Urban Planning for Climate Change

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Abstract

Scientific opinion is now unanimous that global temperatures are likely to continue to rise with concomitant extreme weather patterns and events. There is a protean body of scientific literature available on global warming and climate change, which is affecting urban living in every respect from ‘heat islands’, continuous light and sea level changes as well as severe droughts and floods paralysing urban areas. Urban planning implications are reflected in buildings, street and community design for more environmentally sustainable cities. The urban science related to climate change and its implications for human settlement is in its early stages. Nonetheless, climate change is already becoming a concern of insurance and actuarial industries as they begin to assess risk to human settlement, construction and other risks associated with atmospheric conditions. These cannot be anticipated and need to be examined with a new paradigm for urban problem solving which is outlined in this paper.

About the Author

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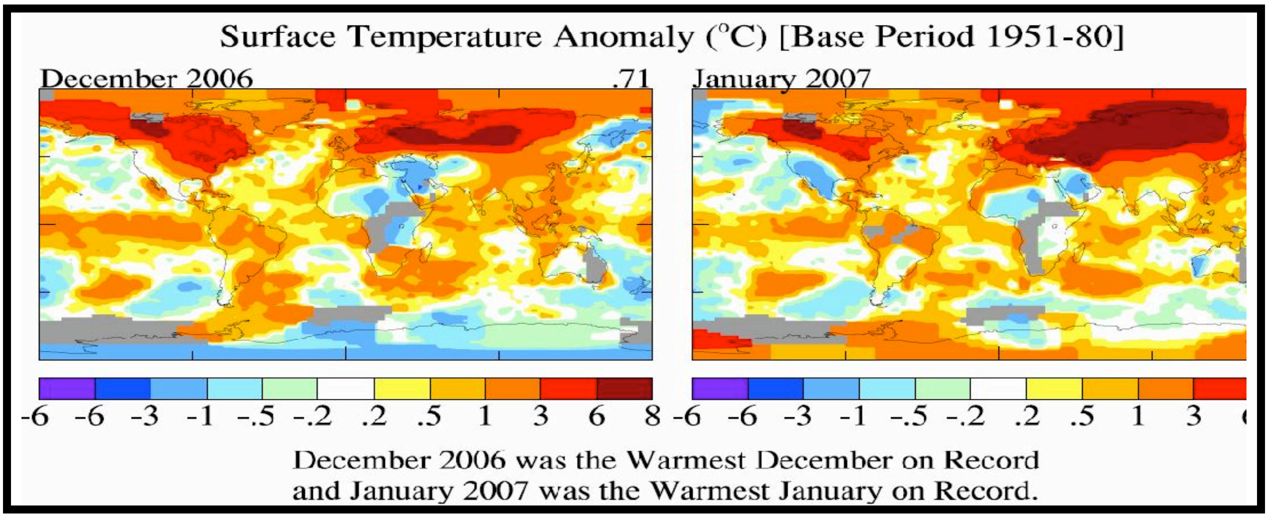
Introduction

Global warming is here. A vast tract, nearly a million square kilometres, of central Siberia is thawing after more than 11,000 years since the last ice age. This frozen landscape contains 70 billion tons of methane gas under the permafrost that might be released into the atmosphere causing a release of a potent and earth shattering amount of carbon dioxide (Pierce, 2005). The world's leading earth and climate scientists are saying that, "the harmful effects of global warming on daily life are already showing up and within a couple of decades hundreds of millions of people will not have enough water... while tens of millions of other people will be flooded out of their homes from rising temperatures and sea levels in other part of the globe (Associated Press, 2007 based on IPPC report). The impact on the world of such a catastrophe was recounted in the motion picture *The Day After Tomorrow.* For a moment we need to think of the scenarios depicted in this motion picture as real and not a script made for Hollywood. This paper is presented to offer a paradigm for examining urban and regional planning needs to take climate change into consideration in the development, design and re-development of urban areas all over the world. Nearly seventy percent of the world's population lives near areas where sea levels are expected to rise dramatically and inundate urban areas. Thus, urban planning is at the forefront of the needs of basic human existence as we face a new challenge of matching the forces of nature against the building systems of mankind. Unfortunately, very few urban planning tools are being considered in the re-deployment of resources in a climate change era by national and local policymakers. It is time to suggest a research and policy paradigm to craft better urban planning systems in response to climate change.

Developing a new approach is hard due to little research available on the impact of rising tides, cyclones, high temperatures, severe wind storms, fires and floods in highly settled areas with mild climates. Within the next few decades most people in the world will be subject to climate change due to rapid and unprecedented movement of people from rural to urban environments. Since metropolitan areas are densely settled and in low lying areas the potential to move people from the coast is very slim. Further, there is little urban planning research that combines scientific knowledge about climate change and its likely effects on the planning and design of cities or suburbs. An integrative research framework is needed for developing new and robust public policies, urban design guidelines and implementation measures. These approaches have to consider doing what we can to replace the current urban fabric since altering this pattern is too expensive and perhaps more drastic than needed.

The recent hurricanes in New Orleans (2005) and in Innisfail, Australia (2006), places which are located in similar latitudes but opposite end of the world, illustrate the devastation that changes in natural systems can have on densely populated coastal urban areas. Subtle impacts of climate change are already occurring that potentially present major problems for many cities around the world. Most of the world's largest cities, for example, are clustered around coastlines with fragile and vulnerable eco-systems. In fact, London is already acting with the establishment of a climate change office for analysing empirical data to deal with the future threat of extreme sea level rise and its impacts on the city. In Australia, another illustration is that the last 15-20 years have seen erratic changes in weather patterns which are already impacting on major population centres - storms and wild fires in Sydney and Canberra and extreme heat in Brisbane. These dramatic weather changes are illustrated in the maps below.



Source: NASA, 2007

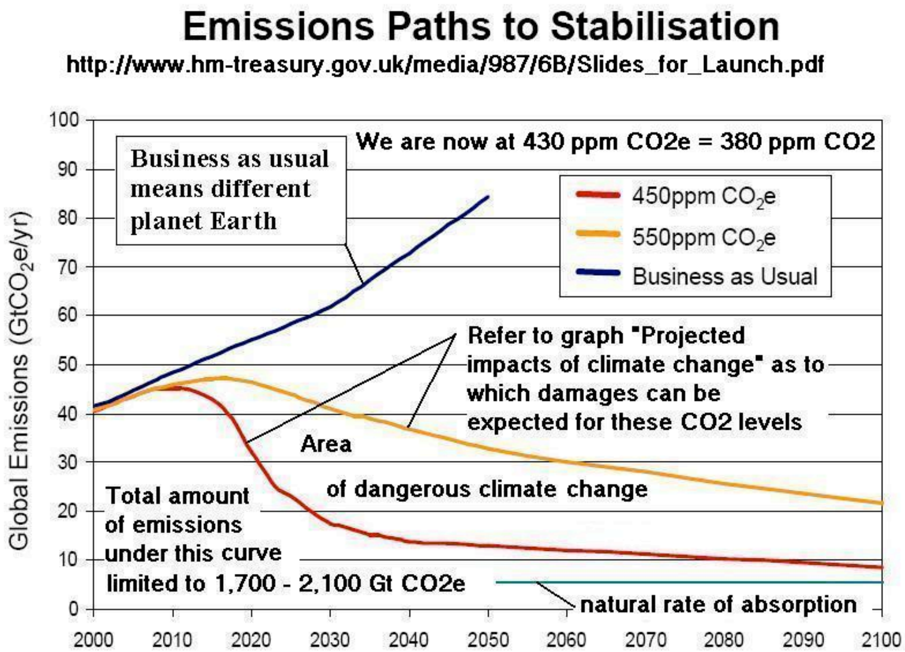
We need to better understand climate change issues by reviewing some of the key literature and its impacts on urban areas. From this understanding, we can develop approaches for future planning scholars interested in climatic change as it applies to public policy.

