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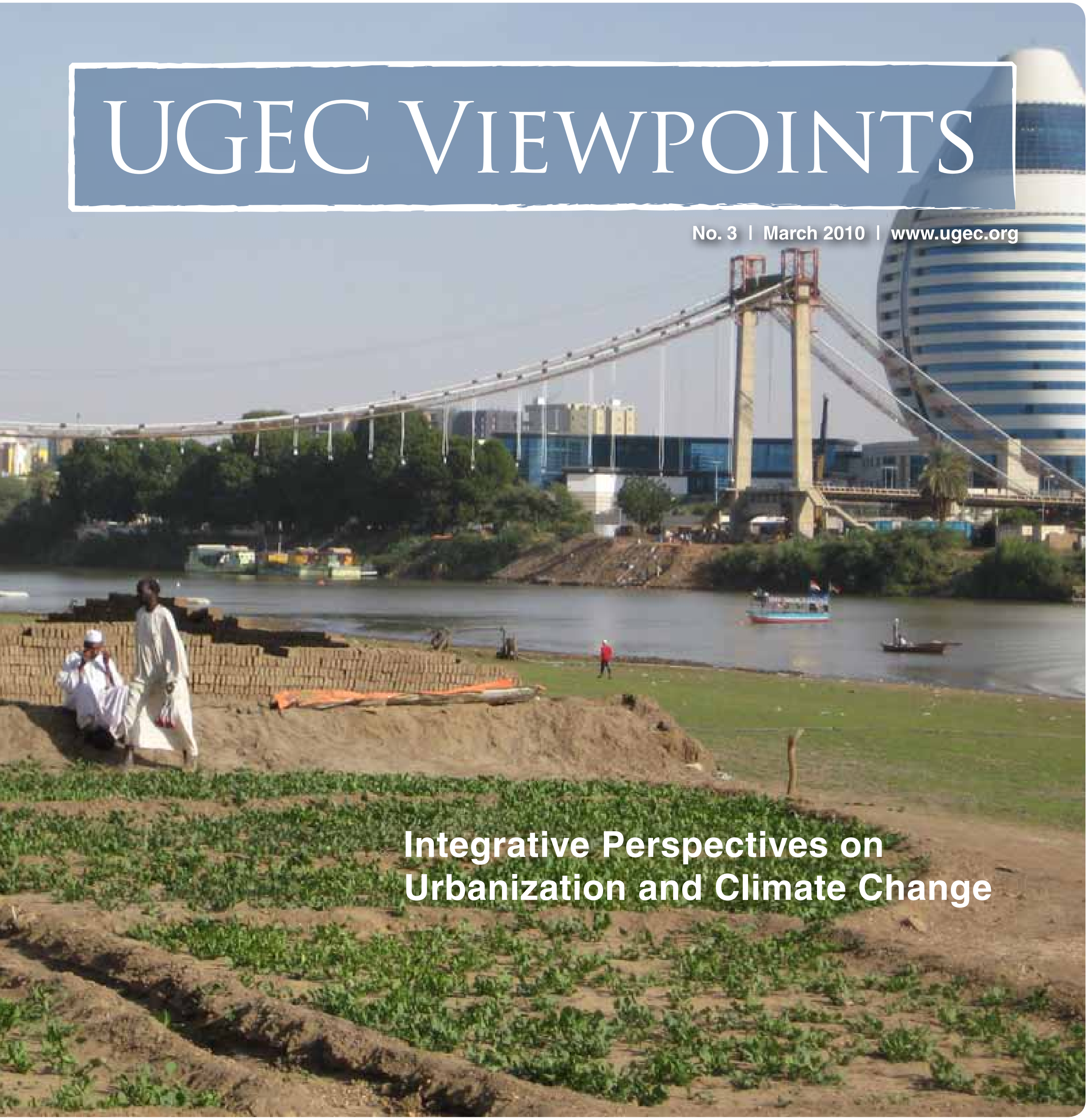

Integrative Perspectives on Urbanization and Climate Change

IHDP
International Human Dimensions Programme on Global Environmental Change

ASU Global Institute of Sustainability
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Editorial

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Dear friends of the UGEC project,

This third issue of *UGEC Viewpoints* includes contributions from the wide spectrum of important thematic and regional foci in the UGEC field. We have put together a great issue and I would like to highlight a few of our contributions: the review of the Tyndall's Urban Integrated Assessment Facility, written by Richard Dawson and colleagues, which focuses on the case study of London; the discussion of climate change adaptation strategies within urban areas of Latin America that includes the case study of Santiago de Chile by Kerstin Krellenberg, Dirk Heinrichs and Jonathan Barton; and J. Marshall Shepherd's analysis of the role that urbanization plays on hydroclimate extremes and changes in the water cycle, highlighting the city of Atlanta.

The joint focus on urbanization and global environmental change now appears more important than ever. A clear message of the recent COP15 United Nations Climate Change Conference in Copenhagen in December 2009 is that humanity's response to climate change – through mitigation and adaptation actions and institutional change – will have to occur concurrently at multiple scales, including but not solely relying on, action from national governments. In particular, the centrality of urban areas in finding solutions to the combined demographic, economic and environmental challenges we will face due to climate change in this century is now undeniable. Thus, we find that our UGEC 2010 Conference, "Opportunities and Challenges for Sustainability in an Urbanizing World" could not be held at a more appropriate time. Scientists, practitioners, policymakers and stakeholders are all invited to participate in a forum for reflection, exchange of knowledge, experiences, lessons, ideas and information on the multifaceted interactions between urban areas and global environmental change. Preparations for the conference are well under way and a call for abstracts is out – which you can find on the last page of this issue. We ask you to please circulate widely the conference website (http://www.ugec2010.org) or the pdf copy of this issue which can be found on the web at http://www.ugec.org.

We hope you will enjoy reading our current *UGEC Viewpoints*. Another issue will be published before next October, so you will be receiving additional information on the conference through that publication. Please do check out our conference website http://www.ugec2010.org for more regular updates. We hope you will seriously consider participating in the event and look forward to meeting as many of you as possible in person in October!

Best regards,

Michail Fragkias

Michail Fragkias
UGEC Executive Officer

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Busy traffic in Santiago, Chile with the Andes in the background

Climate Change and Adaptation Strategies in Latin American City-Regions: The Case of Santiago de Chile

Kerstin Krellenberg, Dirk Heinrichs, Jonathan Barton

Induced by a growing consensus that climate change is inevitable and plausible scenarios of impacts, city administrations worldwide are planning their responses. Although cities are key sources of greenhouse gas emissions and are highly vulnerable to the consequences of changes, they are also initiating actions to both reduce greenhouse gas emissions and to confront the anticipated effects. The Latin American/Caribbean region is no exception to this, as if follows North America (the most urbanized region worldwide), with approximately 80% of the population living in urban areas (United Nations 2008). Megacities like Mexico City or Sao Paulo (Prefeitura da Cidade de São Paulo, 2009) have very recently launched climate action plans to confront local problems related to land use and water management, transportation and disaster risk reduction. Other cities, such as Santiago de Chile, are still awaiting similar action steps, which will be developed from the national action plan established in December 2008.

Climate Change Scenarios for Latin America

In Latin America, anticipated climate changes and their predicted impacts are already experienced and traceable. According to the Intergovernmental Panel on Climate Change (IPCC), median annual temperatures rose by 1°C between 1961 – 1990, accompanied by glacial melting and a rising sea level of 2-3mm. At the same time, precipitation variability and an increase in extreme events that often correlate with the El Niño-Southern Oscillation (ENSO) phenomena have been observed. Related consequences are floods, land slides, and water and energy scarcity.

Following the IPCC (2007) and its global models, these consequences will become increasingly severe in Latin America, considering the predicted median annual temperature rise between 1.4 and 2.6°C exceeds historic trends. The expected consequences are complex, and on the whole negative. Rising temperatures and precipitation variability are expected to aggravate glacial melting along the Andean range, as these countries are already suffering seasonal shortages in water for irrigation, drinking water and hydropower supply. Other predicted impacts are salinization and desertification in arid regions, which will consequently affect the food industry. Together with the sea level rise, an increase in coastal flooding events seems unavoidable. These are only some of the expected multiple impacts on ecosystems, resources and population.

Deducing local consequences of climate change impacts for city-regions is complicated and afflicted with a high level of uncertainty due to the problem of downscaling global climate models and the complexity of synergetic urban and regional processes. Nevertheless, based on different types of information available for the metropolitan area of Santiago de Chile, this article attempts to explore the challenges facing Latin American city-regions in the context of climate change.

