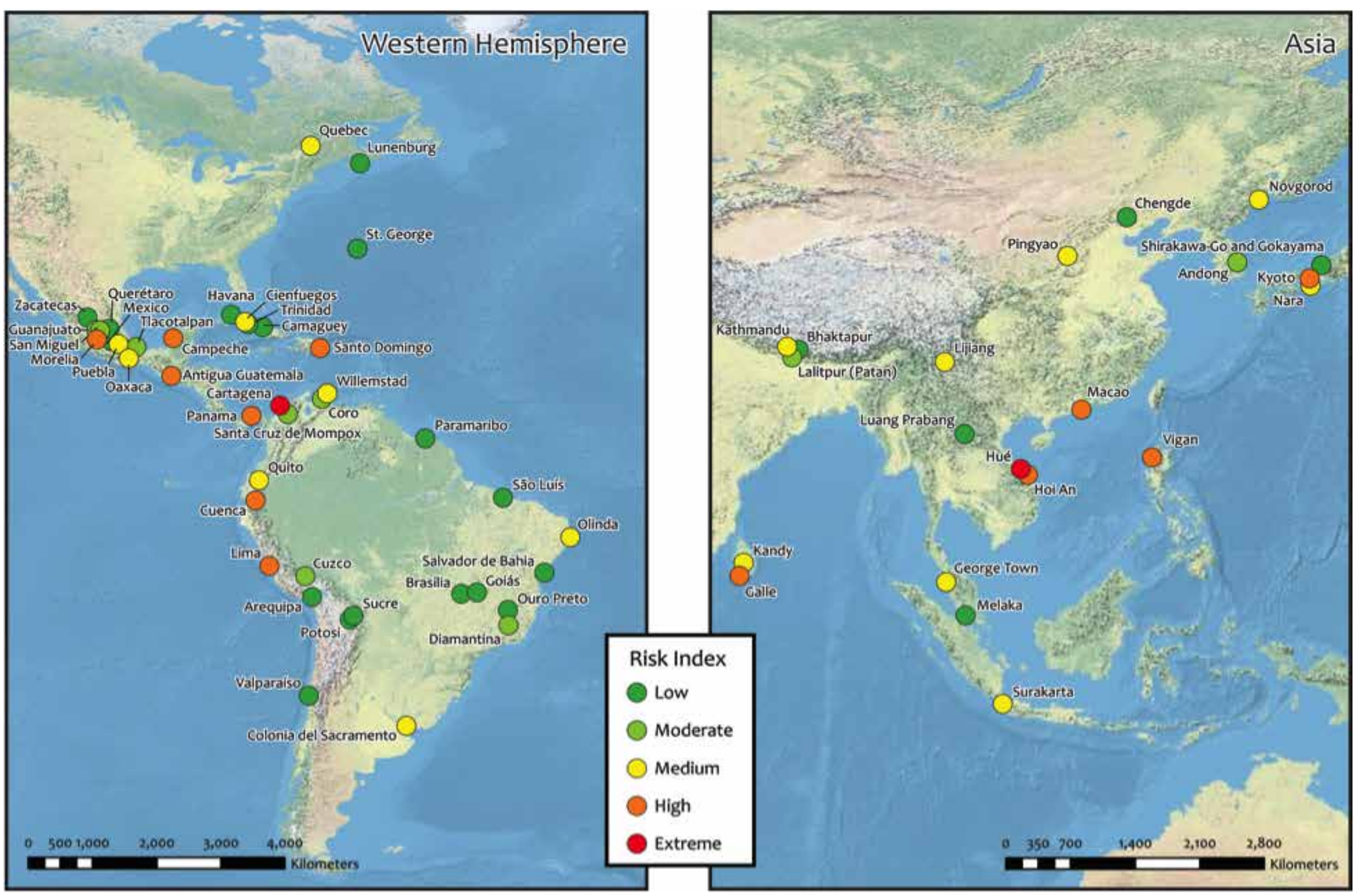
Source: authors.

The World Bank team has conducted a detailed review of the risk exposure of the 237 WHC using the Global Risk Data Platform PREVIEW of the United Nations Environment Program (UNEP), initiated in 1999 by UNEP/GRID-Geneva. The Global Risk Data Platform has now evolved following all standards for Spatial Data Infrastructures (SDI) and providing all the web-services in compliance with the Open Geospatial Consortium (OGC). The data currently present in the platform has benefited from new developments made for the Global Assessment Report on Disaster Risk Reduction version 2009 and updated for the 2011 version. The outcomes were developed by a large, interdisciplinary group of researchers from around the world, making global disaster risk more visible as a key step towards mobilizing the political and economic commitment needed to reduce it. Methodologies on hazards modeling were reviewed by a team of 24 independent experts selected by the World Meteorological Organization (WMO) and the United Nations Education and Scientific Cultural Organization (UNESCO).[2]

The Global Risk Data Platform provides world maps generated on the basis of a Multi-Hazard Index, compounding risks of cyclones, earthquakes, floods, and landslides, and classifying world locations in five categories of risk: (1) Low; (2) Moderate; (3) Medium; (4) High; and (5) Extreme. Each of the 237 WHC was geo-referenced based on latitude and longitude coordinates. The points were then overlaid with the global Multi-Hazard Risk grid. The risk value at each point was extracted and visualized. The specific exposures of WHC to flooding and landslides (two risks compounded by climate change) were also calculated (see figures 5-6 and tables 1-3).

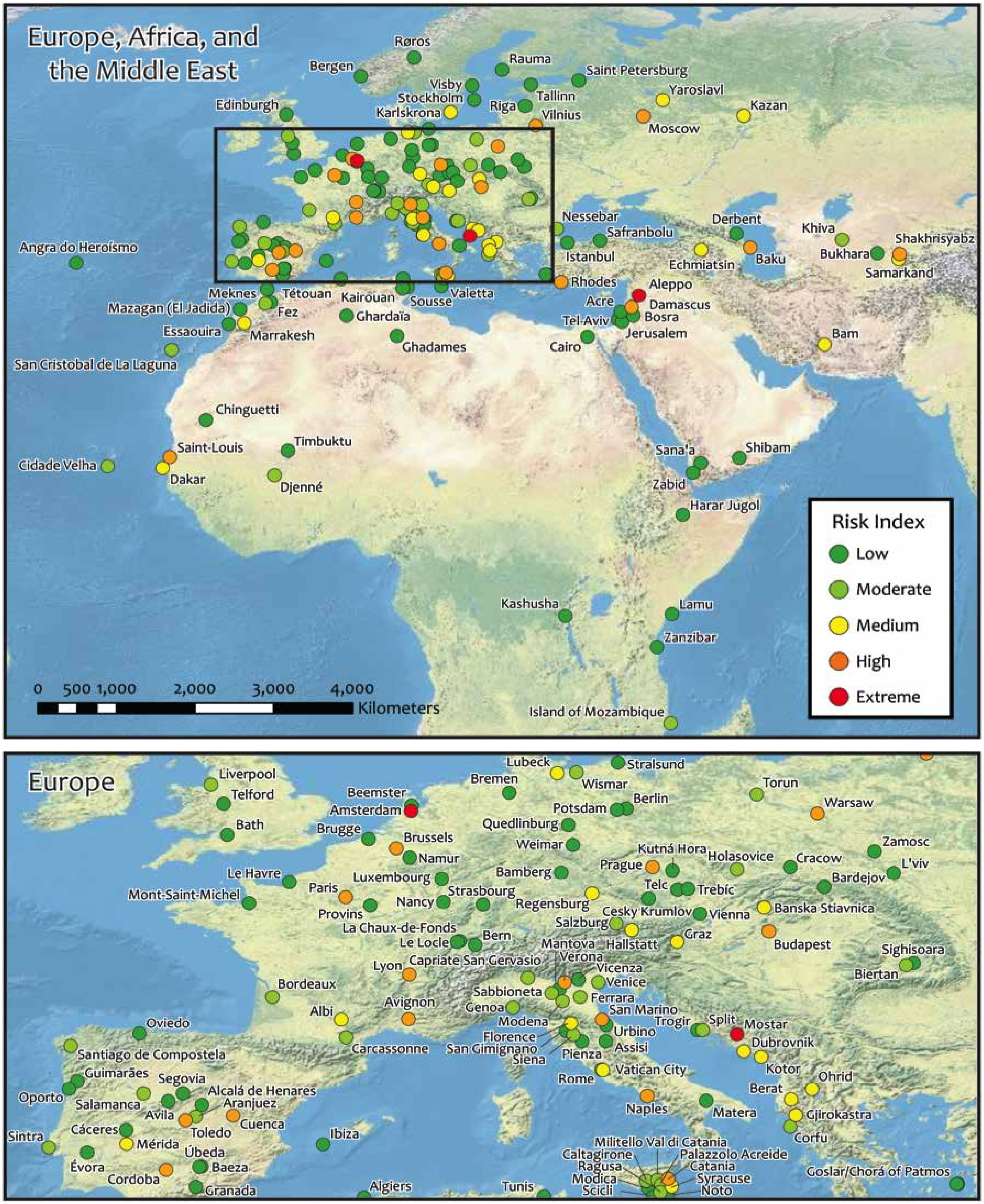
[2] The platform is accessible at: http://preview.grid.unep.ch and is supported by the United Nations International Strategy for Disaster Reduction (UNISDR).

Figure 3. Global distribution of WHC based on multi-hazard risk data



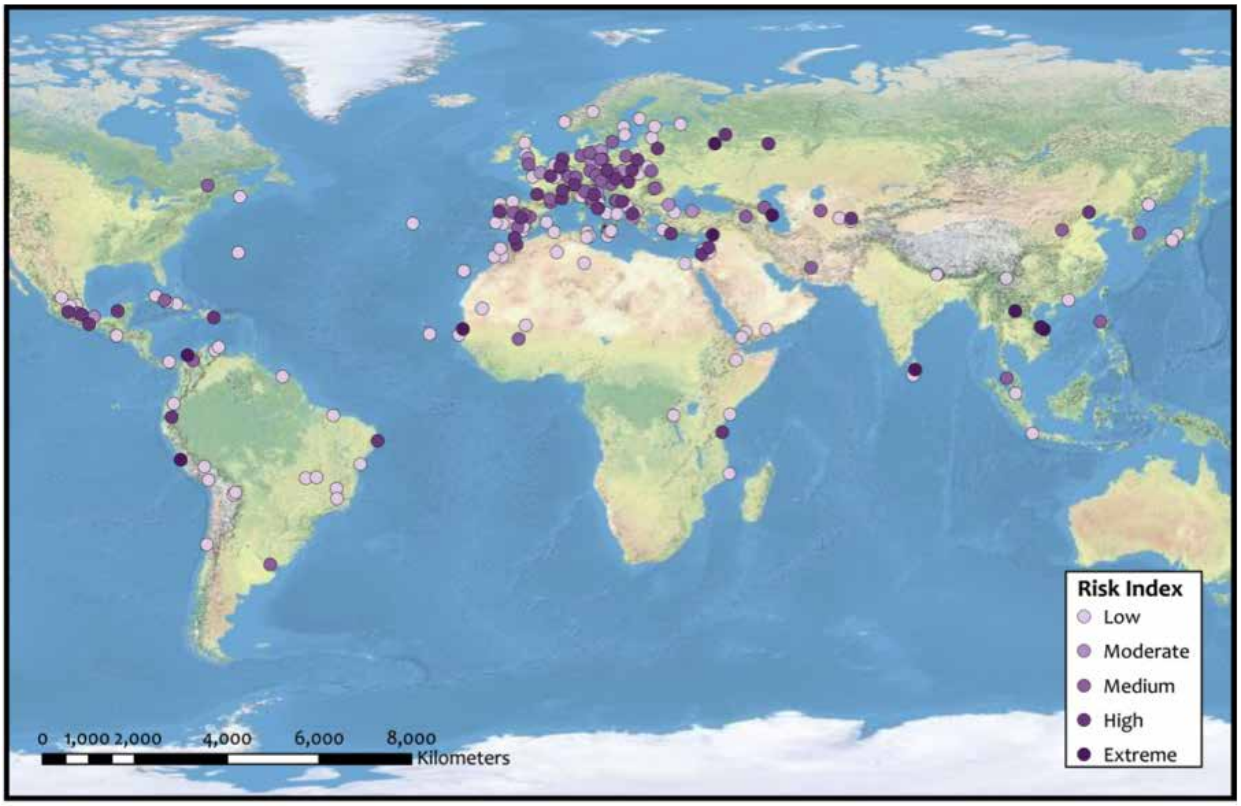
Source: authors.