The Climate Change Debate

The Third Assessment Report of the 'Intergovernmental Panel on Climate Change' (IPCC) brought world attention to the likely impacts of climate change (Metz 2001). Climate change is now at the forefront of debate with dire warnings that worldwide temperatures may rise from 5 to 11 degrees C. over the next 50-100 years (Stainforth et al 2005). In relation to human influences and human-induced changes in atmospheric composition, Karl and Trenberth (2003) observed that these changes are large enough to be considered outside the bounds of natural variability and that anthropogenic climate change is likely to continue for many centuries changing human and animal life patterns (See Adger et al 2003; Adger et al 1999). Crowley (2000) predicts that temperature increase in the late 20th century northern hemisphere has already established itself above the level of natural variability in the climate system and Hoffman (2005) argues that the 21st-century global warming projection has far exceeded the natural variability of the past 1000 years and is greater than the best estimate of global temperature change for the last interglacial period. If these predictions are correct and the current trend of a 3 degree C. rise in temperature continues, the Greenland ice-sheet will melt faster and could be all but eliminated except for residual glaciers in mountainous areas of that land mass (Gregory et al 2004). An occurrence such as this could raise global average sea-level by 6 metres which will require mega cities such as London and New York to start planning for the re-development of vulnerable low lying areas (See Friends of the Earth 2004). If these changes do occur they are likely to create extraordinary wind and wave conditions, which are characteristic of climatic transition, and provide a continued rise in the atmospheric concentration of carbon dioxide (CO_2) largely because of anthropogenic emissions (Cox et al 2000; Rignot and Thomas 2002). Other data by Cox (2000) shows that regional variation in changes will lead to marked drying, most likely occurring in mid-USA and southern Europe and significantly wetter conditions in South Asia, with evidence of the ecological impacts of recent climate change from polar terrestrial to tropical marine environments. Hughes's (2003) writing on climate change and its impact on Australia's ecological systems concludes that the continental average temperature is in the order of a 0.8 degree C increase since 1910 and that this rise has mostly taken place after 1950 (1998 being the warmest year). More significantly, however, Hughes raises as a major concern the night time temperature increase and concomitant decrease in the diurnal range. Hughes suggests that by 2030 an average of .07 - 4.8 degrees C. will lead to "…continued declines in rainfall with extreme events such as fires, floods, droughts and tropical storms" (Hughes 2005a). She also notes that this is an especially vexing issue for Australia because of its large nocturnal animal population (Hughes 2003). This is not the first time climatic changes have impacted human settlement. Recent work on Angor Wat in Cambodia showed that the city was abandoned because its intricate water management system failed due to subtle changes in temperature that reduced the water supply to unsustainable levels (R. Fletcher, 2007). In addition, Jeremy Diamond's book *Collapse* ascribes climate and water management crisis for the demise of the ancient pre-Columbian civilizations (Diamond, 2005).

Meanwhile, decreases in the diurnal temperature range have been linked to human health. There was a high death rate during Europe's heat wave in 2003. Daytime temperatures in Paris rose to 40ºC, which was further exacerbated by night time temperatures at 25.5ºC plus for several nights. These temperature exposures are possible in Australia where air conditioning could fail in extreme events because of power surges. Those without air conditioning were the most vulnerable in Paris (Dorozynski 2003; Haines and Patz 2004). Kalkstein and Greene (1997) estimate that a net rise in weather-related summer mortality will dramatically increase if the climate warms as the models predict. One scenario suggested by Australia's major national research institute the CSIRO (2003) is that the average days in summer over 35 degrees C. in Brisbane would rise from three to thirty by 2070, which is well within the lifetime of existing homes and other built form. Many cities across the world are going through energy shortages as temperature soars with homes built for mild climates unable to cope even with insulation. Hansen suggests with Climate Change that "any increase in global temperatures beyond 1^{o}C could trigger runaway ice melting of the world's ice sheets" (Climate Change, 2007).

CO_2 emissions, a prime factor in global warming, continue to soar. Chart 1 below shows a collision course on the future living conditions around the world as the urbanization process continues.



Source: UK Treasury Research, 2006

Acknowledging that there is opposition from the fossil fuel lobby and some skepticism in the scientific community about anthropogenic Climate Change impacts (see Lomborg 2001), scientific opinion could turn out to be wrong. There is, nevertheless, a broad consensus in the scientific community that global warming and climate change is happening outside the predicted range of natural variability (see Singer 2002). If we reflect on Rittel and Webber's seminal work on 'wicked problems,' a strong argument can be made to suggest that the risk of the doing nothing far outweighs the risk of taking preventative actions to mitigate possible effects on the urban form even if the impacts of climate change are not as significant as predicted[1]. In respect of risk, the insurance industry provides a reasonable guide to the probability and frequency of extreme events. London is taking bold actions to curtail its emissions as a means of lowering greenhouse gases by producing at least 20% of its energy from what are termed micro-newables such as recycling waste to producing energy. The city intends to recycle 95% of all of its waste from construction and demolitions by 2020. Other cities and US States are beginning to look at similarly ambitions programs (London Times, 2007xx). One area that Europeans have turned to lower admissions is carbon trading on a very wide scale. Nicolas Stern the author of the Stern report on Global Warming and the UK indicates that carbon trading which is currently \$28 billion per year will jump to \$40 billion by 2010. But skeptics note this increase as a bit of a shell game since the credits are purchased to shift their pollution burdens to Third World nations (Vencat 2007).