Santiago de Chile: A Case of Rapid Urbanization and Pressures on Natural Resources

The metropolitan region of Santiago de Chile, with its population of six million, is the economic centre of Chile, contributing 42.7% to the national GDP (GORE 2009). The expected population by 2030 will exceed eight million people (MINVU 2008). In comparison with other Latin American city-regions, population density in Santiago de Chile is relatively high with approximately 90 persons per hectare, however, the central area possesses comparatively lower density than other areas due to a process of population loss to more peripheral urban municipalities (according to the national census, 1992-2002); this has generated a process of suburban sprawl during recent decades (Figure 1).

Figure 1 | The "sprawling" city of Santiago de Chile

Source: A. Künzelmann, UFZ

These urbanization processes have led to land use changes in principally agricultural areas and in the Andean piedmont where much of the region's remaining conservation zones are concentrated. With increasing urban land use, there is also increased risk due to the loss of environmental services, e.g. water infiltration, heat mitigation, and biodiversity conservation. Accordingly, a more fragmented city-region has evolved in functional and spatial terms, associated with important socio-ecological ramifications. Urban and regional form and their uses accompany the pressures of population growth and economic productivity that generate different resource demands for land, water and energy. The combined effects of these pressures make the metropolitan region increasingly sensitive to climate change.

While the city of Santiago is a successful case in terms of water supply coverage with almost 100% of the population connected to the domestic water supply and sanitation systems, it registers the highest in aggregate per capita water consumption among all large agglomerations in Latin America. At 616 litres per person/day (INE 2006), the inhabitants of the metropolitan region and their productive activities consume three times the amount of water than those in Lima (SEDAPAL 2008). The figure exceeds that of Mexico City (Del Valle-Cardenas 2009) or Buenos Aires (PNUMA 2003a), which are both known for notoriously high levels of water demand. With roughly 230 litres of per capita domestic use, less than one third is dedicated to domestic uses (PNUMA 2003b). The larger share is reserved for agricultural production[1].

Local Climate Trends and Climate Change Scenarios for Santiago

Santiago de Chile is located in the Maipo river basin on the western flanks of the Andes and is subject to a subtropical dry climate, with median annual temperatures of 14°C and annual median precipitation rates of 312.5mm. The warmest months are December, January and February with an average of 18.9 – 20.0° C; the coldest period is between June and August with an average of 8.1 - 9.1° C. Most of the precipitation occurs between May and August (57 - 85 mm). The driest period is November through April with an average of 2 - 14 mm monthly (median values from the World Meteorological Organization between 1960 - 1991).

Projected data for possible future impacts of climate change on the metropolitan region of Santiago are currently generated from different sources at different spatial resolutions.

1 Note, a comparison between different city-regions is difficult because of different administrative units, survey dates, etc., but nevertheless, the given figures allow a general comparison.

Cable car in San Cristobal hill, overlooking a panoramic view of Santiago de Chile

The principal reference point for downscaled climate change scenarios is that of the CONAMA (2006) study conducted by the University of Chile. Based on long-term measurements (1960-1991), the current climate and two alternatives for 2071-2100 (A2 and B2, according to the IPCC) were modelled with the PRECIS-model (Providing Regional Climates for Impact Studies), developed by the Hadley Centre of the UK Meteorological Met Office. The spatial resolution of cells of $25km^2$ generates large uncertainties and inaccuracies, however, the modelling processes also provide relevant ranges in which public policy must be formulated; one of the 50km wide transects of the model represents an approximation to the metropolitan region of Santiago de Chile.

In terms of the more "pessimistic" (A2) scenario, an increase in the median temperature of around 3-4°C (in parts to 5°C) is expected for the period 2071-2100. In terms of precipitation (scenarios A2 and B2), the reductions are in the order of 40% in lower lying areas, less so as the Andean topography bears an increasing influence moving up into the Cordillera (mountain belt) (CONAMA 2006). Together with rising temperature, this is clearly relevant in terms of glacier dynamics, with their subsequent influence on year-long water availability in the basin's two river systems. The consequence will be higher winter discharges of water, gradually reducing over time as the glacial capacities diminish. The effects will be most evident in the drier months (the first four months of the year, in particular) when glacial thaw provides an important water flow through the system.

The Challenge Ahead: Water and Climate Change Governance within Spatial Planning

The combination of recent urbanization patterns, increasing demand for water in the metropolitan region and expected climate change will provide challenges, particularly with respect to equitable distribution of different resources. It is likely that new conflicts will emerge, e.g. over water availability, leading to demands for climate change governance in relation to spatial planning. To date, national and local government has only partially addressed these concerns. The Chilean national action plan creates a framework for action, but the issues are yet to be incorporated into regional and municipal government instruments and investments. It is also unclear how much of the projected 1.1% of GDP loss (to 2100) will be related to urban management issues, compared with productive sectors, e.g. mining and agriculture (CEPAL 2009).

The changes in temperature and precipitation interact with changing land cover and land uses and are directly connected to water supply in the metropolitan region. As the anticipated temperature rise will increase glacial melting and likely reductions in precipitation will increase the length and intensity of dry periods, the water demands of a growing population will aggravate the entire water balance in the metropolitan region. The recession of the Andean glaciers as the principal source of water in Santiago will not only threaten domestic water consumption, but also the supply of agricultural production. Furthermore, bottlenecks in the energy supply are expected, as about 50% of national energy is generated from hydropower (a loss of 10-20% according to CEPAL 2009). The spatial distribution of associated risks and impacts on different socio-economic groups has not yet been predicted, as vulnerability assessments have not been generated. Likewise, the possible effects of climate change on primary energy demand are uncertain, e.g. a higher demand for summer cooling systems may be compensated by a reduction in energy demand for heating in winter.

Water supply bottlenecks are already evident. The water market is based on water rights that are purchased and transacted (Water Code 1981, modified 2005) based on a minimum stream flow condition and a total availability calculated by the national water authority (DGA: Dirección General de Aguas). Currently, there is an insufficient supply for new surface consumptive rights to be made available in the Maipo basin, while groundwater rights are offered provisionally, subject to better information about the dynamics of the groundwater hydrology in the basin (DGA 2003). Meanwhile, there is pressure from more powerful interests to buy out smaller rights holders, such as small-scale irrigation associations. The market is also unable to respond to fluctuations in the hydrological cycle, e.g. the El Niño phenomenon, since rights are fixed (although subject to extraction volume modifications) and are awarded in perpetuity. In consequence, as water availability decreases, existing rights cannot continue to allow extraction according to initial volumes and no new uses will be catered to without the termination of old uses.

The limitations of the existing water market, its weaknesses in responding to the natural cycles in the water basin, and the anticipated scarcity due to climate change, present a major adaptation challenge. Conflicts over the equitable distribution of water will increase, particularly between the demands from the residential, agricultural, and mining sectors and environmental services. Assuming that the residential expansion of land will continue, the question remains as to how a potential 40% reduction in rain water availability (CONAMA 2006) will be met by a population in the metropolitan area that is 30% larger than at present. Due to the fact that the city's location is in a biodiversity hot spot with current levels of green space per habitant (3.2 m^2/cap, CONAMA 2002) well below the World Health Organization recommendation of 9m^2/cap, water use issues come in to play. These include maintaining the region's ecosystems and increasing public spaces to enhance urban quality of life and to reduce, for example, the heat island effect. This will require a significant shift in water management in many areas, e.g. reduced agricultural irrigation capacity, watering, and species selection in public spaces and domestic gardens, a storm water drainage system that seeks to shift water downstream of the city as swiftly as possible during peak events (rather than capture and storage), and broad-based demand reductions.

A further challenge related to the issue of water is climate change governance within spatial planning. The 2005 national climate change strategy concentrates on productive sectors, particularly mitigation and Clean Development Mechanism (CDM) opportunities, but fails to put much weight on adaptation issues (CONAMA 2005). It also fails to explicitly consider urban centres in spite of over 80% of Chileans living in urban areas, with over 40% of the national population living in the metropolitan region. This has changed slightly with the publication of the 2008 national action plan (CONAMA 2008). The plan focuses on seven fields for action, water being one of them. Although urban change, except coastal city risk, is not an explicit focus of the plan, all seven issues relate to urban transformations. Their incorporation into planning instruments will be a primary challenge for climate change adaptation. To date, the regional development strategy, metropolitan and local regulatory plans, and local development plans have not included climate change considerations explicitly, largely because of the sectoral approach to public management. It is yet unclear how this national and sector-oriented document can be translated into local action in the metropolitan region.