Figure 4. Geographic distribution of WHC based on multi-hazard risk in Europe, Africa, and the Middle East



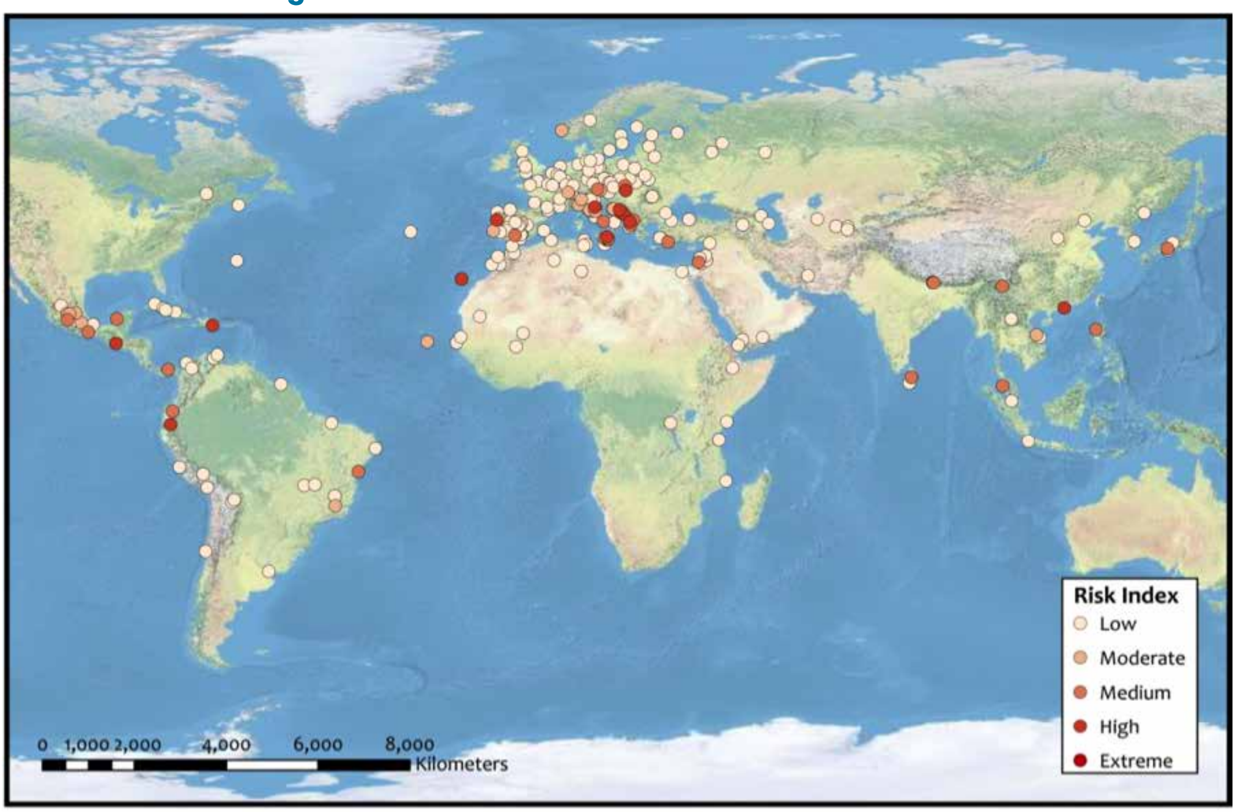
Source: authors.

Figure 5. Distribution of WHC based on flood data



Source: authors.

Figure 6. Distribution of WHC based on landslide risk data



Source: authors.

Note: The following rankings are directly derived from the UNEP/GRID described above, as applied to the geo-referenced WHC. Different methodologies may generate different rankings of WHC most at risk. The UNEP-GRID multi-hazard index does not account for the institutional capacity to build resilience.

Table 1. Top ten WHC by multi-hazard risk

1	**Hué**	Viet Nam	Asia and the Pacific
2	**Aleppo**	Syrian Arab Republic	Arab States
3	**Cartagena**	Colombia	Latin America and Caribbean
4	**Amsterdam**	Netherlands	Europe and North America
5	**Mostar**	Bosnia and Herzegovina	Europe and North America
6	**Morelia**	Mexico	Latin America and Caribbean
7	**Santo Domingo**	Dominican Republic	Latin America and Caribbean
8	**Paris**	France	Europe and North America
9	**Lima**	Peru	Latin America and Caribbean
10	**Vilnius**	Lithuania	Europe and North America

Table 2. Top ten WHC by flood risk

1	**Hué**	Viet Nam	Asia and the Pacific
2	**Aleppo**	Syrian Arab Republic	Arab States
3	**Kandy**	Sri Lanka	Asia and the Pacific
4	**Baku**	Azerbaijan	Asia and the Pacific
5	**Hoi An**	Viet Nam	Asia and the Pacific
6	**Lima**	Peru	Latin America and Caribbean
7	**Cartagena**	Colombia	Latin America and Caribbean
8	**Saint-Louis**	Senegal	Africa
9	**Moscow**	Russian Federation	Europe and North America
10	**Luang Prabang**	Lao People's Democratic Republic	Europe and North America

Table 3. Top ten WHC by landslide risk

1	**Mostar**	Bosnia and Herzegovina	Europe and North America
2	**Santo Domingo**	Dominican Republic	Latin America and Caribbean
3	**Dubrovnik**	Croatia	Europe and North America
4	**Oporto**	Portugal	Europe and North America
5	**Cuenca**	Ecuador	Latin America and Caribbean
6	**Antigua**	Guatemala	Latin America and Caribbean
7	**San Marino**	Republic of San Marino	Europe and North America
8	**San Cristobal**	Spain	Europe and North America
9	**Berat**	Albania	Europe and North America
10	**Macao**	China	Asia and the Pacific

The role of municipalities in ensuring the resilience and adaptation of WHC is critical. This is particularly true in emerging economies and developing countries where national institutions and financial resources for urban development and historic city conservation may be limited. Local governments in charge of WHC already have the special responsibility of managing the historic urban assets, protecting them from encroachment and decay, and contributing to their conservation and contribution for the economic, social, and cultural life of the city. These tasks come in addition to the general responsibilities of managing urban growth, delivering urban services, mobilizing financial resources, and ensuring urban livability of the entire urban agglomeration. Increasing urban resilience to natural hazards and adaptation to climate change of WHC are additional tasks for which municipalities need all the support they can get, from national governments and from international institutions alike.

Adaptation and Resilience Action Plans define responses to climate change and natural hazard risks. They are the result of a combination of technical assessments, consultations among local and national stakeholders, and careful operational and financial planning. Once defined, climate action plans need to be supported politically, institutionally, and financially, in order to get implemented. In the case of World Heritage Cities, climate action plans have to:

- **Concern the entire agglomeration of the WHC**, rather than only the historic urban core, as many of the hazards and risks concern the entire agglomeration and equally the responses must be found at the urban scale, while addressing the specific vulnerabilities and risks of the fabric, buildings, and human activities of the historic city.
- Integrate resilience and adaptation within urban development and conservation plans. Rather than planning separately in order to deal with natural hazards and climate change risks, resilience and adaptation responses should be incorporated in urban planning instruments and in the conservation plans and regulations.
- Be based on priority risks and incorporate specific future climate scenarios for their locations. While some risks are common to clusters of WHC, such as coastal cities, ultimately each city is a unique case which requires careful forecasting of future climate change impacts for the location, which can only be obtained with down-scaling models and detailed risk assessments.
- Integrate resilience and adaptation in addition to mitigation of greenhouse gas (GHG) emissions. Many actions that are required to improve the adaptation of a WHC to climate change also contribute to reducing its GHG emissions. For instance, thermal insulation of the building envelopes to deal with increased ambient temperatures will also reduce the energy consumption, contributing to emissions reduction.

3 Carbon Emissions from World Heritage Cities

$C0_2$ emissions, the primary cause of climate change, are correlated to the quantity of energy consumed in its various forms by end-users. The increased demand for energy for human activity—for refrigeration, transportation, heating, cooling, and industrial processes, among others—is currently mostly met with non-renewable sources. Non-renewable energy largely requires the combustion of fossil fuels, which are the main contributors to the rising of greenhouse gas emissions and climate change. A move towards limiting carbon dioxide emissions to the atmosphere is going to require both (1) a substantial increase in the share of renewable energy (naturally replenished), and (2) a substantial effort to reduce the amount of energy required for a given energy service or level of activity.

Studies suggest that around 70 percent of energy worldwide is consumed in urban areas. Although it is still a subject of debate what exact share of global emissions can be attributed to cities, it is clear that with increased urbanization the share of urban GHG emissions will continue to grow. Cities contribute to climate change mainly through: (i) the direct GHG emissions generated in the city itself, (ii) the emissions embedded in the energy produced outside the city boundaries, which is required to produce goods and services consumed within the city, and (iii) changes in atmospheric chemistry triggered by common urban pollutants. Although some might argue that the total GHG emissions can vary greatly with the way in which they are accounted—whether one accounts for the three categories mentioned above or just for the first one—a life-cycle approach to emissions accounting points at urban areas as being at the same time the "highest emitters" and the best prepared to tackle climate change mitigation.

Cities must reduce local energy demand while national governments must clean its supply. The demand for energy in cities is the main source of emissions, and it comes in general in three main forms: (i) energy required for transportation, (ii) energy required for heating, cooking, and industrial processes, and (iii) electricity used for cooling and other residential uses. Each of these categories has one or more sources, each with an associated energy intensity and carbon content. The main sources of energy required for transportation are gasoline, diesel, and to a lesser extent compressed natural gas. The sources of energy required for cooking, heating and industry are oil and natural gas. Finally, the main sources of energy to produce electricity are coal, nuclear, hydropower, and oil, just to name a few. The sources of energy and the city's final energy mix are in general determined by levels of government beyond the metropolitan area, and therefore beyond the domain of urban public officials.

Per capita GHG emissions vary greatly depending on urban density, lifestyles, mobility patterns, and energy efficiency. These criteria, to a larger extent, are determined by urban form, land use patterns heating systems, economic activities, and transportation systems. For instance the Metropolitan Area of Mexico City has a 2.8 tCO_2e/capita[3], Paris a 5.2 tCO_2e/capita, Brussels has a 7.5 tCO_2e/capita, Chicago has 12 tCO_2e/capita, Minneapolis 18.34 tCO_2e/capita, Sydney 20.3 tCO_2e/capita, and Denver 21.5 tCO_2e/capita[4]. Although a broad comparison between GDP per capita and CO_2 emissions per capita suggests a general correlation between the two variables, an assessment of the correlation over time shows a slightly different story. Cities in Europe have become wealthier without the sharp increase in GHG emissions associated to the increase in GDP of cities in North America. A tradition of living in historic cities and the importance of compact city development as modelled after the WHC have played a major role as WHC are more "climate-friendly" than newer cities.

In general, historic cores of World Heritage Cities have lower emissions compared to the newer parts of town,

[3] Tonnes of carbon dioxide equivalent.

[4] Hoornweg, 2011.

both on the individual building level and the urban fabric as a whole. Historic cores are more energy efficient in general since they were built based on sound elements of environmental sustainability and before the age of air conditioning and auto transport. Such neighborhoods are more energy efficient and have lower emissions due to three factors: (1) building-related energy consumption, (2) the compactness and density of urban form, and (3) efficient mobility patterns.

Building-related energy consumption is attributed to three categories: embodied energy, operating energy, and building transportation energy.[5] Embodied energy is the initial energy investment that is required to construct a building. It can include the up-front energy investment for extraction of natural resources, manufacturing, transportation, and installation of materials. Embodied energy is used by preservation advocates to convince policy makers that adaptive reuse is more energy efficient than building a new construction (see box 1). Operating energy is needed to operate a building and includes energy consumed by heating and cooling systems in addition to all other electrical needs of a building. Operating energy is a major element in evaluating building-related energy

Box 1. Building reuse almost always offers environmental savings over demolition and new construction

The National Trust for Historic Preservation, an American advocacy organization, recently published an extensive report about the potential environmental impact reductions associated with building reuse. This report uses the Life Cycle Analysis methodology and compares the relative environmental impacts of building reuse and renovation versus new construction over the course of a 75-year life span in six different building typologies and concludes with three major findings:

- **Building reuse almost always yields fewer environmental impacts than new construction.** Energy savings from adaptive reuse can be between 4 and 46 percent compared to the new construction. While these reductions in environmental impact reductions of individual buildings sometimes may not seem significant, they can have a substantial role in reducing emissions when considered on the city scale.
- **Reuse of buildings with an average level of energy performance consistently offers immediate climate-change impact reductions compared to more energy-efficient new construction.** Unlike the popular belief, the report proves that the CO_2-reduction benefits gained by a new, energy efficient building are neglected by negative climate change impacts associated with the building construction. Basically, a newer construction that is 30 percent more energy efficient than an average older building will take 10 to 80 years to overcome the negative climate change impacts related to its construction process.
- **Materials Matter: The quantity and type of materials used in a building renovation can reduce, *or even negate,* the benefits of reuse.** Adaptive reuse projects that use new material are less environmentally friendly than the rest.