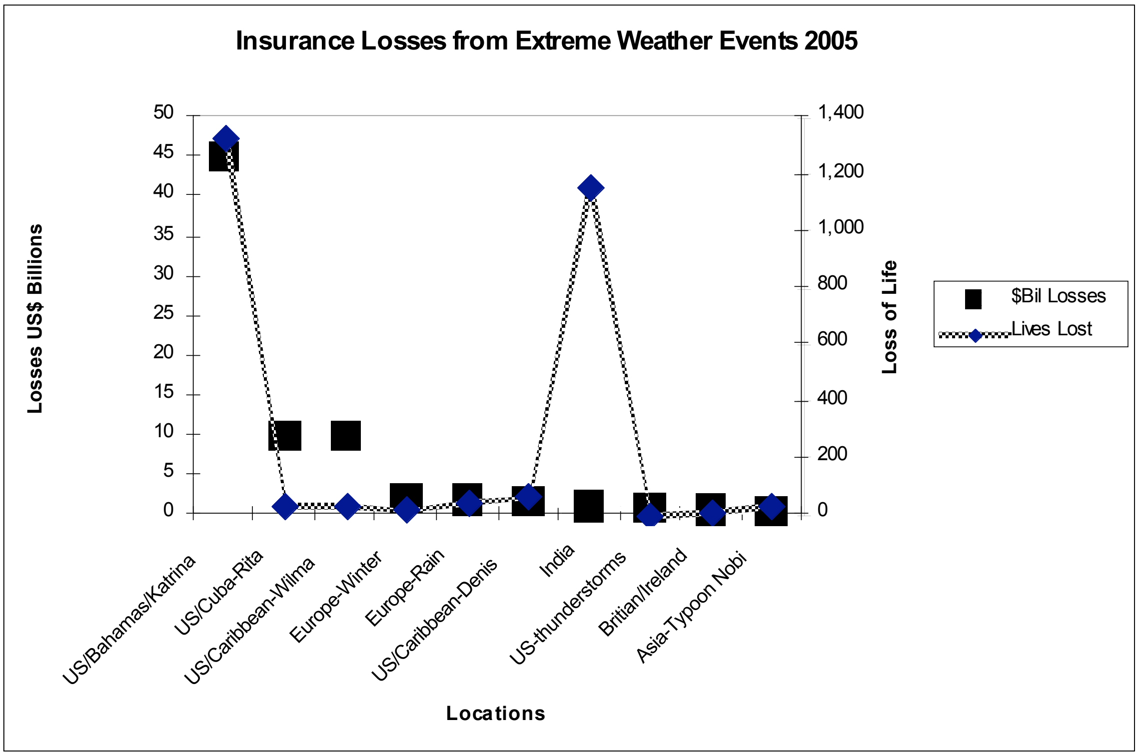
In fact it is clear from the illustrations above that to reduce climate change risks, new planning legislations will have to be designed to require climate change to be included in impact assessments for future development applications in urban areas around the world. So, the question is: "what can we do, with better forecasting capacities, to mitigate and adapt to these natural process regardless of their cause?"

The Climate Change Risk Equation

Insurance has been the primary tool in dealing with natural disasters. But when natural disasters are too frequent the risk becomes too large and the events too unpredictable, insurance may collapse as an alternative to hedge against climate change risks. This is reflected in the current actions of the insurance industry. The Association of American Geographers (1997) published an article on the implications of climate change for the insurance industry predicting a significant increase in major windstorms worldwide and pointing to the growing importance of climate change to the industry particularly with respect to risk. Hence the industry is now beginning to treat climate change as a long-term strategic issue by focusing its actuarial muscle on climate change as a threat to its investments (ibid). Insurance executives speaking on behalf of almost 60 insurance companies addressed delegates of the climate change negotiations at Geneva in 1996 by calling for early and substantial reductions in greenhouse gases. Dlugolecki (1999) argues that at present few insurance companies are treating climate change as a strategic issue because of insufficient information about future weather patterns, the lack of direction by politicians internationally and that most businesses are faced with more immediate priorities. He considers the initiative to form the Insurance Industry Initiative on Sustainable Development under the aegis of the UN Environmental Program (UNEP) as a way forward, although it is still poorly represented in the US and developing countries. This initiative saw executives present a position paper highlighting the industry's concern that

[1] Rittel gives the following example of 'doomsdaying'. 'Is the growing ozone hole, global warming or changes in weather patterns an indication that our atmosphere is undergoing dramatic, maybe incorrigible change at our hands? Or are these simply random fluctuations? Should we just sit back and watch or should we act now? Rittel's position is that we should act now because even if this turns out to be wrong, it is a far better option in the long run.

while the effect of climate change on the frequency and severity of extreme weather events remains unknown, it is clear that even small shifts in regional climate zones or storm patterns could lead to increased property damage. The insurers point out that climate change could potentially have large implications for investment activities as societies anticipate and adapt to a new climate regime. A significant issue raised here is risk assessment as insurers "…know from experience how expensive it can be when people fail to protect themselves adequately from risks." (ibid: UNEP Executive Director Elizabeth Dowdeswell). Some striking examples of heavy losses that can occur from storm damage are Typhoon Mireille, September 1991 and Hurricane Andrew, August 1993, which recorded losses of $5 Billion and $17 Billion respectively (ibid). Hurricane Katrina and related events have affected insurer worldwide as shown below.



Source: Economist March 4-10, 2006 p. 94

Climate Change and Sustainable Environments

Sustainability is now firmly part of the lexicon of planning and is the best grounding for climate change research. Writing on sustainable communities, Blakely (2004) puts the case for innovative and forward thinking planning. He offers planning principles to inform practice: viz—merging land use, social and governance planning into one framework for creating a new and innovative creative economy. Beatley and Manning (1997) and Beatley (1998) describe new patterns of settlement that might well overcome climate change issues. Newman's (2004) analysis of Vancouver, Canada is an example of how innovative transport and urban form policies have been enacted over the past decade which might serve as a benchmark for climate change work on cities. But even the most robust of these approaches is still less than adequate for the large scale transformations needed to deal with changes to the urban environment brought about by wild fires, extreme winds, hale storms, loss of sea coasts and rising oceans. This suggests radical changes to how cities and suburbs are planned, designed or re-designed. Harriet Bulkeley and Michelle Betsill (2002) argue that while governments give lip-service to climate change and even adopt various policies to deal with the problem most of these policies have no implementing or operational capacity.

In response to the problems of clear guiding principles and values that can steer cities to desired long-term social and economic outcomes, Godschalk (2003) puts forward a comprehensive urban hazard mitigation aimed at creating resilient cities. He argues that hazard mitigation policy, practice and knowledge fail to deal with the unique aspects of cities under stress, strongly emphasising, in a similar way to Blakely (op cit), that more expanded urban systems research, education and training with collaboration among professional groups involved in city building and hazard mitigation is urgently needed. A recent research proposal FINADPT (2005) explores the potential for dynamic interaction between the natural and socio-economic systems. This research will view natural and socio-economic systems as developing in a co-evolutionary way, rather than regarding them as independent of each other. For example, the biogeophysical effect of sea-level rise will be studied for its potential socio-economic impacts. Hence impact potential is considered as the socioeconomic equivalent of the natural system's susceptibility, although unlike susceptibility, it is dependent on human influences. The research hypothesizes that socio-economic vulnerability is caused by the impact potential and society's technical, institutional, economic and cultural ability to prevent or cope with these impacts.