Climate change adaptation will demand a coordinated response from government agencies within the context of a regional adaptation plan. Although the DGA manages the water market, the water planning dimension must be brought within the administration of the territorial authority, the Regional Government, as part of a strategy enabling cohesion with the priorities of the national plan and engagement with the multiple public and private actors who are direct stakeholders - from rights holders (agriculturalists, mining firms and others), to the environment commission, the housing and urbanization ministry, the public works ministry, and municipal authorities. It is clear that at present, this natural resource market has serious limitations for facing the climate change challenge of this century.

The references for this article are available on our website: http://ugec.org/docs/ViewpointsIssue3References.pdf

View from the Tower Bridge in London

The Tyndall Centre's Urban Integrated Assessment Facility

Richard Dawson, Jim Hall, Claire Walsh, Terry Barker, Stuart Barr, Mike Batty, Abigail Bristow, Aidan Burton, Sebastian Carney, Athanasios Dagoumas, Steve Evans, Alistair Ford, Vassilis Glennis, Claire Goodess, Colin Harpham, Helen Harwatt, Chris Kilsby, Jonathan Köhler, Phil Jones, Lucy Manning, Mark McCarthy, Mike Sanderson, Miles Tight, Paul Timms, Alberto Zanni

Cities and Climate: Driving the Need for Integrated Responses

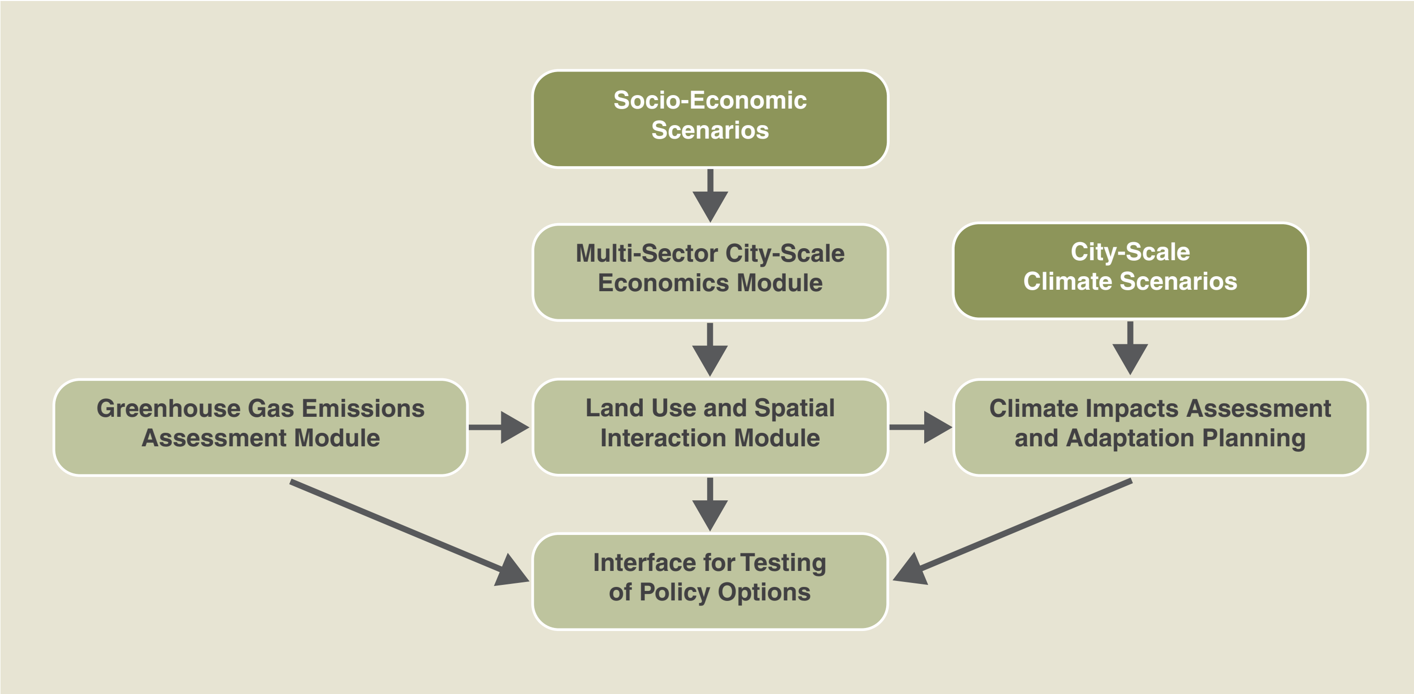
Cities are concentrations of vulnerability to the harmful impacts of climate change. They are also, directly and indirectly, responsible for the majority of the world's emissions of greenhouse gasses. Fifty percent of the world's population lives in cities, a number that is set to increase to 60% by 2030 (UN 2004). For all of these reasons, cities are on the front line in responding to the threats of climate change. Around the world there is a growing awareness of the role that cities have to play in mitigating and adapting to climate change. A wide variety of measures are now being considered and piloted, including schemes to transform urban energy systems, reduce transport emissions, retrofit buildings, conserve water, build resilience to flooding and prepare for heat waves.

These individual policies need to be implemented as part of an integrated strategy that can steer cities towards low carbon and well-adapted futures. To do so requires understanding of the processes that are driving long term change in cities and the ways in which they interact. Demographic, economic, land use, technological and behavioural changes are all drivers, which alongside climate change, will shape the future of cities.

The Tyndall Cities Programme and Integrated Assessment

To address these challenges, the Tyndall Centre for Climate Change Research has developed an Urban Integrated Assessment Facility (UIAF) which simulates the main processes of long term change at the scale of whole cities. The UIAF couples a series of simulation modules within a scenario and policy analysis

Figure 1 | Integrated assessment approach for analysing climate impacts and greenhouse gas emissions in cities



framework. The UIAF is driven by global and national scenarios of climate and socio-economic change, which feed into models of the regional economy and land use change. Simulations of climate, land use and socio-economic change inform analysis of carbon dioxide emissions (focussing upon energy, personal transport and freight transport) and the impacts of climate change (focussing on heat waves, droughts and floods). The final component of the UIAF is the integrated assessment tool that provides the interface between the modelling components, the results and the end-user (Figure 1). This tool enables a number of adaptation and mitigation options to be explored within a common framework. Development of the Tyndall Centre's Urban Integrated Assessment Facility (UIAF) has focussed upon London as the case study.

Pressures in London

London currently has a population of 7.2 million, which is expected to increase to over 8.1 million by 2016 (GLA 2009). Due to geographical location in the warmer part of the UK and widespread urbanisation, London suffers from urban heat and associated air quality problems. Isostatic subsidence in the south of Great Britain will result in London experiencing faster relative sea rise which, coupled with storm surges, will heighten the risk of surge flooding in the tidal Thames. The southeast is the most water scarce region in the UK, having a lower than average rainfall and a very large demand (GLA 2008).

Because of the concentration of population and transport, the southeast is responsible for prolific greenhouse gas (GHG) emissions. London is responsible for 8% of the UK's carbon dioxide emissions, producing 46Mt (GLA 2007) each year (not including aviation) and is projected to increase by 15% to 51 million tonnes by 2025 if vigorous action is not taken to reduce carbon intensity. London's Climate Change Action Plan targets 60% (London Energy and Greenhouse Gas Inventory 2008) reduction in carbon dioxide emissions by 2025 with the UK Climate Change Act demanding an 80% reduction in national emissions by 2050 (OPSI 2008). Excluding aviation, currently, domestic, commercial and public buildings contribute the majority of carbon dioxide emissions. Ground based transport contributes one fifth, the majority of which come from cars. Industrial contribution is relatively small and projected to shrink, due to the relatively small proportion of heavy industry in London's economy.

London has taken several pioneering steps with respect to how climate change, adaptation and mitigation are dealt with at the city scale. The organisations most relevant to the strategic city-scale management issues considered in this work are the Greater London Authority (GLA), the Government Office for London (GOL), and the London Climate Change Partnership (LCCP). The GLA is a public authority designed to provide citywide, strategic government for London. The principal purpose of the

GLA is to promote the economic and social development and the environmental improvement of Greater London. The GOL liaises with the GLA to ensure that London planning is done within the context of national policy and it leads government responses to the GLA's strategies. The London Development Agency (LDA) has the responsibility of reducing London's carbon dioxide emissions. The LCCP focuses on assessing the impact of climate change and identifying adaptation strategies. Each organisation has clear responsibilities, which cross sector boundaries. The GLA is in a position to take an overview of strategic issues related to climate change.