Another report published by the city of New York on energy use of its buildings indicates very clearly that on average, New York City's buildings perform significantly better than the national average. The report suggests that the city's high performance could be attributable in part to the age of the city's building stock. Historic buildings of New York City perform better on energy efficiency measures than newer buildings. This is because such buildings tend to have less extensive ventilation systems, better thermal envelopes, and/or less dense or energy intensive tenant occupations. This extensive report studies a variety of building types including single family and multifamily, office buildings, commercial, and mixed-use. As an example, the report concludes that while there are many factors to be considered, newer office buildings in New York City tend to use more energy per square foot than older ones. This trend is generally true for buildings dating back to the early 1900s, with each 20-year group using more energy per square foot than the prior group. The energy usage of the office building typology has also increased overtime from buildings before 1930 to buildings built after 1990, showing that the oldest office buildings are performing the best in energy usage.

Source: The Greenest Building: Quantifying the Environmental Value of Building Reuse. National Trust for Historic Preservation. Washington DC. 2012.

Source: The New York City Local Law 84 Benchmarking Report. August 2012. http://www.nyc.gov/html/gbee/downloads/pdf/nyc_ll84_benchmarking_report_2012.pdf

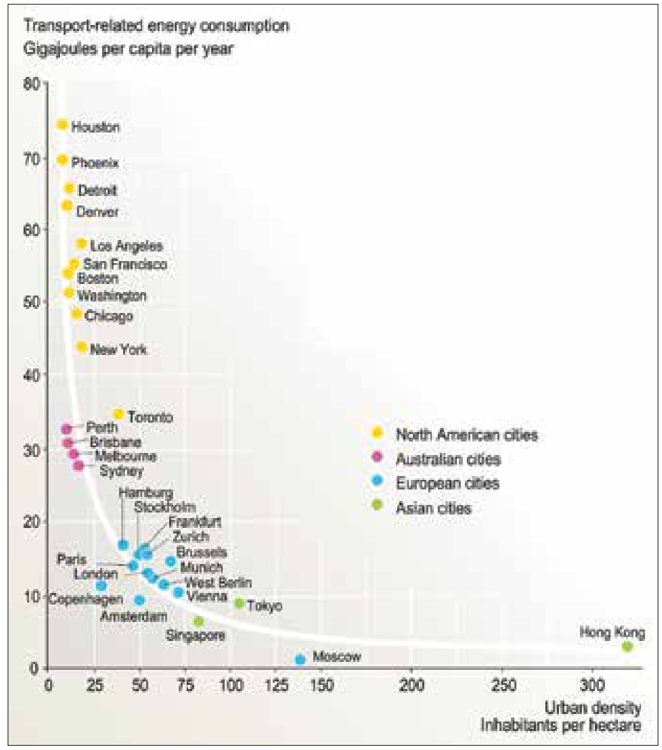
[5] *The Greenest Building: Quantifying the Environmental Value of Building Reuse.* National Trust for Historic Preservation. Washington DC. 2012.

impacts and in general is a large portion of energy use in a city. For example, in 2006, the operating energy of residential and commercial buildings in the United States constituted about 39 percent of total energy consumed nationwide. In most climates, historic cities have lower operation energy than new construction. The reason can be attributed to the absence of heating and cooling systems in historic buildings and their passive design; passive survivability (building operates without energy inputs for key functions, such as during a power failure); and the compactness of the urban form and positioning of the buildings next to one another, which acts as an insulation system. Building transportation energy is related to mobility patterns and is the energy that is used to transport people to and from a building. Due to transportation efficiencies in the historic cores, this category of energy is minimal compared to the newer parts of the city.

The dense and compact urban form of historic cores has several climatic advantages. The historic urban form is concentrated and uniform in its buildings and accommodates various land uses in a tight relationship with each other. The design of the historic urban form minimizes the exposure of the buildings to direct solar radiations. Streets and alleys within the city function as channels for air movement and heat exchange. There are few large open spaces throughout the urban fabric which reduce exposure to the sun and the wind. Additionally, aside from monumental structures, few tall buildings can be observed in the historic neighborhoods. The height of the buildings is uniform throughout the city to prevent the air from downward diversion, resulting in unwanted turbulence. The compact urban form of historic urban cores has a density sometimes higher than the new high-rise developments.

Urban density is the best predictor of urban GHG emissions/capita from the transport sector. There is evidence of strong correlation between energy consumption and urban density.[6] For instance, North American cities like Huston, Phoenix, and Detroit are on the most energy intensive side of the spectrum, with higher energy consumptions per capita and lower densities. On the other hand, European and Asian cities are consuming less energy per capita and have higher densities. Some historic cities and WHC like

Figure 7. Urban density and transport sector energy consumption



Source: Newman and Kenworthy, 1989. Atlas Environnement du Monde Diplomatique 2007.

Amsterdam, Paris, London, Stockholm, Brussels, and Vienna follow this pattern (see figure 7).

The presence of a historic core is a fair predictor of a historical mono-centric growth pattern, which initially concentrated people, services and jobs within walkable distances and dense urban settings. The mono-centric growth pattern followed by historic cores and WHC, values the distance to a main center, which makes land around the center a desirable and scarce resource, fosters density and minimizes travel in climate-inefficient modes. According to some studies[7] each doubling of average density is associated with a decrease in per-household vehicle use of 20–40 percent and the corresponding decline in emissions. A study of GHG emissions in Toronto[8] concluded that as the distance from the central core increases, the share of automobile emissions begins to dominate the total.

[6] Newman and Kenworthy, 1989.

[7] Gottdiener and Budd, 2005.

[8] VandeWeghe and Kennedy, 2007.

Although the historic core of WHC act as a center, a mono-centric growth pattern can only be followed up to a certain threshold of travel distances, after which a city evolves into a polycentric one. Some might argue that a mono-centric city is favorable to energy-efficient public transit, while a dominantly polycentric city is more favorable to individual transport. Yet, a polycentric city can also favor a more efficient use of public transport by eliminating "empty trips" out of the city center in the morning, and into the city in the evening. The balancing of the demand for travel is critical for reducing a city's carbon footprint.

The patterns of urbanization that WHC have followed beyond their historic cores have resulted in a mix of energy efficiency outcomes. Historic cores are a key axis of the urban system and have been the subject of countless transformations, redevelopment, and reinvention to adapt to time. It is throughout these transformations that WHC have proven to be laboratories for the exploration of new ways of urban living while preserving the uniqueness of their character. Many WHC in Europe have evolved from typical pedestrian-oriented mode, to adapting their narrow streets to the streetcar, all the way to partially accommodating the use of private automobiles. Private motorization has subsequently generated urban sprawl outwards of city centers and has led to energy-inefficient urban development patterns. Transport infrastructure construction has locked in many cities into unsustainable land use, resulting in much more difficult ways to reduce GHG emissions per capita. Nevertheless, the protected historic cores of WHC have often managed to maintain a more energy-efficient lifestyle, in comparison to the newer parts of their urban agglomerations.

The third and last attribute of historic city cores is their efficient mobility patterns. Given their urban features, even if embedded in a much larger agglomeration, the WHC maintain unique characteristics which preserve them as naturally energy-efficient and climate-friendly urban areas, which combine cultural qualities with urban livability. Historic cores have different patterns of mobility in comparison with other parts of the city. These mobility patterns are due to:

- Dense network of paths. Historic cities tend to have a more intensive and narrower road network, as well as smaller-size blocks and buildings, all of which favor less use of space and energy per capita. Greater urban density often translates into vibrant city life as well.
- Zoning that fosters accessibility to mixed services with less vehicle travel. Historic cities favor mixed land-uses, minimizing the distance from residential to productive or commercial areas, which results in compact centers with short commutes.
- Mobility by sustainable modes. The compact structure of historic cities allows for pedestrian and non-motorized mobility and for the use of public transit as the preferential transportation modes, as opposed to the use of private motorcars, in view of the size of the road network and limited parking opportunities.
- Historic cities precede the car era, therefore their streets offer limited space to accommodate on-street parking. Limiting on-street parking is considered to be the second best travel demand management strategy after congestion pricing. Not having parking spaces as a sunk cost in a property makes parking costs perceived as monthly expenditures, therefore motivating residents and commuters to consider cheaper, alternative, and more sustainable options as transit and non-motorized modes.

Converting central areas into pedestrian zones is the low-hanging fruit of GHG mitigation by WHC. Creating such car-free environments promotes energy efficiency and economic growth while creating space for citizens to experience the historic core. World Heritage Cities, especially those in Europe, have made an enormous effort after the 1960s to transform their historic centers into pedestrian zones in which to different extents and under different regulations private vehicles have restricted circulation. J.H Crawford, the champion of the "car-free" concept, has developed a list of noteworthy care-free areas. To be included in the list, a sizeable part of the city must be car-free or have a car-free area that is of an exemplary nature for the national context. WHC dominate the list, with cities such as Vienna or Graz in Austria; Rhodes in Greece; Budapest in Hungary; and Guanajuato and Mexico City in Mexico; among others.

Restriction of private vehicle use is the best strategy to maximize non-motorized transportation. However, pedestrian-zone policies need to be articulated with other tools to guarantee a safe, clean, and attractive environment to citizens. Some of the basic actions include improving lighting in streets and plazas, providing universal accessibility through ramps, sound signaling, and widening and leveling sidewalks, and integrating benches, toilets and vegetation into the historic fabric. Many WHC are promoting bike events and bike share systems—including but not limited to Smart Bike Programs—locating stations close to public transit stations and near attractions, such as plazas and historic buildings. By promoting non-motorized (zero emissions) travel, cites foster outdoor life by creating safe urban environments that invite citizens to interact more. Land use policies that promote social interaction through mixed uses at the neighborhood, the block, and the building level contribute significantly to a more energy-efficient life style. See box 2 for a good example of non-motorized transportation option.

As WHC experience further urbanization, the design principles of the historic core should be replicated. Cities are learning from the development patterns of their historic cores and are replicating those principles as they expand. For instance the Autofreie Mustersiedlung Floridsdorf (AMF) housing project in Vienna replicates many of the elements of the historic center and builds upon those to include newly developed energy-efficient technologies. An interesting feature of this development is that tenants have to abstain from owning a vehicle as specified in the lease agreement. Some of the sustainable features of the AMF are: a passive solar design, low-energy building standards, solar-supported heating, on-site recycling facilities, and on-site grey water treatment. Another example of influencing demand management to create sustainable urban communities is the Greenwich Millennium Village in London where only 20 percent of commuting trips are done by private vehicle and one fourth of all trips are done by non-motorized modes (box 3).

Box 2. Copenhagen or the supremacy of travel by sustainable modes

According to UNEP, 36 percent of Copenhagen's population cycles to work every day. This avoids about 90,000 tons of CO_2 urban emissions annually. For comparison's sake, a ton of CO_2 is emitted when driving an average car from Atlanta to Las Vegas (3,200Km) or by powering the average American home for a month. Copenhagen's policy in favor of urban cycling is equivalent to powering 7,500 American households during a year, i.e., equivalent to 9.2 million gallons of gasoline consumed.

TOMOYOSHI/Flickr.com (Creative Commons)

Box 3. London's Greenwich Millennium Village and private vehicle demand management

Thirty minutes by public transit from the emblematic and UNESCO-protected Tower of London, the Greenwich Millennium Village was designed by architect Ralph Erskine is a unique effort to redevelop a brown-field area into an innovative mixed use sustainable community that seeks to minimize car dependency. Critical to attracting residents to the new area has been offering a smooth and fast commute to downtown London, unbundling parking requirements for residences, offering high quality pedestrian and cycling infrastructure, availability of car sharing, mixed uses — including super markets, schools, health centers, cafes, and so on—green spaces, high density, and "human scale" modern urban design inspired by the urban qualities of historic cities.

Martin/Flicker.com (Creative Commons)

The Greenwich Millennium Village was designed as a sustainable community with CO_2 and specific targets bench-marked against a business-as-usual scenario: reducing by 50 percent the embodied energy used for building construction through the use of materials that require low energy for their production; 30 percent reduction in water consumption by using efficient taps, showers, and toilets; 50 percent reduction in construction waste by introducing segregation and recycling practices; a primary energy reduction of 80 percent through the use of improved insulation standards and use of combined heat and power; and a limit of CO_2 emissions of up to 20Kg per square meter during normal operation (Targets from European Sustainable Development projects, Benchmark Study). An interesting feature of the Greenwich Development Village is that despite a car ownership higher than inner London, the majority (79%) of its commuters travels to work by public transit, and around 25 percent of all trips are done by walking and cycling (ITDP, 2011).