There is a large body of planning literature dealing with various aspects of the poor performance of modern urban settlement patterns (Layard, et al 2001; Kenny and Meadowcroft 1999; Ericksen et al 2004). In addition, scientific literature is emerging that focuses on the need to revalue nature and find better ways to live by integrating the long-term welfare of the Australian people and its plants and animals with climate and energy resource requirements (See Flannery 1994, Archer and Beale 2004). Writers such as Calthorpe (1993) and Duany et al (2001) have focused attention on rethinking the planning of new suburbs to make them more environmentally sustainable. While some of these ideas have been incorporated into planning policies and strategic plans in many American and European cities including Australia, none of the strategies adequately consider the radical changes to urban design needed to account for severe climatic change.

Designing For or Against Climate Change

There are several studies on what constitutes an environmentally friendly urban form that might mitigate or adapt to the changes in climate. But again there are none that have responded to the challenges presented by the possibility of extreme events. For example, considerable research has focused on the differences between the temperature of vegetated urban parks and their surrounding built environment (Spronken-Smith and Oke 1998) and observations have been made about surface and air temperature relationships. In Vancouver, British Columbia and Sacramento, California it has been found that during summer conditions of large surface 'park cool island' (PCI) are present by day and at night and that while Vancouver's parks are 1-2 C cooler, larger PCI were found to be possible in Sacramento where irrigated green space is 5-7 C cooler. Trees were also found to play an important role during the day in establishing a cool park effect, perhaps through a combination of shade and evaporative cooling. At night the surface geometry and moisture status of parks were considered to be important controls on surface cooling. These findings are in Arnfield's (2003) review of progress in urban climatology over the last two decades on the conceptual advances made in microclimatology and boundary-layer climatology (See also Wenga et al 2004). This research indicates is it is possible to alter the role of scale, heterogeneity, dynamic source areas for turbulent fluxes and the 'heat island' complexity introduced by the roughness sub-layer over the tall, rigid roughness parts of cities. The Australian Government in 1995 published AMCORD 95: A National Resource Document for Residential Development to induce the states to implement urban design guidelines. But they are really little more than a set conceptual ideas (Australian Government, 1995).

A different approach to engineered works identified in the literature is that of Mileti (1999) and Brown (2001). They suggest incorporating sustainable technologies in the design of communities to make them more self-reliant and independent from outside infrastructure and servicing in times of natural disasters. The U.S. Senate Subcommittee on Natural Disaster Reduction has explored the link between natural hazards and climate change as a part of its mission citing the fragmented approach to natural hazard mitigation and disaster management (Geis 2000). In sum, the works of Mileti (1999), Britton, Burby et al (2000), Cutter, Tierney, and Beatly (1998) acknowledge the connections that must exist between the built environment and the disastrous effects of natural disasters. However their ideas do not get close to developing a normative theory of planning and urban design specifically directed at those effects (See Mitchell 2003).

There is considerable literature dealing with general concept and ideas about how to create environmentally sustainable environments, but little recognizes the enormity of the coming problems. The literature on the connection between climate change, the threat of natural hazards for human settlements resulting from climate change, and urban design is rather scant.[2] Although several scholars (Burby et al 2000; 1999; 1998; Beatly and Berke 1997; Beatly 1998, Geis 2000; 1998; 1987; 1994ab; Sanderson 2000) have raised concerns about the need for serious examinations of climate change integrated with the planning and urban design process, the only work in urban planning that directly addresses the design of cities in relation to climate change disasters is that of Donald Geis (2000). Geis' work consists of a general urban design, planning, and local government guideline to design such communities, although more detailed and graphic urban design guidelines that may serve as blueprints for designing disaster resistant communities are still missing in his published work. His Disaster Resilient Communities (DRCs) are a set of generic guidelines which are not specific to actual geographic locations or climatic conditions. Natural disasters seldom respect general urban design prescriptions. This requires specific geographical location initiatives based on the anticipated hazards (i.e. whether the community is coastal area, a flood plain, etc.) and scale (i.e. whether it is a large city or a small community).

Urban Natural Disasters

Antecedents of the literature that relates urban location to natural disasters can be traced back to the geographer Gilbert White (1936) in an article published in *Planner's Journal* (the predecessor of the Journal of the American Planning Association) and to Hewitt (1997) in his Regions at Risk: a Geographic Introduction to Disasters. Although natural disasters indicate the connections among land use, urban form, urban design, public infrastructure and the community's vulnerability to the impacts of extreme natural events; more is known about building codes and methods of making buildings safe than about these connections (Ceniceros 1997). Geis suggests that while there is great concern about the safety of buildings, it is not possible at this stage to have a safe building "if you don't have a safe community to put it in" (Geis 2000: 3). We would add that the 'safe community' must also include a safe social and economic environment.

[2] This literature review does not concern climate change, or natural hazards, and the design of individual buildings. In contrast with the literature on climate change and urban design, the literature related to the design of buildings is very abundant, specifically in the field of structural engineering.

The International Decade for Natural Disaster Reduction, established by the UN for the 1990-2000 decade raised global concerns about disaster-safe communities and produced a series of studies to address this issue. According to Boulle et al (1997), most of these papers dealt only with the effects of natural disasters with little on climate change mitigations and management. Burby, Beatly and others (Burby et al 1999) stress the connection between federal land use regulations and policies and the losses caused by natural hazards. Their work emphasised how land use planning can be a powerful tool to revaluate the way cities are designed to avoid the risks of natural disasters in developed areas. Other related works that identified the relationship between land use planning and natural hazards are the American Red Cross' Disaster Resistant Neighbourhoods (2000) and Bahrainy's 'Urban Planning and Design in a Seismic-prone Regions' (Bahrainy 1998). Land use and land management are central issues for disaster planning and mitigation since land taxes and land values spring from the classifications of land and purposes it is best suited for. No place is a better illustration of this phenomenon than New Orleans when the flood maps put out by the federal government and the land plan called Bring Back New Orleans sparked a contentious battle between blacks and whites, rich and poor over who could determine what is safe and build-able and who can say so. (Birch and Wachter, 2006)

At the heart of this issue are the Federal Emergency Management Agency (FEMA) and its Project Impact Program in 1996-97. FEMA-sponsored studies that advocate and recommend land use planning adequate to mitigate the effects of natural disasters by constructing area-wide protective works such as hazard-control structures (e.g. flood-control and hurricane-protection levees and flood-control reservoirs) channel alterations, tide gates, pumps, among other engineered measures and building away from floodplains, from seismically active areas, and from wetlands and hillsides (Burby 1998; Geis 2000; Godschalk 1999; Britton 1998; Olshansky). FEMA also advocates so-called "safe development" practices through modification of building and site design. A major shortcoming of the FEMA approach, however, is the assumption that one federally-defined safety plan will fit all localities. Sociologist Dennis Mileti (1999), for example, rightly points out in Disasters by Design, the Second Assessment of Natural Hazards in the United States, that one overarching guidance to inform development in hazard prone areas is still missing from FEMA, i.e.: "Instead, a patchwork of innumerable federal, state and local regulations creates a confusing picture and often mitigates short-term losses while allowing the potential for catastrophic losses to grow" (Mileti 1999: 7).