Key Results and Insights

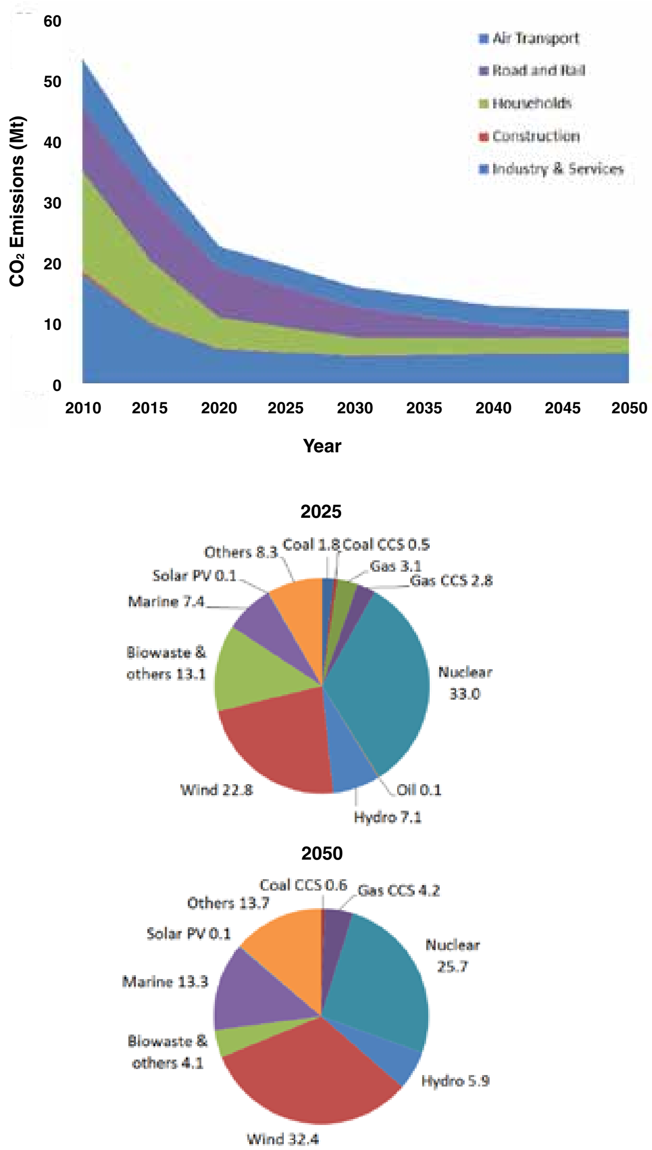
The UIAF was applied to London, yielding the following findings:

Economic drivers of long term change: A multisectoral regional economic model has been used to generate long term projections of employment and Gross Value Added in London. Our base line simulation shows employment in London growing by about 800,000 by 2030, driven by demographic changes and changing working practices. Business and financial services, along with science-based services are expected to grow most rapidly, with heavy industry diminishing.

Land use change: Future patterns of land use between now and 2100, based on changes in employment, the transport network and land use planning policy, have been simulated for all of London and the Thames Gateway. We have studied four alternative land use futures for London: (i) a baseline case, which applied current policies and trends in to the future (ii) "Eastern axis" in which employment opportunities, transport infrastructure development and a preference for lower density living stimulate substantial population growth in east London and the Thames Gateway (iii) "Centralisation" in which employment and population growth is concentrated in central London, with a corresponding increase in density (iv) "Suburbanisation" in which employment remains strong in central London, but expands into the suburbs. To steer land use away from the baseline towards alternative futures requires major shifts in land use planning, transport connectivity and capacity, and employment opportunities.

Carbon dioxide emissions: Various scenarios of carbon dioxide emissions from the energy use, personal transport and freight transport have been analysed. Growth in population, economic activity and mobility are potentially strong upward drivers of emissions. We have analysed portfolios of emissions reduction policies that are currently under consideration, but find that more radical policies are required in order to meet the GLA's target for 60% emissions reductions by 2025 (Figure 2). Their success depends upon the availability of carbon neutral electricity supply and upon progressive physical changes to urban form and function. In this package of mitigation measures, no demand management is assumed, giving an indication of the radical and rapid shift in energy generation mix required to sustain our current per capita energy demands.

Figure 2 I One portfolio of measures that could achieve 80% reduction in CO_2 emissions; showing sector contributions (graph) and technology mix (piecharts)



Heat waves: A new land surface scheme has been introduced into the Hadley Centre's Regional Climate Model to represent the urban heat island effect. Using a weather generator adapted from the UK Climate Impacts Programme (UKCP) 2009 study, we found that by the 2050s, one third of London's summer may exceed the current Met Office heat wave temperature threshold (UK Climate Impacts Programme 2009). However, the UIAF can explore how different spatial patterns of development have the potential to reduce the risk from heatwaves.

Droughts: The UKCP09 rainfall scenarios for the Thames and Lee catchments were combined with catchment hydrology models and simulation of the water resource management system. London is very vulnerable to changes in the surface water regime, which will be increasingly stressed by climate change and population growth. Although new storage facilities can maximise exploitation of the surface water resource, on their own they are insufficient in the long term and will need to be accompanied by vigorous demand management and provision of new resources from desalination or inter-basin transfers (Figure 3).

Flooding: A model of flooding in the tidal Thames floodplain, which is protected by the Thames Barrier and a system of flood defences, has been used to simulate the effects of sea level rise and changing flows in the river Thames. This has been combined with our simulations of land use changes, which have a profound effect on the magnitude of increase in flood risk in the future. The "Eastern Axis" land use scenario leads to a fourfold increase in flood risk by 2100, whilst the risk doubles for the "Suburbanisation" scenario. A number of adaptation options are shown to reduce flood risk under all land use scenarios (Figure 4).

Figure 3 I How to maintain the present day level of service for water resource provision in the 2050s under the UKCP09 medium scenario and given increased demand: the tradeoff between the reduction in water demand (in terms of per capita consumption, industrial use and leakage) or additional supply (from desalination or inter-basin transfers)

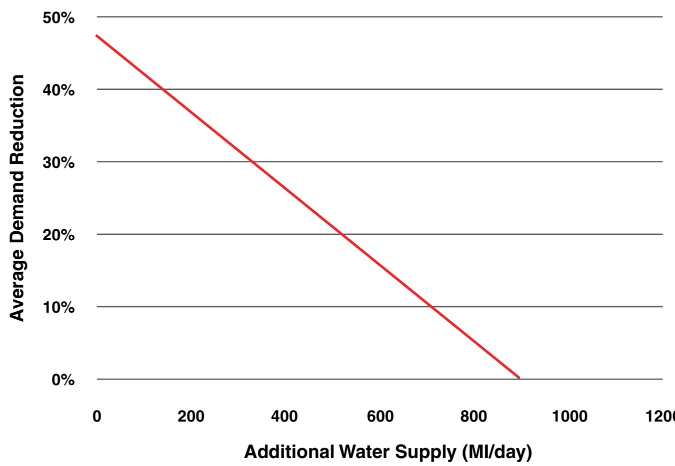
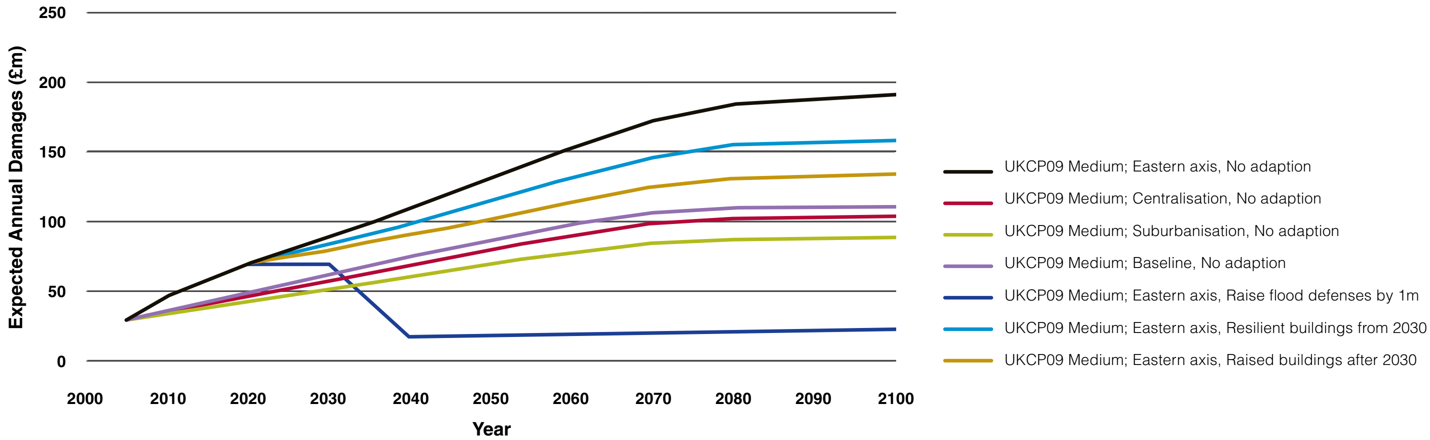