4 Financing Climate Resilience and GHG Abatement in WHC

Financing for the conservation and rehabilitation of WHC mostly comes from local and national government budgets, the resident population, and local businesses. Integrating climate resilience and carbon emissions reduction objectives with conservation and rehabilitation programs creates opportunities for additional funding. Wherever the national or supranational policy context establishes clear goals for carbon emissions reduction, WHC can argue that investments in their urban fabrics generate positive results and climate co-benefits.

International financing for climate change and mitigation and for urban development by the World Bank can promote historic city rehabilitation objectives. The World Bank alone has invested over $1.8 billion in sector operations in and around WHC in the past four decades. These projects have directly and indirectly benefited the conservation and enhancement of WHC. As the World Bank has embarked in financing climate change adaptation and mitigation, it will be possible to combine such objectives with the ones of WHC conservation and urban rehabilitation.

Climate change adaptation and mitigation are public goods that require national and international resources. At the city level, it is a matter of providing protection of exposed assets and resident population and of ensuring the future safety of urban agglomerations in order to remain livable, productive and attractive locations. GHG abatement should be part of the urban transformations and investments pursued to improve access to infrastructure and services for the resident population of fast-growing cities in developing countries and to increase the livability and sustainability of cities in industrialized countries, where GHG emission per capita are currently the highest. Many WHC are already pursuing this agenda.

Incorporating adaptation and mitigation into broader urban development objectives has important financial implications as many of the resources allocated to urban development can be accompanied by requirements to meet climate resilience and carbon mitigation standards. Financing of urban infrastructure such as water and sanitation, transportation, energy distribution and street lighting, and public facilities, is already on-going, either in the form of new construction or of maintenance and retrofitting across all the cities of the world. Additional funding clearly needs to be devoted to obtain significant urban climate resilience and GHG abatement, but these objectives ought to also be integrated, and financed, as a component of sustainable urban growth. Global benefits must be closely related to local benefits in order to garner the support and financing it merits.

Fiscal decentralization has progressively increased the average share of sub-national expenditure, which in OECD countries reached 33 percent in 2005. Therefore regional and local governments in member countries manage significant resources which can be harnessed for climate change action. Urban infrastructure investment financing comes from a variety of sources, including direct central government budgetary investments, intergovernmental transfers to sub-national governments, revenues raised by sub-national governments, project financing by the private sector or via public-private partnerships, resources drawn from the capital markets via municipal bonds or financial intermediaries dedicated to sub-national lending, risk management instruments, and carbon financing. All such sources of financing provide opportunities to implement urban mitigation initiatives in WHC.[9]

Budgetary, fiscal and market-based instruments for urban mitigation

Two main groups of urban regulations, fiscal policies and financial incentives, which are generally under the control of local governments, affect urban carbon emissions: those

[9] ibidem.

related to land-use and those related to transportation. Climate indicators can be introduced to such policies to ensure that carbon mitigation objectives can be met. These regulations and fiscal policies can be adopted by WHC as well.

Land-use impacts carbon emissions through urban form and density, and property taxes will impact land use. In some countries**,** property taxes may be skewed in favor of single-family houses, discouraging compact city development; in the USA, for example, sub-national jurisdictions tax apartments more heavily than single-family homes, considering them commercial real-estate.[0] Elsewhere, like in Greater Copenhagen, the inverse is true, where housing cooperatives are not subject to the municipal property tax. More compact development can be stimulated by introducing split-rate property taxes, as applied in Sydney, Hong Kong, Pittsburg and Harrisburg, and other cities in Denmark and Finland, where land value is taxed more heavily than the buildings on the land, thereby providing an incentive to densify. Many cities depend on land sales for a large part of their revenues, which can create perverse incentives for urban sprawl. In the case of China, local governments have been so motivated to generate revenues from land sale and leasing that they have generated an oversupply of land for construction which in turn has stimulated sprawled development.[11]

Metropolitan or municipal transportation policies and taxes also affect urban carbon emissions. Congestion charges have been applied in a limited number of cities world-wide to control road usage by private vehicles, and some are designed to tax higher-emitting vehicles more heavily, like in London and Milan. Congestion charges have been observed to reduce GHG emissions from transport up to 19.5 percent in London, where receipts are used to finance public transport, thus combining global and local benefits very effectively. Parking charges have led to a 12 percent decrease in vehicle miles of commuters in US cities, a 20 percent reduction in single car trips in Ottawa, Canada, and a 38 percent increase of carpooling in the city of Portland in the USA. In some metropolitan regions, transportation-related taxes are used to fund mass transit systems by applying value capture taxes to the increase in property values arising from public infrastructure development, as in Hong Kong, Milan, and Bogotá. In the Paris metropolitan region, companies employing nine or more employees experience a surcharge of salary rates of up to 2.2 percent, which is dedicated to public transit and provides around 70 percent of the revenues of the metropolitan transport authority.[12]

Other financial instruments beyond budgetary resources, taxes, and user fees come into play for municipalities and their utility companies in order to proceed with investment plans related to increasing the energy efficiency and decreasing the carbon emissions of urban systems. Energy Services Companies, or ESCOs, generally finance their energy efficiency investments via direct borrowing or via loans to end-users, which may be covered via utility bills or property taxes. Municipal bonds can also be issued for raising capital for municipal energy efficiency programs. For instance, the city of Varna in Bulgaria issued municipal bonds to obtain financing to retrofit and modernize the city's street lighting system, a project which had a payback period under three years. The bond raised three million Euros, had a 9 percent interest rate, and was repaid over a three year period.

Financial resources for urban mitigation in industrialized countries

Some G20 countries, and in particular those of the European Union, have made significant commitments, with an EU target of GHG reduction of at least 20 percent below 1990 levels. This is accompanied by the specific climate policies of the individual member states, such as the United Kingdom, which has a national reduction target of 80 percent by 2050. The EU and member countries have put in place EU-wide and national programs to support climate mitigation and related urban transformations. Given the high rate of urbanization of EU countries and the high percentage of carbon emissions from their urban areas, estimated at between 70 and 80 percent of the total, a large share of the mitigation programs and related financing concern cities, directly or indirectly. Many European cities are WHC.

[10] Goodman, 2006.

[11] OECD, 2011.

[12] ibidem.

EU structural funds have a key role to play in greening national and regional spending programs and serve as leverage for the release of additional private and public funds. For the 2007-2013 period, community funding for energy efficiency, co-generation, and energy management totals over 4 billion Euros. In addition, the EU-financed 450 operational programs include investing 9 billion for energy-related projects and nearly 5 billion for renewable energies. Presumably much of this funding will affect cities directly or indirectly. For instance, the JESSICA program (Joint European Support for Sustainable Investment in City Areas) an initiative of the European Commission in cooperation with the European Investment Bank and the Council of Europe Development Bank, currently has commitments of over 1 billion Euros with member states and regions. In Lithuania, the program will invest over 220 million Euros in energy efficiency projects for retrofitting multi-apartment buildings via loans to homeowners, co-financed nationally.

In France, each region is permitted to use up to four percent of its funding for energy efficiency investments and greater use of renewable energy in existing social housing and run-down co-ownership buildings with low-income residents. Specific energy saving targets are to be achieved in all cases. In London, JESSICA funds are being applied to investments in environmental infrastructure (decentralized energy systems, waste processing and reprocessing facilities) for areas of intensification and urban regeneration, in order to create sustainable places for businesses.[13] Finally, the EU's Emissions Trading System (ETS), while not focusing on the urban sector, per se, but rather on heavy industrial production and energy generation, will contribute to bring cleaner energy sources on line for urban end-users.

International sources of urban adaptation and mitigation financing

Emerging economies are making important commitments to and investments in emissions reduction. In 2008 India introduced its first National Action Plan on Climate Change, which includes the objective of dramatically increasing the use of solar energy and enhance energy efficiency, including within the context of urban areas. The Plan aims to make habitat sustainable through improvements in energy efficiency in buildings, management of solid waste, and modal shift to public transport. Mexico's Climate Change Program aspires to achieve 50 percent emissions reductions by 2050, and China's national Climate Change Program states that the country will achieve the target of about 20 percent reduction of energy consumption per unit of GDP by 2010 and consequently reduce carbon emissions. Non-G20 countries, which collectively account for only 10 percent of global GNP, consequently have lower emissions levels and fewer available financial resources for mitigation policies and programs.

Bilateral aid flows to support GHG emissions abatement are monitored by the Development Assistance Committee (DAC) using the "Rio marker on climate change mitigation". The latest available figures show that in 2010-2011 DAC members provided over $16 billion to developing countries for mitigation projects in the sectors of transport, energy, general environmental protection, forestry, and water. Typical projects, relevant to urban areas, will include waste management, sewage treatment, renewable energy, energy efficiency of generators, machines and equipment, demand-side energy management, preparation of inventories, and capacity building (OECD-DAC, 2014).

The Clean Development Mechanism (CDM) and the Joint Implementation program provide resources, under the United Nations Framework Convention for Climate Change, to developing countries for carbon emissions reduction, but urban usage of these instruments has been marginal so far. Of the more than 2,000 CDM projects registered as of March 2010, only a limited number have been urban projects, mostly targeting landfill gas or waste water treatment, and there have been only two urban transportation projects. A similar marginal number of CDM projects (0.57%) and certified emissions reduction by 2012 (0.16%) deal with energy efficiency in the urban building sector (OECD, 2010).

The Global Environment Facility (GEF), a multilateral financial mechanisms established in 1991, is the largest source of grant and concessional financing for mitigation. Up to 2009, the GEF had invested $2.7 billion to support

[13] Rezessy, Bertoldi, 2010.

climate change mitigation projects in developing countries and economies in transition, of which $1 billion was during the 2007-2009 period. This funding has leveraged another $17.2 billion in project co-financing and helped avoid more than 1 billion tons of GHG, an amount equivalent to nearly 5 percent of annual human emissions. Among its strategic programs, energy efficiency in buildings and appliances is of relevance for cities.

Multilateral Development Banks (MDB) have been increasingly contributing to climate change financing. Their investments tripled from $5.4 billion in 2006 to $17 billion in 2009, accompanied by increased advisory and policy services and leveraging additional financing for a total cost of projects and programs estimated at over $55 billion. Of the $17 billion invested, demand-side energy efficiency and renewable energy represent $7.2 billion and climate related Development Policy Loans about $4.9 billion. Funding from MDBs assist developing countries in framing climate change policies and low-carbon, green growth strategies, which can then become the roadmap for investments from various sources and orient public sector spending.

International financing for climate change adaptation is largely insufficient, despite some progress. The international community mobilized first around GHG mitigation in the hopes that the adoption of a global framework agreement, the precursor of which has been the Tokyo Protocol, would have contained GHG emissions, fostered a thriving market of certified emissions, and contained global warming within acceptable limits. It has now become apparent that a global deal is hard to achieve and that manifestations of climate change are increasingly impacting the various regions of the world, with the hardest hit, paradoxically, being the ones that emit the least GHG. Some financial resources for adaptation are made available by the GEF, and the Adaptation Fund is funded from a 2 percent share of proceeds from the issuance of certified emission reductions under the Clean Development Mechanisms. The Pilot Program for Climate Resilience (PPCR), administered by the World Bank on behalf of a number of donors, also provides concessional financing for adaptation. However, none of these sources have invested significantly in urban areas, and the intersection with historic cities and WHC is still to be established.

5 Case Studies of WHC Climate Change Adaptation and Mitigation

This section presents six case studies and aims at familiarizing the reader with current practices and trends with regards to climate change mitigation and adaptation actions in WHC. These cities were chosen from various geographic regions and vary in the nature and intensity of risks they face. They are also different in terms of their GDP per capita, which impacts their ability to access financial resources needed for climate change protection measures. The cities also vary greatly in their size and economic activities, ranging from a mega city such as Mexico City with 21 million inhabitants to Hué, a small city with less than 500,000 people. The city of Hué has had a limited growth outside its historic structure, while Mexico City's historic center is only a fraction of its area today.

Although the cases are different from one another, they also share some common facts. The climate change action plans all show that such plans need to be prepared with an interdisciplinary focus and integrated approach. In some cases, such as Mexico City, climate change actions are paired with large-scale urban development and infrastructure projects, such as building BRT systems or the addition of a metro line. It demonstrates that climate measures should be undertaken while the city is planning its capital investment projects. In developed countries' cases, such as Paris, the transport sector is already in place and is currently improving its inter-city connections to the growing suburbs.

Almost all actions in all case studies promote the role of awareness raising, GHG inventories, and creation of databases as a starting point. Paris is far advanced in this manner, planning on establishing an energy and climate inventory for each and every building. Quito has developed a campaign for its youth, to familiarize them with concepts and issues related to climate change, hoping that the new generation will take this serious agenda forward by understanding it clearly in early stages.