A publication that addresses the relationship of natural disasters in urban planning is Beatly and Berke's After the Hurricane: Linking Recovery to Sustainable Development in the Caribbean (1997). This study draws on three years of field research that examined the effects of hurricanes in the Caribbean in 1988 and 1989. Berke and Beatley lay the basis for sustainable development and growth in the areas affected by the hurricanes. When focusing on post-disaster recovery, the authors explore the opportunities offered by the recovery period for strengthening local institutions to provide for long-term social, economic and physical development. Nonetheless, like similar studies, their research does not cover specific guidelines for comprehensive disaster resistant development. The importance of Geis (2000; 1998; 1994a; 1994b; 1987), who coined the term 'Disaster Resistant Communities' (DRCs), is that he provides the only structure for understanding how climate change responses might be conceptually modelled. Geis points out that "While traditional emergency management programs and planning, viz—mitigation, preparedness, response and recovery—are essential, the only real way to reduce the growing human and property losses from earthquakes, hurricanes and severe flooding is rooted "… in how we design and build our communities in the first place in these hazard prone areas" (Geis 2000, 3). The DRC concept is explicitly created to provide a vision of an "overarching guidance that informs development in hazard prone areas" (ibid)[3].

The DRC concept was introduced in a symposium in 1994 and evolved from a perceived need for a more integrated approach to address natural hazard disasters, human and property losses, and associated socioeconomic disruption costs resulting from extreme natural events such as earthquakes, hurricanes and severe flooding (Geis 1994a). A major concern to arise from the symposium was the recognition that the design of the affected community was essential for an approach that would include mitigation policies. Another major influence in the design of the DRCs was a study sponsored by the National Science Foundation on the architectural and urban design lessons learned from the Mexico City earthquake of 1985 (Geis 2000; Geis et al. 1989; Geis and Arnold 1987). Geis advanced the DRC concept with the view to apply it to the U.S. and to other countries (Geis 1995; Geis 1996). In Geis' own words, a DRC

> … represents the safest possible community that we have the knowledge to design and build in a natural hazard context. It is a means to assist communities minimize their vulnerability to natural hazards by maximizing the application of the principles and techniques of mitigation to their development and/or redevelopment decision-making process. While theoretically possible, a Disaster Resistant Community is in reality a model and a process, an optimal set of goals to work toward, and a set of guidelines to get there. It is also a means for envisioning these goals and a practical framework for implementing them. … The DRC approach must obviously address the structural aspects of a community's buildings and infrastructure through effective building codes, and location considerations through general land use plans. These two aspects, however, represent only one dimension of the multi-dimensional sphere necessary for creating such communities. It also recognizes that numerous other non-structural and functional considerations of the overall community are just as important. The DRC approach is based on the premise that it is impossible to have a truly 'safe building' without also having a safe overall community and region in which to build and support it (Geis 2000, 3-4).[4]

Geis proposes design principles to be implemented through urban planning regulations and mechanisms to include:

- The relationship between the built and natural environments.
- The configuration, hierarchy, location, and scale of transportation systems and other public infrastructure.
- The design and patterns of open space.
- Housing, neighborhood, and community buildings design.
- The design and location of community felicities such as hospitals, fire and police stations, and certain administrative offices (Geis 2000)[5].

[3] DRC Concept provides guidance for urban design in disaster situations

[5] The DRC concept continued to change in 1994 through a series of presentations at various professional meetings in the U.S. The first comprehensive paper on DRCs was presented in Tel-Aviv in 1994 at the 1st International Congress of Local Authorities Confronting Disasters and Emergencies (LACDE) (Geis 1994b). This work stresses the role of local governments and further develops the connection between natural hazard mitigation, disaster resistant communities and sustainable development (Geis 2000).

The notion of New Urbanism and DRCs has been linked in a master's thesis (Mitchell 2003) which tries to produce a blueprint for cities threatened by the devastating effects of natural hazards. Mitchell's study is based in the apparent natural relationship between Disaster Resistant Communities and "quality of life" or "sustainable communities." It starts from the assumption that all sustainable community proposals—such as Calthorpe's Transit Oriented Developments, Duany's Traditional Neighborhood Developments (Op cit) and Australian Liveable Neighbourhood Structure communities (Western Australian Planning Commission 2000)—are based on development patterns that address all DRC principles[6].

Mitchell claims that New Urbanism may embody the principles advocated by Geis because the street grid pattern in New Urbanists communities is the best for evacuating people in emergencies. The reason he gives is that the central locations of most public buildings and facilities in New Urbanism lend themselves easily to a government response to mitigate natural disasters with the preservation and location of open space serving as buffers and spaces for the gathering of people in post-disaster situations etc.

Over 500 US cities and 17 states have signed to be bound by the Kyoto Protocols including the most aggressive approach in the nation taken by two Republicans Governor Arnold Schwarzenegger of California and Mayor Michel Bloomberg of New York. These public officials have agreed to:

- Strive to meet or beat the Kyoto Protocol targets in their own communities, through actions ranging from anti-sprawl land-use policies to urban forest restoration projects to public information campaigns;
- Urge their state governments, and the federal government, to enact policies and programs to meet or beat the greenhouse gas emission reduction target suggested for the United States in the Kyoto Protocol -- 7% reduction from 1990 levels by 2012; and
- Urge the U.S. Congress to pass the bipartisan greenhouse gas reduction legislation, which would establish a national emission trading system.

Cities and states are setting the agenda for the United States which produces 22% of all the greenhouse gases. This bottom up action is the focus of this paper. Research and policy go hand and hand.

A Policy Research Agenda for Climate Change Planning

From the above examination it is evident that a significance body of information exists in urban planning about what constitutes an environmentally sustainable urban form. The literature, however, is not adequately informed by scientific knowledge about likely climate change scenarios. Thus research is needed to bring current knowledge about temperature rises and 'heat island effects', air pollution, sea level rise, storms, flooding and wild fires to bear on the design DRCs that are much better able withstand extreme events. A critical issue, therefore, is to collate the various strands of scientific knowledge so as its implications can be modeled and understood in the urban context, which will then allow new scenarios for planning the urban form to proceed on a solid knowledge base rather than

[6] Mitchell tries to merge Geis' design guidelines with the urban planning and design precepts of New Urbanism to suggest what he calls Disaster Resistant New Urbanism. Mitchell's work seems to arise out of the coincidences between paradigms; his study remains rather superficial and schematic.

the well intentioned but often misleading 'feel good' policies and statements about sustainable urban forms that abound in statutory planning policies and instruments. This is important for many on coastal cities that are highly vulnerable to the climate change predictions. Recent climate events could be considered as early warnings of what is to come and stay for hundreds of years. Hence there is an urgent need to inform planning practice with current scientific information to develop better methods and procedures for designing the urban form.

Most works that point to the problems of interconnecting land use, urban development, and government policies to withstand the negative effects of natural hazards fall short in prescribing specific and robust planning policies and urban design guidelines that can face the impacts of climate change-induced natural disasters. In response to the above gaps in the literature, we suggest that research on the relationship between climate-change induced natural hazards and the design of cities must respond to the scale of the development under study, its geographical location, and to an assessment of new natural hazards threatening the settlement with climate changes.