Figure 4 I Profile of flood risk (expressed in terms of expected annual damages in London and the Thames estuary, real terms and not discounted) through time on same axis for (i) the four different landuse paradigms under the UKCP09 Medium climate change scenario, (ii) a range of adaptation options for the Eastern axis land use paradigm including (a) raising the existing flood defence system by 1m, (b) making all new development after 2030 fully flood resilient, (c) raising all new development (e.g. on stilts) after 2030



Concluding Remarks

By analysing demographic, economic and land use changes, we have quantified the extent to which socioeconomic changes determine how hard it will be to reduce emissions and how severe impacts of climate change may be. Indeed, socio-economic change over the 21st century could influence vulnerability to natural hazards as much as climate change. The research has shown that no single policy will enable cities to grow whilst reducing emissions and vulnerability to climate change impacts – a portfolio of measures is required. Due to long lead times, immediate and in some instances radical action to reduce fossil fuel dependence in the energy, building and transport sectors is required if an 80% cut in emissions is to be achieved by 2050. Measures to reduce demand (in use of energy, transport, water, etc.) tend to be more cost effective and less likely to have adverse impacts in other sectors than measures taken to increase supply. However, both supply and demand side measures will be required to respond adequately to the climate and socio-economic changes.

The research has demonstrated the central role of land use planning in guiding and constraining pathways to sustainable urban layout in the long term. Land use profoundly influences carbon dioxide emissions and vulnerability to climate change. It also constrains opportunities for innovations like sustainable urban drainage systems or local heat networks. Land use and infrastructure planning decisions can become "locked in" because of the way in which infrastructure shapes land use and the built environment, and vice versa.

Furthermore, it has demonstrated scenarios of how these interactions can operate over the 21st century on spatial scales from the whole city and beyond to individual neighbourhoods, providing tools for planners and infrastructure designers to assess the long term sustainability of plans and policies. By integrating adaptation and mitigation, we have been able to quantify some of their potential synergies and conflicts, for example, by examining the contribution that urban energy use makes to the urban heat island. The UIAF has helped to understand how policies can be devised that yield benefits in relation to a number of objectives and avoid undesirable side-effects.

The references for this article are available on our website: http://ugec.org/docs/ViewpointsIssue3References.pdf

Acknowledgements

This work has been funded by the Tyndall Centre for Climate Change Research. The full stakeholder report for this work can be downloaded from: http://www.ceser.org.uk/demonstrations/cities/tyndallcitiesreport/view or copies can be requested from Richard Dawson (richard.dawson@newcastle.ac.uk)

CO_2 Emissions in U.S. Counties: The Importance and Interplay of Population Size, Income and Creative Economic Activity

Michail Fragkias & Jose Lobo

The spatial organization of human populations is a central concern in any consideration of the human dimensions of global environmental change. Debates over what constitutes a sustainable growth of populations (both in urban and rural areas) must be informed by scenarios regarding the need for energy consumption, GHG emissions and the wider environmental implications of this growth. We present here some initial results of our ongoing research examining the determinants of CO_2 emissions in the continental Unites States. We employ various datasets for U.S. counties — CO_2 emissions, population, income, geography, industrial composition, creativity of labor force — and use analytical methods common in statistical physics, biology and economic geography, such as scaling laws, in order to identify characteristics of the relationship between population size and energy use.

Important properties of many physical, biological, economic and urban systems depend crucially on the size (measured as the number of constituent units) of the system (Crane and Kinzig 2005); the scaling relationship can be mathematically expressed as c, a

$$Y = cN^{\beta},$$

constant, and the scaling exponent, β, determining how system size (N) affects systemic performance (Y). The presence of a scaling relationship "self-similarity" across different sizes or scales signifies that the two quantities are proportional, (at minimum, for a range of orders of magnitude) so that one can be used for the calculation of the other one's value at a different order of magnitude.

We organize information on carbon dioxide emissions at the county scale utilizing data from the Vulcan Project – a collaborative effort by Purdue University, Colorado State University and Lawrence Berkeley National Laboratory, funded by NASA and the U.S. Department of Energy. This project recently quantified North American fossil fuel carbon dioxide (CO_2) emissions at a fine-grained spatial scale and at the scale of workplaces, power plants, roadways and residential areas[1]. In this paper we use the project's reported data for 2002 fossil fuel CO_2 emissions in U.S. counties, measured in millions of metric tons, examining how the size of counties affects their use of energy (generated using fossil-fuels) through a *scaling analysis*.

Recent scaling analysis by Lobo, Strumsky and Bettencourt (2009) aggregated the CO_2 emissions data to construct measures of metropolitan CO_2 emissions (the metropolitan "carbon footprint") and contrasted them with measures of metropolitan size. Metropolitan size can be measured either with respect to population or economic output, using Gross Metropolitan Product (GMP, the metropolitan equivalent of GDP); data for both is made available by the U.S. Department of Commerce's Bureau of Economic Analysis. In order to determine the scaling coefficient, the authors linearly transformed the basic scaling equation by taking the natural log of both sides of the equal sign:

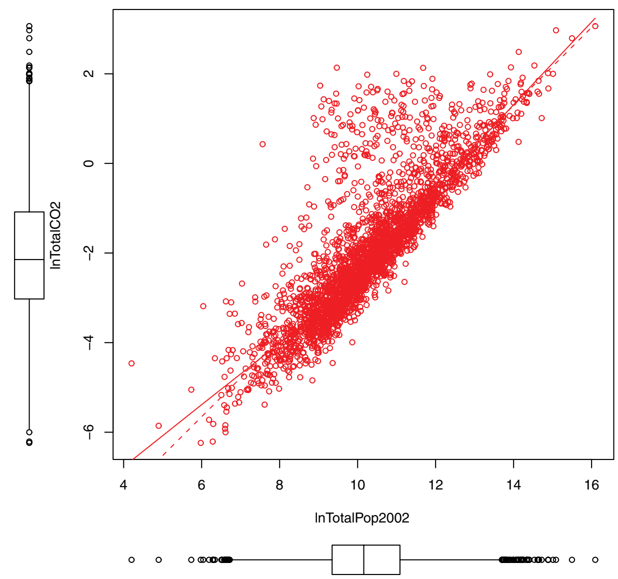
$$\ln(Y) = c' + \beta \ln(N)$$

Performing OLS regression (with a correction for heteroskedasticity) they obtain an estimate of β. They find that using population (or economic output) to measure metropolitan size, the scaling coefficient is 0.92 (or 0.79 respectively), which means that a 1% increase in population (or economic output) is associated with only a 0.92% (or 0.79% respectively) increase in CO_2 emissions. The R-squared statistics were 0.83 and 0.81 respectively. This is a very important finding, but is it the end of the story?

Our results derived for U.S. counties are shown in the scatterplots below. Figure 1 shows the relationship between total carbon emissions and population size for each county, while Figure 2 plots total carbon emissions against personal income in 2002. Both plots use data for over 3,000 counties in the United States. Not surprisingly, the total amount of CO_2 emissions increase with county size measured in terms of total population and income, with high R-squared values suggesting that size is an important determinant of carbon footprint.

The scaling (or regression) coefficients tell a particularly interesting story. When using total population to measure county size, the coefficient of 0.88 indicates that the effect on total carbon emissions of increasing population size is slightly less than proportional: more precisely, a 1% increase in population is associated with a 0.87% increase in carbon emissions. In particular, we find a relationship of $E[\ln(Y)]=-10.95+0.88*\ln(N)$ with an adjusted R-squared of 0.68 (Table 1, column [1]). When using economic output to measure size, the scaling coefficient is 0.81, which means that a 1% increase in economic output is associated with only a 0.81% increase in CO_2 emissions (Table 1, column [1']). Together, these two results tell us that "larger" counties are indeed more energy efficient than "smaller" counties—and in particular, that increasing wealth (as measured by Personal Income[2]) is associated with proportionately less energy consumption. The energy metabolism of counties *slows down* with increasing size.