Another key common feature is the participation of several entities in climate change action planning, under the supervision of the local government. Edinburgh illustrates this well. The City Council has prepared a World Heritage Management Plan, an Action Plan, and a Fire Plan. Other entities in the city have contributed to protection of the World Heritage status of the city as well. The "Water of Leith" management plan devotes a section to the World Heritage status of the city and actionable measures taken to protect it. The city's energy entity produced a plan on energy efficiency measures, of which many count as climate change mitigation actions. The city also has a Biodiversity Action Plan, which aims at protecting the natural and cultural assets of the city as a whole. Edinburgh is a perfect example of a World Heritage city, working in all sectors to protect and promote its World Heritage, while adapting to climate change and mitigating its effects.

Overall, the cases present actions related to most known risks of climate change. They cover floods, landslides, coastal erosions, glacier melts, droughts, saltwater intrusion, water scarcity and heat waves, among others. On the mitigation side, they incorporate measures related to energy-efficiency in buildings and public utilities, transport, waste management, and water resources use. While in some cities the actions explicitly address the historic urban fabric, in others they focus more on the urban agglomeration as a whole, of which the WHC is the central core.

PARIS[14]

Figure 8. Historic monuments along the banks of the River Seine

Angelina Dimitrova/Shutterstock.com

The collection of monuments on the banks of the River Seine was listed as World Heritage in 1991. The world-renowned Louvre and Eiffel Tower, in addition to Notre Dame, palaces and governmental structures, and the development of Paris as a whole has been linked to the river and its banks. The UNESCO inscription recognizes this role. The Greater Paris region or Ile-de-France with a population of 12 million is one of the largest and most densely populated areas in Europe, with a service-based economy gearing towards finance and information technology, while still continuing its manufacturing roles.[15]

Paris has a good baseline of GHG emissions, estimated at 5.2 tons per inhabitant in 2006, which considering its scale and density is notably low and is better than Berlin's and London's.[16] Energy usage in Paris is also at a reasonable rate. One of Paris' best performances however is in the building energy efficiency category. Its residential buildings consume energy on a scale below the annual average of European cities, which is considerable given the city's well-preserved historic buildings. Nevertheless, the city established a new set of thermal regulations in 2010 and has planned on renovations and setting energy efficiency measures for its historic structures.

Risks

With the current trend in energy price increase, the city of Paris will face a major energy deficit in the heating and transport sectors if it continues to consume energy at the current rate. This is expected to affect lower-income families the most. In 2003, Paris experienced a long and intense heat wave, with adverse effects on residents' health. A 127 percent increase in death rates was observed that August, effecting mostly vulnerable and exposed populations. Paris also faces the risk of flooding from the river Seine. The last major flood happened in 1910. If a flood with the same intensity happens today, it would distress 3,000,000 people. The potential flood could harm electricity and water distribution systems and could disable the city's economy for months. Paris' buildings are the source of 27 percent of its GHG emissions, mainly through heating. However, the long life of buildings in

[14] Most of this section is excerpted from "Plan Parisien de lutte contre le déreglement climatique" unless otherwise stated.

[15] Siemens European Green City Index. http://www.siemens.com/entry/cc/features/urbanization_development/all/en/pdf/report_en.pdf.

[16] World Bank data accessed October 2011 http://siteresources.worldbank.org/INTUWM/Resources/GHG_Index_May_18.pdf.

Paris is a good measure for reducing emissions since new construction emits much more CO_2 due to building materials, energy use, and transport.

Actions

The Paris Climate Protection Plan was published in 2004 and envisions a series of mitigation and adaptation measures for the period of 2004-2020. The city of Paris targets a 30 percent emissions reduction (against the 2004 baseline), a 30 percent reduction in energy consumption in municipal buildings and street lighting, and plans on procuring 30 percent of its energy usage from renewable sources. For Ile-de-France (Paris Metropolitan Region), these numbers are 25 percent emissions reduction, 25 percent reduction in energy consumption, and 25 percent share of renewable energy respectively.

Mitigation Actions

Paris' carbon audit in 2004 showed that, tourism sector aside, three sectors are producing 80 percent of the city's emissions: buildings, passenger transport, and goods transport. Most of the mitigation measures proposed in the Paris Climate Plan focus on these sectors. In order to reduce energy consumption in the building sector, the city has launched a detailed plan to address energy efficiency issues of governmental buildings and social housing.

There are 3,000 public buildings in Paris, and the city plans to reduce their energy consumption by 39 percent by 2020. In doing so, Paris focuses on reducing consumption levels, improving energy efficiency, and using renewable energy sources. To reduce energy consumption in public buildings, the first step was to organize an information campaign and public energy consumption figures, to inform the employees about climate change and its negative impacts. In addition, each public building is subject to an energy audit by the city to determine the necessary budget for renovations and thermal insulations. The city's public buildings will be subject to thermal renovations, which will reduce GHG emissions by 12 percent. Insulations are planned to be installed on the outside of the buildings. However, due to the historic nature of many of these structures, a working group has been formed to work with government entities responsible for historic monuments.

Energy efficiency measures are enforced in all of the municipality's new construction. Furthermore, a 30 percent reduction in electricity usage of public buildings has been envisaged. Paris is applying energy efficiency measures on its municipal buildings, public spaces, and street furniture simultaneously. For public buildings, the city is replacing high-energy lamps with lower-energy ones. The light bulbs used in street lighting are in the process of being replaced with LEDs, which consume 10 times less energy than low-energy bulbs and 70 times less energy than traditional bulbs. The city also has started to turn off streetlights at nights. Just by these two measures alone, the city is expected to use 30 percent less energy by 2020.

In order to reduce the energy usage of social housing projects in Paris, public housing authorities were asked to incorporated renewable energy sources in their new construction. The older structures are planned to be renovated and insulated for lower energy usage. Each public housing authority will be provided with a thermal map of its housing stock for any future renovation and thermal insulations.

Paris is determined to supply 30 percent of its energy needs from renewable sources by 2020. Renewable energies will be incorporate into new constructions while the older structures will replace their source of energy with renewable sources as much as possible. The electricity needed for Paris' facilities will be provided—as much as possible—by green sources. The use of photovoltaic fixtures on street furniture in Paris is the subject of a technical study to determine its feasibility. The city also launched a design competition for a zero-energy street kiosk that uses renewable energy sources. The new land-use regulations for public land will take into consideration the sustainability measures for granting permits.

Energy audit and renovation of Paris' building stock

Paris is a city of history and culture. Many of the city's 100,000 buildings are historic and worthy of preservation. While the density and compactness of the old town planning system adds to the energy efficiency of the city as a whole, individual buildings need to be renovated to adapt to the effects of climate change, such as urban heat waves and colder winters. This is planned to be done through insulating roofs, exterior walls, replacing old window frames and doors, and changes in the types of energy used in the buildings.

Paris has launched a three-year pilot program to improve thermal and acoustic efficiency of its private buildings. The program works by providing the owners with financial assistance for including energy efficiency measurements on their properties. This assistance is in the form of a subsidy equivalent to 20 percent of the cost of energy efficiency renovations recommended in energy audits. The costs of audits are subsidized by the public sector.

Additionally, the city has launched a program called the "100,000 buildings plan" for renovation of all the buildings in Paris. However, since the majority of Paris' buildings are co-owned, finding consensus to work on common areas of buildings has been challenging; these areas are usually where substantial energy saving measures can be implemented. The plan, therefore focuses on awareness-raising and advocacy to achieve consensus within co-owners' associations. The city has provided some funding for this program, in addition to developing innovative financial solutions. The city successfully partnered with the banking sector to provide financing at attractive interest rates and to adjust loan repayment charges to the cost-effectiveness of energy-saving measures that were taken. In addition to financing, the city supported the owners by providing advisory services allocating grants.

Energy distribution

In Paris, energy distribution is in the form of public-private partnership and is through concession holders. Paris obliges the partner companies to ensure climate change mitigation measures in their service delivery. These measures include air quality and reduction of GHG emissions, optimal management of natural resources, controls over energy demand, and sound energy choices for the future.

Waste Management

Even before the Climate Plan, Paris used waste incineration to provide a good share of its energy. The incineration process works with an improved renewable energy mix to reduce the use of coal. Under the new provisions, the city of Paris will build a new incineration plant to consolidate heat recovery from waste. Furthermore, the city is enhancing its recycling system and converting organic waste to produce biogas and compost.

Urban Planning

Paris' "Development Zones" will adopt urban planning provisions to ensure environmental quality by conducting Environmental Impact Assessments and developing alternative scenarios. The criteria used for choosing the best scenario include energy efficiency, reduction in carbon footprint, development of renewable energies, promoting density and high architectural quality, and measurements to reduce the rate of urban sprawl. A set of environmental recommendations was published in 2004 to address the environmental aspects of construction and renovation projects, from reducing site nuisances to managing energy.

Accordingly, the city published a sustainable development guide to advise municipalities on environmental and social sustainability measures on every step of carbon-neutral urban development, from decision making to the construction process. This document is prepared to guide municipalities on designing attractive public spaces, using sustainable material, and moving to carbon-neutral urban planning programs. When a major urban development project is in progress, other investments will be planned to offset the additional emissions resulting from the new development, by advanced insulation materials, envisioned high-density, and heat-recovery techniques.

Transport

Mitigation measures relating to the transport sector are focused on the City of Paris employees and on the general public. City employees are encouraged to use various kinds of public transport or share transport means to reduce emissions. In addition, the city's new travel plan targets a 60 percent reduction in emissions from inner-city traffic by 2020. Specific actions have been developed to achieve this goal.

First and foremost, Paris is developing new forms of transport as an alternative to private cars and is giving priority to clean vehicles. The actions include the extension of the tram system, expanding the major bus network, the extension of metro lines and metro service hours, a bet-

Figure 9. The Paris municipality close to the Seine River

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ter public transport linkage between Paris and its suburbs, and development of a river-boat shuttle on the Seine. In addition, Paris is enhancing its inter-mobility by facilitating transfers on various modes of public transport and from bus/bicycle to suburban lines. One last category of this set of actions is development of "soft" transport alternatives. These include a bike-sharing system, lowering the speed limit of motor vehicles, and the creation of pedestrian streets.

Secondly, Paris encourages businesses, social partners, and public offices to follow its "Enterprise Transport Plan" to increase access for employees and customers, while reducing travel times and traffic volume. The city will advise businesses on their mobility needs and setting up their operations in the city's planned development zones. Lastly, by analyzing travel demand, Paris will give priority to business purposes associated with specific industry sectors, while reducing nuisance, pollution, and negative environmental impacts.

Green Jobs

France expects to add 75,000 new jobs in the renewable energy sector and 50,000 jobs in the wood-energy sector by 2015. France's Environmental Agency also predicts that the energy renovation work on historic buildings will create an additional 100,000 jobs. Aligned with the country as a whole, the City of Paris will encourage large and small industries, labs, and universities to develop a job cluster on eco-industries. In addition, the city will develop a business incubator dedicated to eco-industries and will contract with eco-industry SMEs to encourage this type of business development.

Sustainable Tourism

Paris is one of the major tourism destinations in the world. It receives about 27 million visitors every year. The tourism industry is a major contributor to France's GDP, while creating about 300,000 jobs, directly or indirectly. Unfortunately, air travel is part of any tourism industry and a major polluter of the environment. Paris' carbon audit found out that each year, 4 million tons coal equivalent of GHGs emissions is resulted from air travel. However, most tourists use the city's metro system while in Paris, accounting for 10 percent of the city's metro usage. The Paris Climate Protection Plan set up several actions to reduce the impacts of its leading industry on the environment. These actions include improving inventories and awareness of tourism's impact, increasing awareness among tourism sector professionals, promoting the use of less polluting means of transport when possible, reducing the environmental impacts of tourist buses, extending public transport services, incorporating the Climate Protection Plan into the city's tourism policy, and offsetting emissions caused by air travel by developing sustainable development measures in other sectors.

Adaptation Measures

While Paris' Climate Plan is heavily focused on mitigation measures, it also lays out a framework for adaptation actions:

Heat wave plan

To adapt to heat wave events, Paris acknowledges the effect of air pollution on increasing the intensity of heat waves and therefore has restricted urban motor vehicle traffic during heat waves. The risk of heat waves is especially high for Paris. The city was built based on a pleasant climate and the historic structures are designed to preserve the heat inside their elements and release it at night. Spaces under roofs with poor insulation, which were not intended for habitat, have turned into living spaces. Many of these poorly insulated spaces are home to poor and vulnerable groups.

To reduce the risk of heat waves, the city plans to: i) update a database of self-enrolled elderly and disabled people to be able to check on them during heat waves. ii) partner with groups of doctors and chemists and younger volunteer population willing to provide support and services to the vulnerable groups during heat waves, and iii) adjust working hours and conditions for city employees to cope with heat waves. Moreover, the city administration will monitor the effects of heat waves on local wildlife.