Type of Urban Research Needs

	Residential	**Commercial**	**Institutional**	**Open Space**
Flood	Land use and tidal basin research	Building size, and building foot prints where surfaces add to flood damage via run off	Risk assessments of prolonged floods and droughts on ground cracking or softening. Impacts on animal life of floods	Better design to carry water—examination of old stream beds and movement channels that may re-emerge in flood periods and across open space causing more damage Retarding basins for flood mitigation
Rising sea level	Coastal community, beach erosion and tidal change scenarios	Building locations near water, with piling and footings as well as underground facilities such as car parks	Examining coastal building regulations, moving residential areas away form high risk locations	Coastal and beach areas Studies of flora and fauna as sea level rises Studies into unstable dune systems
Heat Waves	Impact of continuous heat on energy systems; building materials, house orientations to the sun, roofing materials and construction	Building energy use, roof materials and elevator systems as well as evacuation	Long term city government plans to replace roofing material and invest in energy wise materials and regulatory practices	Cooling sink research on open areas-looking at type of tree and performance of open areas-like ball fields in heat periods
Wind and Rain Storms	Building design, street trees and other materials in residential areas as protectors or dangers	Building foot prints and wind tunnel effects	City wind research units to measure impacts of winds and storms on city	Open areas as wind carriers—open area wind tunnels or wind shields

Specific designs solutions tied to particular types of extreme event occurrences to withstand the negative effects of climate change may also prove cost-ineffective for most cities. Each city region must be evaluated for its potential risks to prescribe corresponding urban design guidelines as the above figure shows. Climate change research will need to be targeted in relation to the particular type of climatic events and to local geographic areas where they may strike. Obviously, many large cities in the developing world are at great risk. Most of these cities have poor infrastructure for urban living and will be disastrously impacted by major climate changes. The World Bank and other agencies must take stock in this situation because the implications of the Asia-Pacific Tsunami in 2005 show how devastating such events can be. Although most cities have some form of disaster mitigation structures or area-wide protective works such as flood-control reservoirs, flood retention basins, hurricane-protection levees, and the like; these precautions do not consider the unexpected and new potential hazards that the current trends in climate change may bring about to the same city. Therefore, an agenda for research must include not only the contingency of hazards occurring in cities; but also the devastating impacts on nearby cities with economic and social linkages. In the next instalment of this work there will be an attempt to look at how risk can be measured and displayed to assist in understanding risk parameters and risk reduction options and map these against several cases in Australia and the United States. In addition, there will be more data on how both American and European communities are crafting strategies to reduce risk using various land management tools and crafting new mechanisms that affect land and land use policies. In many respects the Henry George presumptions about land as a public good come into play in this new perspective of it use having communal and not merely individual impacts. In many respects, the solutions to and understanding of climate change will challenge the foundations of land use control and notions of property rights.

A Climate Change Agenda for Cities

Cities have essentially three roles in the climate change arena. The first is to reduce the risk of climate change; second, developing risk profiles for the range of risk they face based on geography and geology of their location, and finally, developing strategies for adapting to climate change on a macro and micro-scale. Each of these roles needs to be examined in some depth so cities can act responsibly in responding to the dilemmas of climate change. In the next section of this paper we will develop a template for the role of cities in each of these areas. In subsequent chapters we will flesh these out more completely to guide cities on how to use the policy concepts tools and technologies available to re-cast the city framework it self to deal with the gravity of climate change. To bring some degree of reality to this framework, I will use New Orleans as the model for risk assessment design at the municipal level as well as refer to other local government around the world who have sued similar tools to determine their vulnerabilities.

Profiling Risk—the New Orleans Case

The form and potential for risk vary from place to place but there are many macro-elements in common that any city can use as it analysis it vulnerabilities. The approach used here is collective expert opinion in a semi Delphi technique[7]. The risks below are not the only ones cities can or will face but this is a good list for constructing a matrix useful for local policymakers.

Heat Waves

A heat wave is a prolonged period of extreme hot weather – the parameters of what constitutes 'extreme hot' can vary in relation to usual temperatures in a given area. Heat waves are often accompanied by high humidity.

Extremely hot days can also increase the risk of spontaneous combustion of flammable materials, which, compounded with dry weather, can lead to increased fire risk. Fire risk are greater win places that have large wooded or unprotected range lands that react to either man made flammables as well as to intense temperature rupturing the landscape and causing fire destruction. Fire danger increases exponentially as homes

[7] Delphi Technique is an approach to gathering opinions via qualitative and quantitative means and normalizing them. In this case we used quantitative ratings among local experts in New Orleans.

and other structures are added to fire prone areas. Home development has increased as second homes become increasingly used year around in heavily wooded areas or developers increase penetrations into areas formerly devoted entirely to wilderness in the developing world and the urbanization of forest areas increases in the developing world.

In places like New Orleans, fire dangers have been magnified by all of the forces described. The increased penetration of former swamp lands for recreation and even housing developments has increased five fold since 1968 when the oil extraction firms came to the southern part of the state near New Orleans. There has been permanent loss of over 500,000 acres of forest thorough fire and associated deterioration as result to the New Orleans levee system (Coastal Wetlands Forest Report 2005). Prophetically, in April 2005, just 4 months before Hurricane Katrina, a report was delivered to the Governor depicting the dangers of fire and environmental degradation from the continuing decline of the forest lands that bound New Orleans and both endanger and protect it (Coastal Wetlands Forest Report, 2005).

Infrastructure Risks

Extreme heat continued long term rains and cold can affect road materials and undermine the stability of roads, and can lead to drying out and cracking of building materials. Major city infrastructure is directly affected by weather if it is unprotected. Bridges, roads and can be damaged as a result of bitumen melting or concrete expanding and cracking. As these impacts are more closely linked to persistent increased mean temperatures, they are more fully discussed below.

Table.1Major risks associated with heat waves. 25= high to 1 low

Mode of Impact	Code	Impact	Risk Score		
			2020	2050	2100
Heatwave	HW5	Increased illness in vulnerable populations (i.e. elderly, children, and people with existing illness)	20	25	25
	HW4	Increase in heat related illnesses	16	20	25
	HW10	Increase fire risk	12	15	20
	HW1	Decrease in outdoor tourist activity	12	16	20
	HW9	Increased water demand	12	16	20
	HW8	Increased peak energy demand	12	16	20
	HW2	Decreased attendance at festivals and outdoor events; etc.	9	12	20
	HW7	Pressure on emergency services	9	16	20
	HW6	Increase in certain types of criminal activity	8	12	16
	HW3	Increase tourism at indoor centres	6	8	10

Heat-Related Illness

The primary risk associated with heat waves is the potential increase in the incidence of heat-related illnesses. In New Orleans, heat waves have caused more deaths than any other natural hazard (except disease) in the 20th Century. Vulnerable populations, as identified in the previous section, are particularly susceptible to illness relating to heat waves. For example, during a heatwave in France in August 2003, the elderly (above 75 years of age) experienced a 70% increase in mortality. The general population is also at risk from heat-related illnesses associated with heat waves. This may increase the pressure on emergency and medical services. In New Orleans, the absence of air conditioning in many low income homes leads to death because people in these neighbourhoods remain shut in their homes because of fear of violence. As a result, children who would normally be in outdoor porches for sleeping are indoors in hot uninsulated circumstances that can end in death or severe health problems.