Figure 1 I Scaling of U.S. county carbon emissions with population size



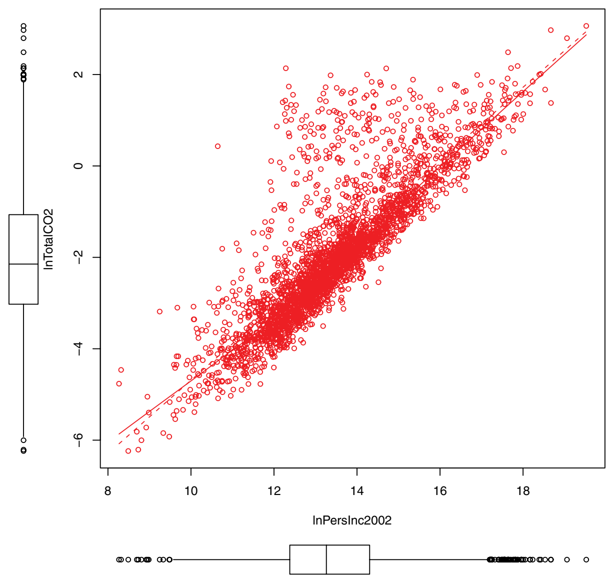
Moving away from the biological metaphor, closer to regional and urban economics, we identified the particular effect of the size of different economic sectors and employment types

1 The project can be found at http://www.purdue.edu/eas/carbon/vulcan/index.php. The methodology used to measure CO_2 is explained in a forthcoming article in *Environmental Science &Technology* (http://www.purdue.edu/eas/carbon/vulcan/Gurney.EST.2009.pdf). The measure of metro carbon emissions used here includes emissions from commercial, industrial, residential, transportation energy usage and utility power plants occurring within counties. In the future, we may consider excluding carbon dioxide emissions generated from utility plants; in the U.S. the location of utility plants is determined as much by a maze of political, regulatory and tax considerations at the state and county-levels, than by economic ones. Therefore, the location of utility plants does not simply reflect demand considerations. Furthermore, utility plants often serve populations far away. In the future, we may employ a measure excluding utilities to better reflect activities associated with population size; this may alter results to showcase further support for our thesis.

2 Source: Regional Economic Information System, Bureau of Economic Analysis, U.S. Department of Commerce, CA1-3 http://www.bea.gov/regional/docs/footnotes.cfm?tablename=CA1-3.

in the local economic areas. To what extent is the general scaling finding a result of the sectoral composition of local economies? We do know, for example, from urban economics that different types of cities (service, manufacturing, textile, etc.) arrive at different equilibrium sizes (Henderson 1974). To what extent does the concentration of economic activity type drive the general scaling findings? Is it just the size of the county or is it the type of economic activity and employment in the local area driving total energy consumption and CO_2 emissions? What is the contribution of the sectoral composition?

Figure 2 | Scaling of U.S. county carbon emissions with personal income



In our quest to derive the single best measure to explore these questions, we find that the "creative class" concept (Florida 2002) is appropriate for the task and helps us demonstrate convincingly our argument[3]. Florida (2002) argues for the existence of a socioeconomic class that accounted for slightly less than 40 million workers (about 27% of the U.S. workforce) circa 2000. Florida (ibid.) broke down this group into two subgroups: (i) the super-creative core consisting of about 12% of all U.S. employment; "[t]he super- creative core of this new class includes scientists and engineers, university professors, poets and novelists, artists, entertainers, actors, designers, and architects, as well as the 'thought leadership' of modern society: nonfiction writers, editors, cultural figures, think-tank researchers, analysts, and other opinion-makers"[4]. This subgroup engages in creative activities and product innovation. (ii) The creative professionals category is composed of highly educated knowledge workers who are employed in "knowledge-intensive industries such as high-tech sectors, financial services, the legal and healthcare professions, and business management".

We use the U.S. Department of Agriculture's (USDA) Economic Research Service (ERS) Creative Class County Codes Dataset - an updated version of the original Florida creative class dataset. This dataset "excludes from the original Florida measure many occupations with low creativity requirements and those involved primarily in economic reproduction (i.e., numbers proportional to population); [the] measure conforms more closely to the concept of creative class and proves to be more highly associated with regional development than the original Florida measure"[5].

We find that there exists a substantial difference in the estimated coefficients when one examines the scaling relationship between CO_2 emissions and population, broken by the type of economic activity of that population – in this case, "creative" vs. "non-creative" according to the creative class dataset. When using the measure of number of "creatives" in each county, the effect on total carbon emissions of increasing "creative" employment is considerably less than proportional: more precisely, a 1% increase in population is associated with a 0.74% increase in carbon emissions (Table 1, column [2]). But, using the number of "non-creatives" in the scaling analysis, we find that a 1% increase in population is associated with a 0.90% increase in carbon emissions (Table 1, column [3]). This signifies an important result: while the energy metabolism of counties *slows down* with increasing population and economic size, it does so much faster as counties increase the number of knowledge workers compared to the increase of the number of other types of employment.

3 Similar findings can be generated when we use number of employees and establishments for different North American Industry Classification System (NAICS) codes using information from the County Business Patterns dataset for 2002 (results not reported here).

4 http://www.washingtonmonthly.com/features/2001/0205.florida.html

5 We use the terms "creative" (as it appears in the relevant dataset) and "non-creative" with the understanding that this is loaded terminology and may seem controversial; we use the dataset as a proxy for "knowledge workers" in healthcare, business, law, education and finance; we understand though the danger of falsely appearing "elitist". The U.S. Department of Agriculture's (USDA) Economic Research Service (ERS) Creative Class County Codes Dataset can be found here: http://www.ers.usda.gov/Data/CreativeClassCodes/#2007-10-17. "Variables used to construct the ERS creative class measure include number and percent employed in creative class occupations and a metro/non-metro indicator for all counties for the years 1990 and 2000. A break-out of employment in the arts is included."

Table 1 I Regression Results

	[1] *ln* total CO_2	[1'] *ln* total CO_2	[2] *ln* total CO_2	[3] *ln* total CO_2	[4] *ln* total CO_2 (metro2003==1)	[5]	[6] *ln* total CO_2 (metro2003==0)	[7]
ln total pop 2002	0.88*** (81.55)	-	-	-	-	-	-	-
ln pers inc 2002	- (81.27)	0.81*** -	-	-	-	-	-	-
ln creative	-	-	0.74*** (71.13)	-	0.75*** (43.02)	- -	0.75*** (38.15)	-
ln non creative	-	-	-	0.90*** (75.44)	-	0.94*** (47.71)	-	0.88*** (40.09)
Constant	-10.95*** (-98.52)	-12.81 (-95.40)	-7.58*** (-92.72)	-10.31*** (-91.42)	-7.77*** (-48.27)	-10.68*** (-51.95)	-7.63*** (-55.25)	-10.06*** (-52.50)
Adj. r-squared	0.68	0.68	0.65	0.68	0.65	0.70	0.46	0.48
N	3134	3134	2711	2711	980	980	1731	1731