Adapting buildings

One consequence of heat waves is the extreme increase in the use of air conditioners, which is a big contributor to GHG emissions. To reduce the usage of air conditioners, Paris Climate Plan has envisioned measurements to prevent overheating of the buildings by creating a whole business sector around summer comfort. The actions include installation of insulations on buildings exteriors, shutters and blinds for the windows, ventilation and humidification, and active cooling systems.

Planting trees

The role of trees in curbing global warming is obvious. Green open spaces and roof gardens contribute to improving the water cycle by limiting impervious areas and reducing the amount of water flowing into the gutters. Furthermore, they create shades and cool urban environment, which allows for social integration as well as preventing pollution. Paris is planting trees to help prevent climate change and adapt to its effects. More than 250 wall gardens have so far been completed. The roof gardens are also being created for insulation use. Paris is promoting the role of community gardens on public land. Just in 2007, about 10,000 sqm of community gardens were developed and much more is in progress. By 2008, 100,000 trees were planted in the streets of Paris.

Flood Risk Protection Plan

Paris Risk Protection Plan aims to prepare Paris in case of a flood. It has developed measures for the city facilities and infrastructure to be able to continue service for several days after a potential flood. Paris Climate Plan has required public service providers to provide ground floors of buildings in flood-prone areas with service networks which would continue to work in case of a flood.

Carbon offsetting

Some emissions are unavoidable. To reduce the effects of such emissions (such as air transport) Paris will make investments to reduce emissions elsewhere. The city is involved in projects regarding energy efficiency, renewable energies, and planting forests in developing countries to make up for its GHG emissions. In collaboration with France's National Forest Authority, Paris will plant 2,000 hectares of forests in the next 5 years, reducing emissions equivalent to 400,000 tons of CO_2.

TUNIS

Figure 10. Medina of Tunis

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The Medina of Tunis was listed as a World Heritage site in 1979, due to its collection of about 700 monuments including mosques, palaces, mausoleums, and madrassas. Today the city consists of three parts: the Medina, the French quarter, and the newer sections in the south and north of the city.[17] The Medina of Tunis—expanding over 270 hectares—is still inhabited by local residents while being a major tourist attraction. The three main Islamic monuments of the city are located here: the Great Mosque, the Zitouna Mosque, and the Palace, in addition to the city's main "Suq" or market. The organic network of streets and public spaces defines the boundaries of monuments and buildings. The monuments manifest various tiers of historic development of Tunis, dating back to the early Islamic period and the Ottoman influence of 1500s.[18]

Risks

While the medina of Tunis is located in a lower risk area compared to other parts of the city, Tunis as a whole is exposed to high risks resulted from climate change. A World Bank report, published in July 2011 by Marseille Center for Mediterranean Integration (CMI), explains these risks in detail for the period between 2010 and 2030. The report indicates that in addition to natural risks threatening the city, urbanization and population growth will also raise the risks of climate change impacts.

The current trends of urban growth show that the expansion of the city will be in the form of low-density development going beyond its natural limits, including development on hillsides and in flood prone areas. This is a result of the emerging middle-class who tends to live in the suburbs of the city in areas near the water. The lower-income classes reside in the denser areas of the city in the west and southwest districts. In terms of geographic distribution, the most vulnerable urban area appears to be "Basse Ville" or "lower city", also known as the French or European Quarter, a dense urban neighborhood, located between the Tunis port and the Medina, exposed to the risks of flooding, marine submersion, and geological instability. The major categories of risk to Tunis are summarized below.[19]

[17] UNESCO.

[18] Organization of World Heritage Cities.

[19] Climate Change Adaptation and Natural Disasters Preparedness in Coastal Cities of North Africa. Final Report. July 2011. http://www.cmimarseille.com/Cities-and-climate-change.php Accessed November 2011.

Ground instability/seismicity: The location of Tunis at the edge of a zone of active tectonic convergence between European and African plates, exposes the city to high seismic risks. The city and its surrounding areas have a gradient generally over five percent in the northwest and the southeast. The slopes increase the risk of ground instability, which can result in landslides and rock movements. Ground instability can increase the risk of seismicity. The increase in built-up areas due to urbanization on vulnerable soils and unstable grounds and areas of high subsistence will increase the geographic distribution of seismic risks. Tunis is exposed to "medium" risk level, mostly in the area of structural damages to buildings, which may result in collapses and structural damages. The "Basse Ville" as well as informal urban settlements with their dense residential areas built with poor quality material are in danger of land subsidence.

Tsunami marine submersion:[20] The urbanized and industrial areas in areas known as Basse Ville, Radès, Ezzahra and Hammam Lif Ouest of Tunis, along with North and South Lakes' shores are considered vulnerable to marine submersion. In 2010, 4,500 hectares of Tunis' waterfront urban areas were at risk of flooding and it is expected that this will increase to 5,500 hectares in 2030. Structural damages to the buildings located on the sea-front, and submersion of low areas can be expected as a result of tsunami risks. Urbanization along the seafront and lakeshores in Tunis will increase the city's vulnerability.

Coastal erosion: Erosion can happen due to different factors such as long term physical trends, construction of dams, or presence of hard structure in the beaches. However, a more contemporary form of erosion is due to sea level rise. Tunis' coastal areas have been undergoing natural erosion for at least 50 years. The rate of erosion has attained one meter per year on average. Nevertheless, the coastline in the future may recede up to 10 meters per year in some stretches of local beaches, on account of forecasted sea-level rise. The projected sea level rise of 20 cm by 2030 will increase the rate of erosion, resulting in receding of the coastline. The city is already planning on adapting to this phenomenon and therefore some protective work is in progress. The adaptation measures include massive beach nourishment, in addition to construction of breakwaters and groins. Currently, about 16 kilometers of Tunis's coastline is considered at risk of erosion. This number is projected to increase to 27 kilometers in 2030.

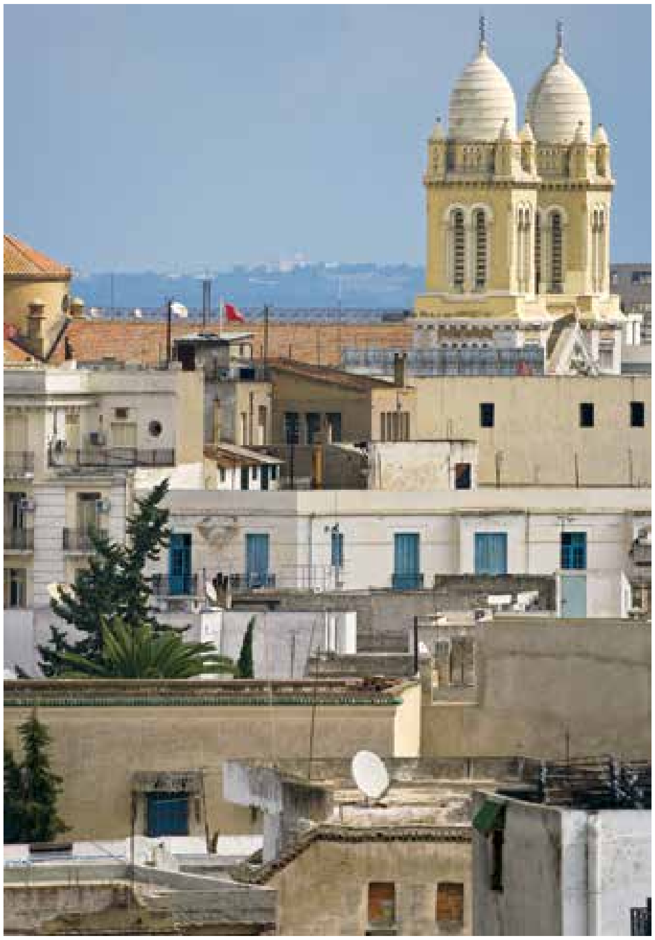
Flooding: Tunis is exposed to severe risk of flooding. The main areas at risk in Tunis are areas around the lake or areas crossed by wadis[21], which are also densely populated and urbanized and occupied by informal settlements and pre-war city centers. The latest floods occurred in September 2003 with 186 mm of rain in 24 hours. This event is expected to occur once in a century. Water levels of 50 to 100 cm were observed and a total surface area of 4,500 hectares was flooded. Climate change is expected to change the frequency and intensity of exceptional precipitation events. Excessive urbanization will have a magnifying effect on climate change outcomes. For example, urbanization will change the current rate of waterproofed ground surface from 31 percent to 47 percent, which will pose an obstacle to drainage.

Water Scarcity: The Northern Africa region suffers from water scarcity, especially in successive dry years. Northern Tunisia experienced such years in 1987-1990 and 1993-1995. Droughts are expected to happen every 30 years. The city of Tunis' main water supply channel is Mejerda-Cap Bon canal which accumulates water from the wadis in the north of Tunisia which in turn receive their flows from various dams. The governmental entity responsible for water supply in Tunis collects 13 percent of its flows from this canal for Greater Tunis' drinking water supply while using most of the remaining water for irrigation. Tunisia started a drought management program after the successive dry years of 1993-1995. The program set restrictions on agriculture use and increased the quality of urban drinking water. Water scarcity will be a major problem for Tunis in 2030 with the current rate of urbanization. The usage of water from Mejerda-Cap Bon canal will go up to 32 percent with already planned urban development projects.

[20] Marine submersions are flooding of coastal regions during natural disasters such as tsunamis and storm surges due to weather conditions and sea level rise.

[21] Wadi in the Arabic language is a riverbed or a stream, which carries water in the event of heavy rain or floods. In historic Arab town planning system and in Medinas, wadis are considered the main drainage network of the city.

Figure 11. French Quarter



WitR/Shutterstock.com

Adaptation Actions

Unlike Paris, most of the strategies for dealing with climate change in Tunis are focused on adaptation rather than mitigation. These strategies discussed in the World Bank study have been organized into three groups: infrastructure and technical measures; urban planning; and institutional preparedness, training and awareness-raising. The actionable measures identified by the report are the following:

Actions against multiple hazard risks

- Institutional coordination to reduce natural hazards and for adaptation to climate change
- Advanced planning, operational response and streamlining of procedures for managing natural hazards
- Implementation of planning regulations
- Insurance against the impact of major risks and climate change
- Zoning and planning regulations to prevent exposure to risks
- Ecological framework to reduce environmental hazards
- Urban risk reduction in the French Quarter
- Environmental approach to large urban development projects

Earthquake risk management

- Establishment of a national seismic map and zoning
- Development of the network of seismic monitoring and recording
- Finalization of the seismic micro zoning of Tunis and its integration into urban development plans
- Analysis of subsidence phenomena and zoning the hazards resulting from ground movements at the scale of planning documents of Tunis
- Vulnerability analysis of existing buildings

Risk control of erosion and marine flooding

- Changes in legislative framework for maritime public domain
- Development of a tsunami warning system
- Improvement of knowledge on the tsunami in Tunis
- Prevention of potential marine inundation along the coast of Tunis
- Enhancement of the local knowledge on the evolution of coastal beaches
- Development of a strategy to fight against erosion and the river between Rades Seltene
- Monitoring the development and maintenance of the North coast of the Gulf of Tunis

Flood protection

- System monitoring and flood warning systems
- Hydraulic Management of urbanized areas exposed to flood risk
- Limiting the water level of the Sebkha Sedjoumi and flood protection along the river
- Run-off management for new neighborhoods or in urban rehabilitation projects
- Control measures for suburban sprawl in order to control runoff
- Investments to protect the Basse Ville from flooding

- Management and monitoring of the lake water levels and the port
- Investments for protection against flooding for all major urban watersheds
- Maintenance of networks, waterways and dams to reduce flood risk

Management of water resources

- Monitor and optimize water consumption

EDINBURGH

Figure 12. Old and new Edinburgh

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Edinburgh is a harmonious juxtaposition of organic medieval and planned neoclassical town systems. The combination of Old and New Towns of Edinburgh was listed as World Heritage in 1995. The Old Town represents the Scottish enlightenment while the new town exemplifies its thinking and ideals.[22] The buildings in the Old Town have continuous and unified façades, neatly bordering the streets. Behind the streets, the urban fabric tends to be more fragmented and organically shaped, with random enclosed gardens scattered across the fabric. On the other hand, the buildings of the New Town were built upon a plan with a precise street network, which is laid out in a hierarchical way. The buildings shape a harmonious façade with consistent material (sandstones and slate roofs) and shape.[23] What makes Edinburgh a unique historic city is that the World Heritage site includes a large portion of the city center which functions as a living urban environment. The World Heritage status has helped the city with economic development and has highlighted the importance of the city as the political and economic heart of Scotland. A city of nearly 500,000 inhabitants, Edinburgh is the second largest tourist destination in the UK generating about

[22] UNESCO.