Tourism

Heat waves impact tourist activities in that the number of people engaging in outdoor activities will decrease, while indoor activities (particularly air conditioned indoor venues such as shopping centres and cinemas) will experience an increase. Currently, tourism activities in New Orleans are focused primarily on outdoor venues, such as the French Quater and gardens, and as a result, New Orleans can experience a decrease in tourist numbers, and subsequent decrease in tourist generated revenue, during summer heat waves. Festivals and outdoor events, such as the Essence Festival can suffer a decrease in attendance.

Further impacts associated with tourism could be increased demand for emergency and medical services due to the potentially large numbers of tourists in the area, particularly during festivals and outdoor events. Moreover, since summer is associated with hurricanes, tourism may be curtailed by many tourists who hear or read of the hurricane season. Post Katrina, television news services such as the weather channels provide information that is both valuable and also potentially damaging since they speculate on the vulnerability for extreme events like hurricanes as they track hot weather patterns.

Energy and Water Demand

Historical evidence suggests that water consumption increases dramatically during heat waves. As heat waves often accompany dry weather, this can exacerbate already stressed water supply systems.
As mentioned previously, increased use of air conditioners can increase peak electricity demands during extremely hot weather and heat waves. Prolonged heat, and hence prolonged peak energy use can increase the risk of power failure.

Criminal Behaviour

The link between heat waves and increased crime rates is well documented. Several studies have also found a link between high temperatures and aggressive human behaviour (Jacob *et al.* 2004). Crime rates in New Orleans are extraordinarily high but in the summer they exceed all other period of the year.

Increased Mean Temperature

Though the predicted increase in mean temperature (0.5°C by 2020 and 1.5°C by 2050) may seem insignificant, climatologists suggests that a 1°C increase in mean temperatures is equivalent to cities in the north like Chicago experiencing temperatures similar to Miami in November. This would mean the Great Lakes would not freeze changing the flora and fauna around the Great Lakes greatly. In New Orleans, this would mean perpetual summer with a strain on the energy system that could not be sustained using current technologies. New Orleans is heated and cooled by fossil fuels. The costs of these fuels are increasing and the ability to find and use alternative resources is constrained by the fact that the Mississippi has been reduced and continued unable to release it natural energy for hydropower.

The risk assessment identified twenty risks associated with increased mean temperature (Table.3). Of these, none are considered major risks (i.e. with a score of over 20).

Table.2 Major risks associated with increased mean temperature.

Mode of Impact	Code	Impact	Risk Score		
			2020	2050	2100
Increased Mean Temperatures	MT9	Increased attendance at festivals and outdoor events; etc.	20	25	25
	MT8	Increased number of people visiting tourist areas in summer or hot months	15	20	256
	MT12	Loss of sensitive species and / or species of conservation significance	12	16	20
	MT16	Increased heat-related illness	12	16	20
	MT6	Increased water use / demand	9	16	20
	MT13	Habitat and food resource loss	10	12	16
	MT4	Increased insect pest problems	9	9	12
	MT5	Road pavement buckling and road material degradation	10	12	15
	MT10	Decreased survival of heat sensitive / water intensive plant species	10	12	16
	MT18	Pressure on emergency services	20	20	25
	MT1	Stress on building materials	8	10	12
	MT2	Thermal comfort of buildings and increased energy use (summer)	8	12	16
	MT11	Increase weed and invasive plant growth and pest species (rodents and insects)	4	6	8
	MT14	Change in animal breeding patterns	4	12	16
	MT15	Change in animal activity	4	6	12
	MT19	Increase street cleaning / beach cleaning requirements	4	6	8
	MT20	Increase maintenance of recreational areas (i.e. ovals; pitches; bowling greens; etc.)	4	6	8
	MT3	Decreased energy use (winter)	3	4	5
	MT7	Increased evapotranspiration	3	8	12
	MT21	Increased use of parks and recreation areas	3	8	8
	MT17	Increased spread of infectious disease	2	6	9

<u>Tourism</u>

The primary impact of increased mean temperatures is beneficial – increased attendance at festivals and outdoor events and an increased number of people visiting beaches and outdoor tourist venues.

The flip side of an increase in tourism includes an increased requirement for the management of tourism-related issues, such as waste management (litter in recreational areas) and a possible increase demand for emergency services.

Water Resources and Energy Demand

Water use and energy demand both tend to increase as temperature increases. As these were both discussed in previous sections, the discussion will not be repeated here. Higher temperatures can exacerbate some water quality issues. Generally, an increase in temperature will increase the reactivity of some compounds and can facilitation chemical reactions, which can result in increased mobilization of pollutants. Combined with intense rainfall events and general low water levels, high temperatures could exacerbate water quality concerns. New Orleans has no subsurface water reserves. As a result, water loss via evaporation is a very serious issue and the potential for contamination of the water supplies is very high. Moreover, the current water system is well beyond its useful life.

Warmer winters and the associated lower heating requirements will somewhat offset this energy use, but it is likely that the increased cooling requirements will be more significant than the decreased cooling requirements.

Damage to the Built Environment

From a built environment perspective, higher mean temperatures can result in damage to building materials (i.e. warping, cracking) from heat expansion and moisture loss. Evidence suggests that clay and timber materials are most susceptible to damage. Building foundations may also be affected as a result of drying and wetting conditions of soils. In New Orleans, all of the central area of the city will be affected as temperature and humilities increase. Since the city is largely on reclaimed land especially Eastern New Orleans there is severe risk to of settling and foundation damage.

As mentioned previously heat can lead to melting of bitumen and cracking of concrete resulting in potential damage to road networks. As a result, there will be increased road maintenance requirements, road closure leading to traffic jams and accidents.

Storm Tide and Surges

No risk is as well known and understood to New Orleans than storm surge. The Corp of Engineers has recently completed an extensive examination of the risks of storm rising and surging in New Orleans. Sea levels have been rising about 3 ft per century. But recent changes in climate are increasing higher tides and increasingly rapid sea rise. The sea is warmer as ti rises increasing its volatility. The National Weather Service indicates that Global Warming is contributing to not only increased hurricane activity, that activity is predicted to hit the coast near New Orleans more frequently and with greater intensity than any other part of the Gulf Coast.

Table 4 Risks associated with storm surge and storm tide.