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001

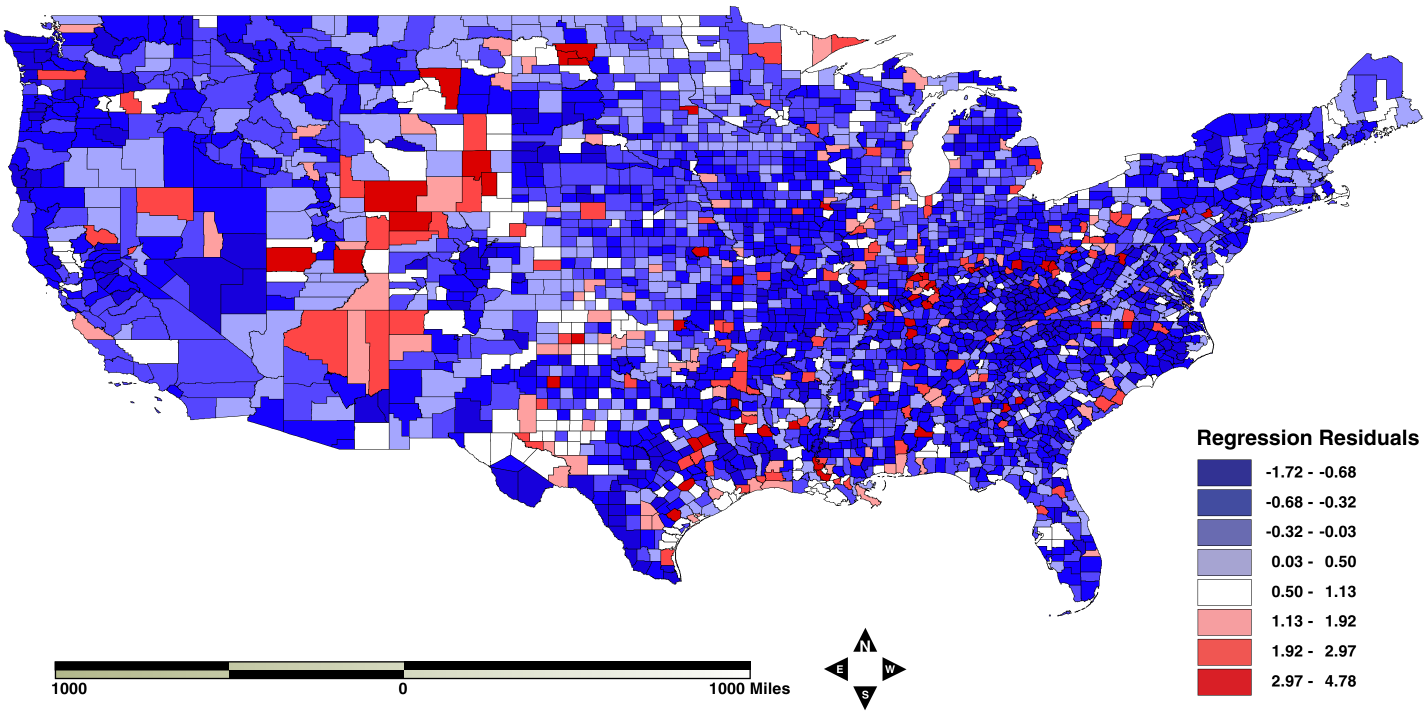
The next step we follow is to break the dataset into two parts: a subset of counties that belong in a metropolitan statistical area (MSA)[6] and a subset of counties that do not belong in an MSA. We find that the difference in the estimated coefficient for the creative vs. non-creative regressions increases when one looks at counties that belong in MSAs only (Table 1; columns [4] and [5] vs. [2] and [3]). Also, the estimated coefficients become larger for both the creative and the non-creatives when compared to the coefficients generated by the full county population dataset. The same effect holds with the adjusted R-squared measures – the scaling relationship becomes sharper when one looks only at counties that belong to MSAs. This constitutes further evidence of energy saving scaling processes that play out at the urban scale (Lobo, Strumsky and Bettencourt 2009), which synchronously interact with the economic sector composition of the local areas.

We also find that the difference in the estimated coefficients for the creative vs. non-creative regressions is reduced when one looks at counties that belong in non-MSAs only (Table 1; columns [6] and [7] vs. [2] and [3]). Only the estimated coefficient for the non-creative regression is substantially different (lower) when compared to the coefficient generated by the full county population dataset. Adjusted R-squared measures drop substantially – the scaling relationship is not as clear for non-MSA counties.

Finally, we map the residuals from the regression of total CO_2 emissions on total population (Figure 3), in order to inspect the observations (counties) that do not conform to the identified scaling law – in particular the positive outliers that can be seen close to the center of the population and income size distributions in Figure 1 and Figure 2. These are generally average sized (both in terms of population and income) counties, but experience a significantly higher level of total CO_2 emissions than their size would suggest, given the existence of the scaling law. The majority of counties with significantly positive residuals exist in the states of Texas, Indiana, Oklahoma, Illinois, Wyoming and Alaska. While for the east of the country there is no visible spatial pattern in the distribution of these counties, in the West, we observe a "Rocky Mountain" cluster that extends from northern Arizona to eastern Utah to northwest Colorado and southern Wyoming. Alaska (not mapped here) is also a state with the vast majority of its counties having high residuals. While the phenomenon in the West could be potentially explained by the size of the counties –

6 The United States Office of Management and Budget (OMB) defines metropolitan and micropolitan statistical areas according to published standards that are applied to Census Bureau data. The general concept of a metropolitan or micropolitan statistical area is that of a core area containing a substantial population nucleus, together with adjacent communities having a high degree of economic and social integration with that core. http://www.census.gov/population/www/metroareas/index.html

Figure 3 | Total CO_2 - Total Population Regression Residuals



signifying larger transportation-related emissions ceteris paribus – this is not a good explanation for the outliers in the East which are counties with smaller sizes. Along this line of reasoning, it may be beneficial to examine datasets that identify levels of sprawling settlements in each county.

Finally, we present some concluding thoughts. Our results are consistent with recent arguments that dense urban agglomerations are less harmful on the environment than smaller settlements (Glaeser 2009). Together, the results suggest a sustainability policy prescription: increase the concentration of populations (and in particular, populations with high human capital) in both metropolitan and non-metropolitan counties. We acknowledge a severe shortcoming of our analysis, namely the lack of time series data. We simply do not observe the emissions of a particular county across time as its population or income grows. This does not give us the full view of urban environmental transitions (Marcotullio and McGranahan 2006). As a next step, we plan to examine these relationships by geographical region.

The references for this article are available on our website: http://ugec.org/docs/ViewpointsIssue3References.pdf

Islands of Tumaco, La Viciosa and El Morro

Challenges to Adaptation for Risk-Prone Coastal Livelihoods in Tumaco, Pacific Coast (Colombia)

Andrea Lampis

Due to several interlinked drivers and factors of environmental degradation (Capra 1996), the impacts of global environmental change (GEC) on livelihoods and sustainability are already experienced in many urban settlements with respect to water resources, food security and human health (Arnold 2006, Erhart 2008, IPCC 2007 and 2007a, Satterthwaite et al. 2007). These impacts affect social vulnerability due to the fact that people's assets are directly affected, which in turn, also affects resiliency and their ability to adapt to environmental changes. Furthermore, GEC-related impacts and asset depletion or loss disproportionately affects low-income groups, often generating a mutually reinforcing dynamic between assets and income loss.

This article presents a summary of the main research findings from fieldwork research that took place in October 2008 in the city of Tumaco, located on the Colombian Pacific Coast near the border of Ecuador. To date, research on climate change in Colombia has mainly focused on the study of ecosystems. The country's main research and policy approaches to adaptation have largely skipped over key social and institutional implications. This first stage of research helps to uncover factors contributing to vulnerability and capacity for adaptation in the face of environmental change and global warming in coastal Afro-Colombian communities, using the city of Tumaco as a case study.

Global Environmental Change, Social Vulnerability and Adaptation

Research on the interactions and responses of urban systems and populations in the face of indirect social impacts of GEC (San-

Photo Source: Alcaldía de Tumaco (2008), Photo by Giuliano Marín. Clockwise from right to left: islands of Tumaco (most densely built), La Viciosa and El Morro (connected with a bridge and to the local Airport).

chéz-Rodríguez et al. 2005) cannot be fully accomplished while ignoring how livelihoods of diverse groups in cities of the global south are impacted. People's adaptation depends on resilience to structurally adverse conditions, economic crisis or environmental events such as disasters. Research on vulnerability approaches to the study of urban populations, particularly low-income groups, shows us that resilience is a function of people's access to assets, social protection and opportunities (Chambers 1989, Moser 1996). During the early 1990s, Moser and Chambers, who drew important insights from the work of Amartya Sen (1981, 1999) on entitlement theory[1], highlighted a people-centered perspective, steering away from the standard economic approach of poverty analysis couched in the neo-liberal tradition. Moser (2009) indicates that asset-based adaptation analysis is key to understanding the different effects of urban climate change and its impacts on poor urban communities[2].