[23] Organization of World Heritage Cities.

Figure 13. Edinburgh World Heritage City next to the river

jean morrison/Shutterstock.com

£2 billion income a year from tourist receipts.[24] The city constantly renews itself by long-term investments in building conservation and quality new buildings.

Risks

Edinburgh Management Plan acknowledges that there are threats to the World Heritage site posed by the impacts of climate change. Among these impacts are fire and floods. While fires are not predictable, the flood risk has been studied and identified in a limited part of Edinburgh's World Heritage Site around the Dean Village and Stockbridge. It is estimated that Scotland will experience about a 20-30 percent increase in peak river flows by the 2080.[25] In addition, climate change can impact the architectural quality of the World Heritage City. For example, it can speed up stone decay or can cause possible damage to the integrity of historic buildings from adaptation actions to reduce emissions.[26]

Actions

To address the risk of fire damage to Old and New Towns of Historic Scotland, the City of Edinburgh Council has prepared an information catalogue, which outlines methods to reduce risk of fire, fire safety management, and suppression and detection systems. In addition, the Council works with the Fire and Rescue Services to develop and manage a database on historic buildings. This database provides fire-fighting crews with information on the importance and value of category 'A' listed buildings.[27]

Flood risk mainly comes from "the Water of Leith", which is the main river of Edinburgh. This threat became clear when after a period of heavy rainfall in April of 2000, the riverbanks broke and about 500 neighboring properties were damaged. In order to prevent similar events, the city developed a flood prevention scheme in 2003 (and a revision in 2007) with regards to effects of climate change in the next 200 years. The "water of Leith" management plan acknowledges the role of river, not only as a natural resource but also as an integral part of the World Heritage of Edinburgh. While aiming at maintaining a clean urban river, the plan also emphasizes on promoting awareness about Leith's natural, cultural and historical heritage. The management plan also aims at identifying, safeguarding, and promoting features of archaeological and cultural importance.[28]

[24] The Old and New Towns of Edinburgh World Heritage Site, Management Plan 2011-2016.

[25] JBA Consulting, 2007.

[26] The Old and New Towns of Edinburgh World Heritage Site, Management Plan 2011-2016.

[27] Edinburgh World Heritage management plan has divided the buildings in Old and New Towns into three categories: A, B, and C, based on their architectural and historic significance.

[28] The Water of Leith Management Scheme. http://www.wateroffleith.org.uk/management/ Accessed October 2011.

The Water of Leith scheme emphasizes building flood protection walls, sound reservoir management and maintenance of flood plains, by restricting development where necessary. Water reservoirs were designed originally to supplement low water-flows for mills during dry seasons. Today, they are used to protect the city against downstream flooding. By discharging extra water from the reservoirs, they can play an active role in flood protection. The water scheme also includes a rain retention section, which suggests contour ploughing, tree planting, urban agriculture, and creation of wetlands. The water scheme will also contribute to improved water quality, while establishing limitations against development, which may lead to a significant increase in the risk of flooding.

The city of Edinburgh has prepared an extensive management plan for the World Heritage site. This plan specifically addresses climate change issues under the Scottish Government's agenda regarding climate change. The Scottish Climate Change Programme was published in March 2006 with ambitious goals of leading the Northern European climate change agenda. The goal of the plan is to reduce the current carbon emissions by 26.7 percent by 2050 (compared to the 2005 baseline). The World Heritage management plan also establishes a relationship between the natural heritage and cultural heritage of Edinburgh and acknowledges the role of natural heritage in the universal value of Edinburgh, which consists of architectural spaces and gardens. Therefore, the open spaces within the site and those on its edges, along with Water of Leith, contribute to this setting.

The Edinburgh Biodiversity Action Plan is another instrument designed to provide a framework for ensuring that the integrity of Edinburgh as a whole is conserved as a World Heritage city.[29] The Old and New Towns of Edinburgh World Heritage Site Action Plan have further actionable measures. It plans to address the issues of fuel poverty and changes of energy behavior in the Edinburgh World Heritage city and to develop mechanisms for adapting historic buildings to reduce carbon reductions.[30]

In 2006, to project energy demand for heat and electricity and develop emissions reductions actions, the City of Edinburgh Council commissioned a report called "Powering Edinburgh into the 21st century". The report assumes that the target for building-related emissions is the same as the target for overall emissions, including those from transport and industry. Due to population increase and demolition of some old housing units, Edinburgh is expected to need 27,200 new dwellings in 2025. Meanwhile, the city plans to improve insulation in existing units to decrease heat demand by 10 percent, while the average domestic boiler efficiency is assumed to increase to 86 percent. Electricity demand per dwelling is assumed to remain the same. The new dwellings are expected to have considerably lower heat demand and 20 percent less electricity demand, while their average domestic boiler efficiency is assumed to be 92 percent. Overall, Edinburgh is expected to have 25 percent reduction in annual heat demand and 30 percent reduction in electricity usage by 2050.[31]

"Powering Edinburgh into the 21st century" suggests that the most certain way the city can meet its emissions reduction goals is to proceed with the Decentralized Energy (DE) scenario.[32] This scheme includes gas-engine combined heat and power (CHP). CHP has several environmental benefits. The plan suggests that Edinburgh works on a community heating (CH) system to encourage the usage of CHP. The historic sections of the city can be barriers to this initiative. However, the plan suggests that the operation cannot be more invasive than establishing pipe utilities or communication networks. Community heating networks have been successfully installed in other historic cities in Europe such as Copenhagen, Amsterdam, and Paris.[33]

[29] The Old and New Towns of Edinburgh World Heritage Site, Management Plan 2011-2016.

[30] Edinburgh World Heritage Site Action Plan. August 2011. http://www.edinburgh.gov.uk/downloads/file/5655/edinburgh_old_and_new_towns_world_heritage_site_draft_action_plan.

[31] Powering Edinburgh into the 21st century. November 2006. http://www.localpower.org/documents/reporto_greenpeace_poweringedinburgh.pdf.

[32] DE includes a mix of decentralized energy sources and conventional centralized energy generation.

[33] Powering Edinburgh into the 21st century. November 2006. http://www.localpower.org/documents/reporto_greenpeace_poweringedinburgh.pdf.

MEXICO CITY

Figure 14. Metropolitan Cathedral

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One of the best-preserved historic cities in the world, Mexico City manifests the coexistence of the Aztec and Spanish cultures. It was built in the 16th century after Spanish invaders attacked the Valley of Mexico in search of gold. Mexico City's Zocalo, the heart of its historic center, is an esplanade superimposed on the earlier Aztec square of Tenochtitlan, surrounded by structures that vary in style, from Neoclassical to Baroque, to Aztec traditional architecture.[34] Mexico City was inscribed as World Heritage in 1987. Mexico City today is the largest metropolitan area in Latin America and one of the largest in the world. Mexico City Metropolitan Area (MCMA) has a population estimated at 21.2 million (18 percent of the country's total population), and it generates about 21.8 percent of Mexico's GDP.[35]

Risks

Mexico City is vulnerable to various risks. The most important risks of climate change for MCMA are temperature increase, heat waves and droughts, flooding, storms, and landslides. About 40 percent of the city's 4.6 million vulnerable inhabitants live in high risk areas, prone to landslides, extreme precipitation, and heat waves.

Consistent with other parts of the world, temperature in the Mexico Valley is increasing, which contributes to a major heat island effect for the city. Projections confirm that the mean temperature will increase by 2–3 degrees by the end of the century. The number of heat waves (days with temperatures over 30 degrees) has increased and will increase in the future. The increase in temperature causes floods and droughts.

On average the annual precipitation rate for Mexico City is about 700–900 mm. The western region of MCMA has the highest rate of precipitation, and this trend is expected to continue to reach a rate of over 30 mm/hour of rain during September and October, which presents the city with the risk of floods and landslides. This is very critical considering the poor and vulnerable groups who reside on hillsides with slopes more than 15 degrees. The increase in precipitation also increases the risk of water run-offs,

[34] Organization of World Heritage Cities.

[35] World Bank 2011.

Figure 15. Mexico City Museum of Fine Arts

Mauricio Avramow/Shutterstock.com

especially given the current drainage system, which presents a great risk to the well-being of Mexico City's large homeless population.[36] UNESCO also identified the major risks to the historic center, which includes seismic instability and continued sinking of the city caused by the depletion of the aquifer.

Actions

Mexico City is the first city in Latin America to prepare a climate change action plan, called Plan Verde. This plan is a combination of mitigation and adaptation measures designated to reduce emissions while preparing the city to adapt to consequences of climate change. Plan Verde is designed for a 4-year period from 2008 to 2012. It plans to i) reduce carbon dioxide (CO_2) equivalent emissions by seven million tons from 2008 to 2012, and ii) initiate an integrated program for adaptation to climate change to be fully functional by 2012.[37]

Mexico City's GHG emissions per capita is calculated at 4.25 tons of CO_2 equivalent for the city proper and 2.84 in MCMA, which compared to other megacities of the world in not so high.[38] However, due to Mexico City's size and population, the effect of such emissions on the country and on the planet is significant. Some of these effects have already been manifested in Mexico City by an increase in the number and intensity of rain events and landslides and an increase in the mean annual temperature. About 88 percent of GHG emissions in Mexico City are the result of energy consumption.

Mitigation Actions

The expected emissions reductions have been allocated to different sectors: 12 percent to the water sector, 10 percent to the energy sector, 35 percent in the waste sector, and 42 percent in the transportation sector. Each sector specific actions are described below.[39]

Energy sector: most of the plan's actions in the energy sector are related to energy use in buildings. In the housing sub-sector, new funding for sustainable multi-family housing is envisioned to construct housing complexes equipped with solar power plants, energy and water sav-

[36] Climate Change, Disaster Risk And The Urban Poor: Cities Building Resilience For A Changing World. World Bank 2010.

[37] Mexico City Climate Action Plan 2008-2012 http://www.sma.df.gob.mx/sma/links/download/archivos/paccm_summary.pdf, accessed October 2011.

[38] World Bank data accessed October 2011 http://siteresources.worldbank.org/INTUWM/Resources/GHG_Index_May_18.pdf.

[39] Mexico City Climate Action Plan 2008-2012 http://www.sma.df.gob.mx/sma/links/download/archivos/paccm_summary.pdf, accessed October 2011.

ing systems, rain water collection and reuse infrastructure, waste-water treatment plants, and absorption walls. Beyond housing complexes, the plan lays out an environmental certification system for commercial and residential properties in Mexico City while promoting the use of renewable energy sources. The plan urges the Mexico City Government to reduce its energy footprint by using an energy-efficient lighting system in public buildings and for public transport and street lighting. In parallel, the government distributed 10 million compact fluorescent lamps to residential buildings.

Water sector: the major part of the water action plan in Mexico City is focused on reduction of sludge emissions from the city's biological treatment plant. The city also established a home water savings program to reduce the water demand by 2.2 m3/s by installation of low-flow toilets and water saving accessories. In parallel, the city made improvements to the water infrastructure to prevent leaks and water loss while installing electrical energy generators in hydro plants. Finally, the sewage system of Mexico City was improved to reduce emission from the septic system.

Transport sector: the plan expects to reduce most emissions in the transport sector by 10 different actions. One major step for this sector is the obligatory school transport system, expected to reduce 471,000 CO_2 equivalent tons per year by gradually changing the transportation mode for students from private to public transport. The next major steps for the city are to construct an additional metro line and replace taxis with new energy-efficient vehicles. In parallel, nine Bus Rapid Transit (BRT) corridors with 200 km of restricted lanes and 800 tandem buses will replace the city's 3,000 microbuses, while high capacity vehicles will replace medium capacity vehicle service concession. The city also established a vehicle inspection program for trucks and plans to replace its vehicle stock with energy-efficient cars by 2012.

Waste sector: the city plans to take a major step to capture and exploit the biogas emitted from its major landfill by building a gas-fired power plant. Also, a compost production plant in Central de Abostos market will be constructed to exploit the daily 700 tons of organic waste. The city is also rethinking its recycling system and modernizing its waste transfer stations and waste collection vehicles.