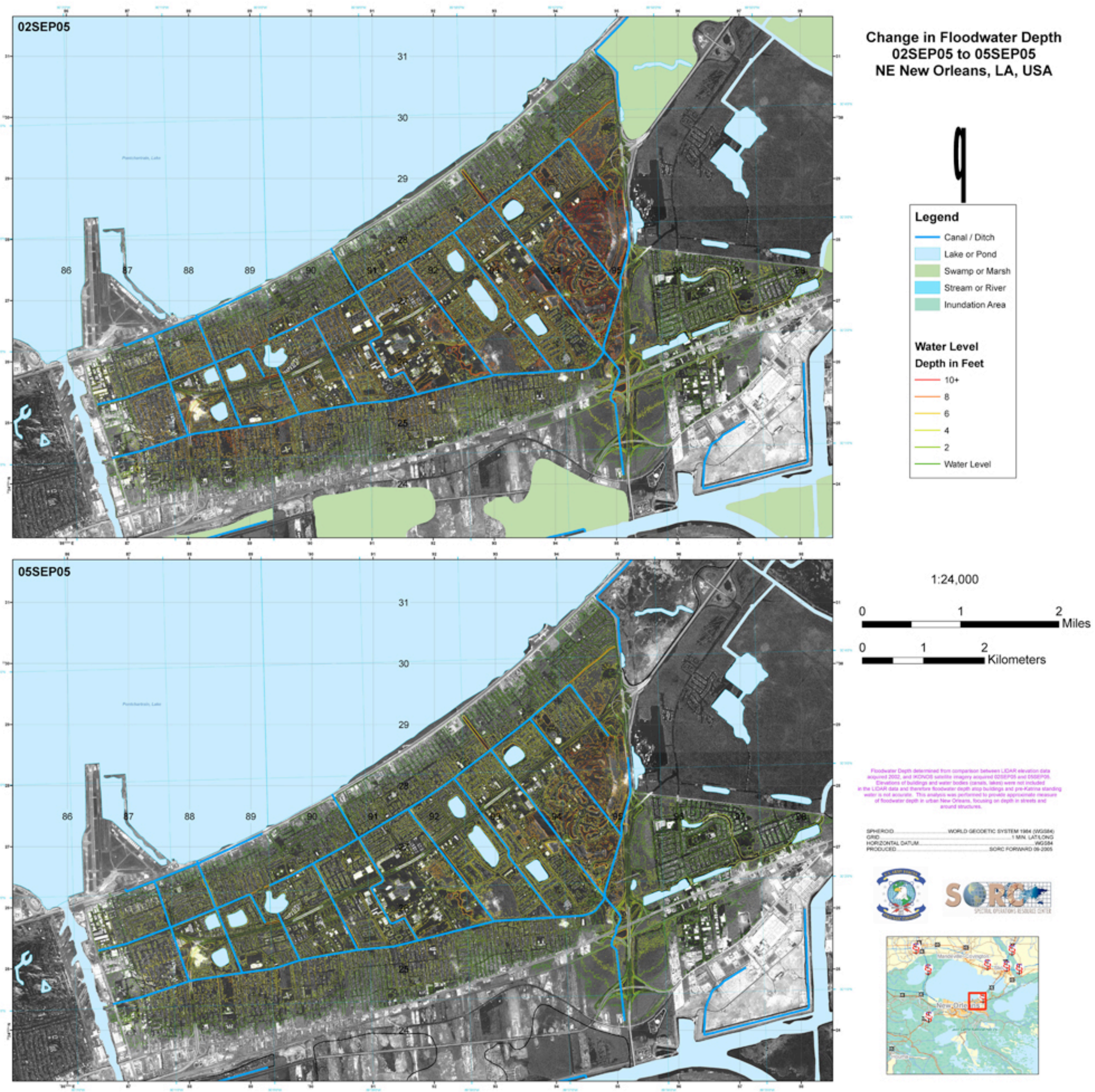
Mode of Impact	Code	Impact	Risk Score		
			2020	2050	2100
Storm Surge / Tide	SS4	Loss of wetlands	20	25	25
	SLR8	Impacts on planning zones	20	20	25
	SS1	Flooding of coastal properties	16	20	25
	SS5	Loss of sediment deposits from rivers	16	20	25
	SS6	Coastal erosion and infrastructure instability	15	20	25

SS8	Damage to coastal ecosystems	12	16	20
SS7	Damage to bike trails and coastal roads	9	12	15
SS2	Impacts of salt on fresh water systems	4	9	20

The risk assessment identified two major risk associated with storm surge in the short-term: loss of wetlands and impacts on flood zone designations. Though loss of wetlands erosion is inevitable, it is important to point out here that storm surge events will increase both the rate and magnitude of wetland erosion and subsequent loss. As an example, there will be several thousand yards of sand during the major storm events throughout the next decade.

Impacts to Planning Zones and Flooding

Planning designations are likely to be affected by future storm surge events. As these events become more frequent, more intense and move further inland; it will become more difficult to protect properties already at risk, and additional properties not currently at risk (and therefore not currently protected) will be vulnerable. Though the third highest risk, flooding of coastal properties, is the primary driver behind impacts on planning zones; it was given as high of a risk score because it has very high likelihood of occurrence. Despite this high likelihood, the potential magnitude of the consequences of flooding, the increased risk of flooding over time (refer to 2050 and 2100 risk scores) and public perception will most likely affect planning zone designations more than the information associated with flood designations.
Within the case study area, the locations most at risk from coastal inundation are very close to the City of New Orleans. The map below shows the consequences of intense flood events on the City.



Climate Change Justice Impacts

Like all other forms of social and physical interaction climate change has uneven social as well as environmental impacts on various communities. Some rural farm areas will be dramatically affected by increasing temperatures that dry out soils while other areas that have been too cool will be more inviting to new crops because of decreased snow pack. But in urban areas these impacts are not as quickly grasped until events unfold as they did in New Orleans with Katrina. The world saw how years of unequal allocations of housing stock and other resources limited the options of the poor in their attempts to evacuate. So, too climate change events and even the slow transformation of energy costs and related impacts will have dramatic impacts on the most vulnerable residents in every city. The key issues relate to locational vulnerabilities. Poor people in cities frequently live near the levees and other buttresses because the land is cheaper. Similarly, low income neighbourhoods are less able to adapt new technologies since even with cost reductions via tax breaks they do not qualify for such incentives and are locked into old technology regimes. The issues explored in this matrix relate to the obvious resource differences and locational attributes between the haves and have nots. Clearly there are wider ranges of choices for such an analytical assessment. Each community can develop its own standards in this area.

Mode of Impact	Code	Impact	Risk Score		
			2020	2050	2100
Storm Surge / Tide	CJ4	Narrow choice of escape routes	20	25	25
	CLR8	Inappropriate siting of residential areas in vulnerable areas	20	20	25
	CS1	Prone to Regular Flooding	16	20	25
	CJ5	Public transportation choices	16	20	25
	CJ6	Neighbourhood infrastructure instability	15	20	25
	CJ8	Damage to public facilities like schools and churches	12	20	20
	SS7	Damage to community health facilities	9	12	15
	SS2	Impacts on water quality	4	9	20

Conclusions

New Orleans is not unique. Cities all over the world will have to learn how to cope with extreme events. What is laid out here is the means to understand and graphically depict the potential of such events on a city's infrastructure and economic systems. The heart of this analysis is the diagnosis performed by expert panels that can lead to policy alternatives. In the next sections we will examine how these policy dimensions that lead to a calculus of responses.

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