Adaptation Actions

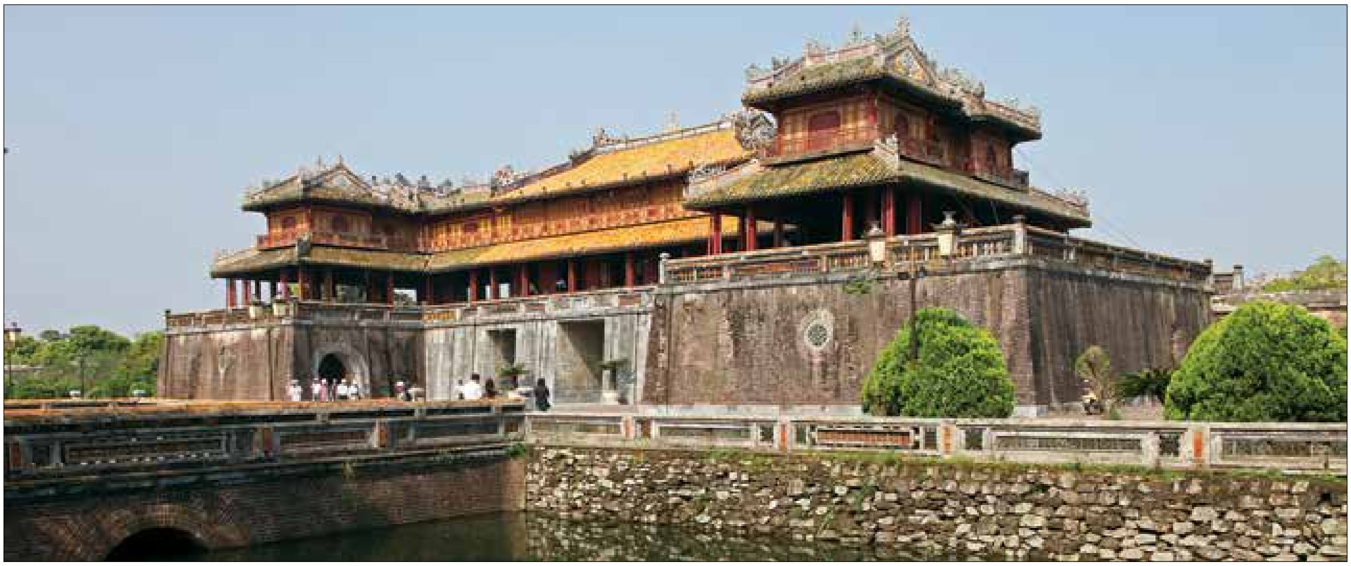
Some of the mitigation measures in the water sector described above also act as adaptation measures. For example, the city plans to improve its infrastructure to prevent leakage and rehabilitate pipe sectioning, which will help rationalize water usage for coping with its scarcity. In addition, Mexico City has prepared an adaptation plan with medium- and long-term strategies to moderate possible damage and forecast risk.

The plan envisions two groups of adaptation measures: early alert system and medium-term actions. The first group includes six actions. One is an early warning system for the Valley of Mexico through the Metropolitan Hydrometeorological Monitoring and Forecasting System. This initiative aims at identifying risks to the citizens and defines short-, medium-, and long-term actions. In order to deal with the threat of heavy rains, the plan integrates a micro-basin management component for the urban rivers. The plan also lays out an action plan for providing assistance to the vulnerable groups in areas prone to extreme climate events such as droughts or heavy rains. Another actions is to set up a remote detection and monitoring system for forest fires. Epidemiological monitoring in the context of climate change, and as a result of extreme climate events, is also included in the plan. Last but not least, the plan envisages protecting and recuperating the native crops and herbs in order to maintain the diversity and resilience of agro-systems.

The second group of adaptation measures focuses on medium-term goals, mostly in the rural zone of Mexico City Metropolitan Area. Two major actions target micro-basin management by conservation of soil and water on agricultural lands. In addition, this set of actions intelligently addresses the issue of genetically modified foods and suggests fomentation of organic agricultural production. Soil recovery and reforestation is also included for the rural zone of Mexico City. For the urban zone of the city, rooftop greening is proposed.

HUÉ

Figure 16. Hue historic city



Stephen Chung/Shutterstock.com

Hué, the former capital of Vietnam was listed as a World Heritage city in 1993 and represents the art, architecture, and town planning system of the Vietnamese feudal empire. The complex of monuments in Hué are planned and built based on ancient oriental philosophy and Vietnamese traditions. Laid out symmetrically on a north-south axis, the elements of this urban ensemble—Capital City, Imperial City, Forbidden City, Inner City, and the Coastal Bastion—are designed in accordance with the natural site to protect the imperial dynasty against assaults from the land and sea.[40] The majority of buildings are built with brick, however wood elements and colorful tiles have added to the beauty and mysticism of Hué.[41] Hué has a population of 350,000 with a population density of 4,660 persons per km^2.

Risks

Hué is the capital of Thua Thien-Hué Province, located at the banks of Huong River. Hué is one of the most disaster prone cities in Vietnam and is ranked first among World Heritage Cities on the Mutli-hazard Risk Index. The seasons change drastically from long dry seasons to short rainy seasons with very high rainfall in a short period of time, which is the main cause of floods. The region suffers from various kinds of natural disasters such as typhoons and tropical cyclones causing heavy rain and landslide. The area has the highest amount of rainfall in the country, ranging from five meters per year in the higher-altitude areas to three meters per year in the city of Hué. About 66 percent of this rainfall occurs from September to November each year.[42] As a result of these floods, Hué is faced with soil erosion and degradation, and saltwater intrusion, which in turn can cause changes in availability of fish for fisherman communities, affecting their livelihoods.[43]

On the other hand, Hué is also impacted by droughts every year. This is due to the increase in length of the dry seasons and insufficient water resources. During this dry season, river flows diminish to the extent that sea water moves up into the river and penetrates the residential water intake of the Hué city.[44] One important economic loss due to sea-level rise is an estimated 28.8 percent loss in tourism revenues, according to the National Center for

[40] UNESCO

[41] Organization of World Heritage Cities.

[42] Climate Change Impacts In Huong River Basin And Adaptation In Its Coastal District Phu Vang, Ha Noi—December 2005. Netherlands Climate Assistance Programme.

[43] Enhancing Human Security, the Environment and Disaster Management. Hue, Viet Nam. Submitted to Asian Development Bank (http://www.adb.org/Documents/Reports/Consultant/REG/37715/37715-02-reg-tacr.pdf).

[44] Climate Change Impacts In Huong River Basin And Adaptation In Its Coastal District Phu Vang, Ha Noi—December 2005. Netherlands Climate Assistance Programme.

Figure 17. An example of deterioration of the historic monuments of Hué

jejim/Shutterstock.com

Hydro-Meteorological Forecasting. The estimated one-meter increase in the sea level could cause the touristic beaches of Thua Thien-Hué Province to disappear. The economic loss is estimated at 10 percent of GDP.[45]

Climate change is negatively impacting these already adverse climatic conditions. In a report published by the Institute of Meteorology, Hydrology and Environment of Vietnam, it is projected that the annual mean temperature in Vietnam will increase by 1.1–1.9°C and 2.1–3.6°C in low and high emissions scenarios, respectively. The same report predicts that the rainfall increase will be 1–5.2 percent and 1.8–10.1 percent in low and high emissions scenarios, respectively, and the sea level rise is likely to be in the range of 65–100cm.[46]

Adaptation Actions

The city of Hué does not have a standalone adaption or mitigation plan yet. However, the Government has prepared general plans for both mitigation and adaptation. On adaptation actions, the plan is focused on these sectors: water resources, agriculture, forestry, fisheries, coastal zones, energy and transport, and human health. Within these sectors, some specific activities relate to the urban environment. In the water sector, adaptation actions focus on building water reservoirs, upgrading existing sea and river-mouth dykes, and conducting studies in long-term water resource prediction. In the coastal zone management sector, the plan suggests building protection measures and relocating settlements and infrastructure in the threatened areas. The energy sector focuses on rational and efficient use of energy.

Mitigation Actions

The Government of Vietnam has integrated environmental concerns and GHG mitigation strategies in its development plans. These plans are still in process of development and currently serve as guidelines only. Among the urban mitigation measures, the plan focuses on developing new and renewable forms of energy (such as solar, wind, and hydro power-plants) and on sustainable use of existing energy resources. For example, the government plans to improve lighting efficiency of households, commercial facilities, and public areas. In addition, the country plans to achieve methane recovery from large landfills in and around the cities.[47]

[45] http://vietnambusiness.asia/vietnam-central-province-faces-28-8-tourism-loss-due-to-climate-change/ Accessed October 2011.

[46] Vietnam Assessment Report on Climate Change. Institute of Strategy and Policy on Natural Resources and Environment. Hanoi, 2009. http://www.unep.org/pdf/dtie/VTN_ASS_REP_CC.pdf Accessed October 2011.

[47] Same source.

QUITO

Figure 18. San Francisco plaza in historic Quito

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Quito was the first World Heritage City inscribed by UNESCO on the World Heritage List in 1978. A fusion of Spanish, Italian, Moorish, Flemish, and indigenous architecture, Quito's historic center and buildings present a specific style of architecture and town planning as famous as the "Baroque School of Quito". Laid out in rectangular squares, the buildings of historic Quito are made of stucco-covered bricks and in Spanish or Moorish style.[48]

Quito is the second highest capital city in the world, located about 2,800 meters above the sea level in the Andes Mountains and on the border of the Pichincha Volcano. The city is laid out on a complex topography with regular blocks, a central civic square and several other secondary squares all surrounded by palaces and religious buildings of the 16th to 18th century.[49] Today, Quito has a population of 2.1 million, of which 43.5 percent live below the national poverty line.

Risks

The annual mean temperature of Quito has increased by 1.2°C in the last 100 years. At the same time a precipitation decrease of 8 mm per decade has been observed. This combination contributes to the already existing water-shortage problem of Quito. In parallel, it is projected that the contribution of water supply from glaciers will also be reduced in the course of the century. Water shortage seems to be the main risk faced by Quito due to a decrease in precipitation and reduction of water stream flows as a result of climate change. Moreover, the risk of natural disasters has also increased in Quito. These include urban floods due to melting of glaciers, landslides in the mountain slopes, mud and debris flows from ravines, increased run off and erosion of soil, and risks to the infrastructure.[50]

Quito's Climate Change Strategy (QCCS)

The authors of Quito's Climate Change Strategy have used the city's ecological footprint as a planning tool and have aimed at a sound local response to adverse risks of climate change. The QCCS is a combination of mitigation and adaptation measures. It was approved in 2009 with the main objective of developing comprehensive policies that guarantee the implementation of adequate, crosscutting, and equitable adaptation and mitigation measures to counteract climate change.[51]

[48] UNESCO.
[49] Organization of World Heritage Cities.
[50] Moreno, 2010.
[51] ibidem.

Figure 19. Historic urban fabric of Quito

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Actions

QCCS's adaptation plan has five separate areas: i) ecosystems and biodiversity; ii) drinking water provision; iii) health; iv) infrastructure and productive systems, including hydroelectric power; and v) risk management. The city is gathering all the necessary information for a climate change database by preparing vegetation maps, maps of forest fires, a local GHG inventory, watershed models, and monitoring systems for glaciers. In addition, the municipality is in process of developing vulnerability analysis, socio-economic and poverty analysis, land-use analysis, and a climate change information system.[52]

Quito is determined to use education and communication to involve citizens in the climate change adaptation process. To this end, the municipality, with help of the World Bank, has developed "Quito's Youth Action on Climate Change" to educate and inform the youth in marginalized neighborhoods about the effects of climate change and ways to cope with it.[53] The city also developed a joint research agenda with local universities and established a social forestry initiative to engage local and indigenous communities. In addition, the municipality also established an inclusive informal recycling program.

QCCS has laid out a detailed Water Master Plan from 2010 to 2040, which includes strategic short,- medium- and long-term plans. Within the master plan, Quito addresses the issue of increased demand for water by reducing water loss and consumption, in addition to increasing water supply and invest in storm water drainage system. The city has established an investment fund called Water Protection Financial Fund, or FONAG, for watershed conservation. FONAG has been operating through a trust (contributed to by Quito's water company with 1.5 percent of the amount of its billing) since January 2000. Currently FONAG is in charge of contributing to several programs on watersheds, education, and environmental monitoring, with an operating budget of US$ 6.6 million.

Furthermore, the eco-neighborhoods program works on neighborhood scale water conservation through incorporating innovative concepts in residential water management and wastewater separation in homes. The Control and Reduction of Unaccounted Water (ANC) Program is

[52] Zambrano-Barragán et al., 2010.

[53] Moreno, 2010.

another action taken by the Municipality of Quito, which began in 2007. This program is in the process of installing meters and implementing the Telemetry and Control System.

Quito launched a Hillside Management Program in 1997. The program focused on integrated management of slopes on northern and central Quito to reduce the threats they pose on the city. So far, an investment of approximately US$ 40 million has been made to mitigate and reduce risks on the slopes of northern and central Quito.[54]

In addition to the Water Master Plan, the Municipality of Quito has also prepared a Fire Plan, a contingency plan, and is in process of relocating the families living in risk-prone areas. Climate change considerations have been integrated in land use planning and watershed management, and the city has taken actions for slope protection, reforestation, and ecosystem restoration, and has set up campaigns for efficient water and energy use.[55]

[54] Zambrano-Barragán et al., 2010.

[55] ibidem.

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