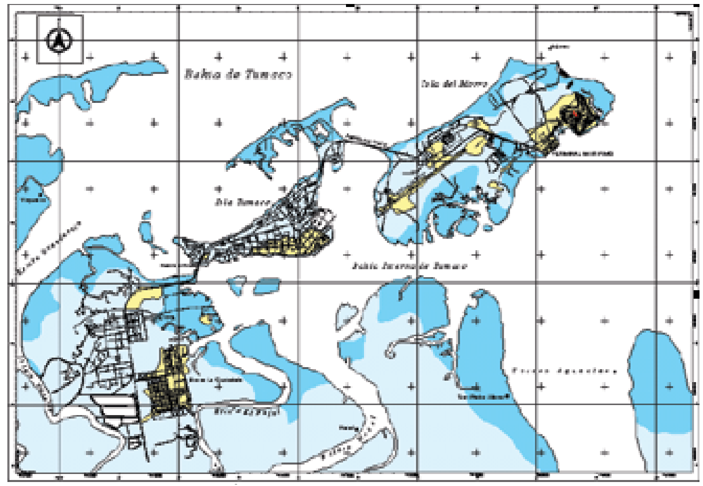
Cultural Origins and Local Geographies of Violence

Due to centuries of violence attributed to slavery and colonization and confrontations over resources and land, Afro-Colombian communities of the Pacific coast have paid the highest toll with respect to casualties, massacres, migration and cultural loss (Villa 1998). It is their relationship with the land that has allowed their development as an ethnic group, as it shapes their world vision and provides the basis of a cultural unity. In this sense, the nexus between culture and the environment determines identity and, as Wade (2004) has pointed out, nature and culture are powerful forces that are deeply entrenched with one another in these communities. These contextual elements are of extreme importance in the analysis of adaptation-related processes and constraints, as the dynamics that shape people's vulnerability and resilience occur within locally specific contexts.

Environmental Risk

Because the majority of the city lies below three meters above sea level, Tumaco is at high risk of flooding; as illustrated by Map 1. As an example, the El Niño phenomenon in 1997 caused the sea level to rise from 20 to 40 cm, when compared to 1982. Consequently, flooding occurred in the neighbourhood of *El Bajito*, located close to the airport on El Morro island; most of the houses were lost and had to be relocated inland (Alcaldía de Tumaco 2008). High tides greater than 1.5 and up to 3.6 meters (depicted in light blue on the map) already cause flooding of the majority of the peripheral areas of Tumaco's islands, and closely mirrors the likely effects that will occur from a sea level rise of 0.33 cm.

Map 1 I Areas at risk from flooding in Tumaco



Area at risk of flooding with medium tides
Area at risk of flooding with high tides
Area not at risk
Water bodies

Source: DIMAR (2001)

Environmental Degradation

The bay of Tumaco has traditionally been one of the main resources for people's livelihoods and for the city's economy. Over the last decade, environmental degradation has worsened due to the overlapping of industrial activities (i.e., palm oil, shrimp harvesting and the timber industry) (page 20, top left photo). The impact of pollution generated by human activities, such as small commerce and untreated domestic waste, mostly dumped directly into the water from pole house dwellers, dramatically increases environmental degradation. Furthermore, poorly controlled industrial processes affect the environmental dynamics of the nearby river Mira, thus, increasing the speed of sedimentation in the bay. Consequently, mangroves have been severely affected with a potential survival rate of 12.75% in a worst case scenario

1 Assets and entitlements both relate in a similar way to well-being. The processes that lead to their control and use both entail the inclusion of the importance of agency as a key variable in the conceptual frame. Assets are mobilised by the agency of individuals or households in such a way that is very similar to how entitlements are exchanged in the market. Although Sen does not say it explicitly, the difference is in terms of categorical level: entitlements are based on endowments, i.e., assets and resources. Therefore, if we allow for a broad use of the term "assets", focusing more on the concept of exchange than on the definitional issue, the key concept is that of buffering, or the achievement of a decrease in vulnerability through attaining higher degrees of "freedom from" viz. security. (Lampis, A. 2009, page 58, Ph.D. thesis "Urban Poverty and Vulnerability: An assets, resources and capability impact study of low-income groups in Bogotá". Social Policy, London School of Economics).

2 Building on previous frameworks from research on asset vulnerability, risk management and urban poverty reduction, asset-based vulnerability and adaptation analysis identifies two important elements of a new operative framework: the range of bottom-up strategies that individuals, households and communities have developed to cope with climate change and GEC-related impacts, and the range of top-down interventions of external actors at the city, regional, and national level.

Poorly regulated timber industry in the bay of Tumaco

Typical pole houses in Tumaco

and 47.62% assuming more optimistic scenarios (Alcaldía de Tumaco 2008). The net result is the collapse of the ecosystem of the internal bay of Tumaco and the virtual extension of the fisheries. The impact on the livelihoods of the many families of fishermen has been dramatic, compelling them to displace their fishing activities outside the bay where they cannot compete with the more sophisticated fishing boats from Ecuador.

Housing and Infrastructure

Approximately 65% of the 160,000 inhabitants of the central island of Tumaco live in pole houses, such as those in top right photo. The situation of public service provisioning including water, sanitation and electricity has not improved. For instance, in the neighbourhood of Las Americas, one of the three neighbourhoods included in the study, the percentage of people living in pole houses is 91.7%, according to official statistics, while those who can only afford to rent but one room in a pole house is 7.65%. Virtually no other type of housing exists for low-income households in Tumaco. While official data (DANE 2006) report a rate of 77% connected to electricity, up to 98% of interviewed households has electricity, thus showing the probable existence of illegal connections. According to official data, only 21.3% of the population has no water service; while in the households interviewed, this percentage rises to 49.46%. Most of the existing water connections for low-income households consist of an illegal connection (bottom right photo) made by a pipe often passing through enormous quantities of solid waste floating in water severely contaminated by human excreta. There is absolutely no waste collection along the whole ring of pole houses on the main island of Tumaco. Up to 60% of interviewed households have suffered some type of flooding, mostly related to the tidal cycle that peaks each fortnight.

Social Vulnerability

Critical life events powerfully impact the fragile assets upon which a large number of households depend. Their livelihoods are pushed to the verge of collapse, often nearing below the threshold which guarantees the household a decent meal at least twice a day. Social vulnerability is a condition depending on the capacity to foresee, prevent, cope with and recuperate from life events that imply the loss of material and intangible assets (Lampis 2007).

People living in the pole houses along the perimeter of Tumaco's islands can hardly prevent critical life events, as they have

Illegal water connection

Children playing in polluted waters

little resiliency. Here, in-depth qualitative interviews were conducted in order to analyze vulnerability patterns. Out of a random sample of 54 households, only 15 said they did not experience any events worth mentioning in the three years prior to the interview. Vulnerability patterns connect critical life events to their related causes, consequences and coping strategies (Lampis 2007).

Box 1 provides an example of one of the many dramatic situations found among low-income households in Tumaco. On the whole, there are three groups of critical life events affecting households. One such life event consists of the death of a household member related to causes associated with health (mostly illnesses) and violence (mostly assassinations due to interpersonal problems or urban violence). A second group of critical life events concerns economic problems related to unemployment and indebtedness, and the third major group relates to internal displacement, reflecting at the micro level the broader dynamic of rural-urban migration due to the armed conflict.

Concluding Remarks

Tumaco is a distinct example of how a multi-layered analysis of macro, meso and micro-level constraints may illustrate the interaction of a number of critical failures in terms of human rights, human needs and human security. This point is highly relevant on three grounds with regards to the debate on adaptation policies to GEC.

First, since all strategies and policies of adaptation eventually have to be shaped at the local level, the case of Tumaco illustrates the challenges of multi-level, multi-layered constraints. In fact, no local institution can easily face them, just as much as no national

Box 1 I A fisherman's story: René (33 years of age) is a fisherman living in one of the hundreds of pole houses built on the shore along the beach that runs parallel to the Avenida La Playa on the western and most exposed side of the island of Tumaco. This area is one that maps associate with the highest risk, regardless the kind; tsunami, earthquake or flooding. However, maps still do not tell about the oil spill in 1998 that cut the fishing catch in half. From 2005 onwards –René recalls the most critical life events of his recent past – the availability of fish has dwindled even more and he and his colleagues must go out of the bay to search for better livelihoods facing Ecuadorian well-equipped fishing boats. "Sometimes," he says, "we go out the whole night and day with 10 dollars of gear and come back with 10 dollars worth of catch, and my wife is not happy about it". As a consequence, the house lacks enough to provide for the three children's notebooks, pencils or snacks at school. René and other fishermen have tried to create their own organization to pool resources. However, they have little capital and in spite of working together, they are still not bringing in enough to make some gain from their day out on boat. Four months before the interview, René's brother died after having gone blind from a surgery years before, leaving him with moral and economic obligations, as well as the emotional pain. Three months later, his wife fell ill from a kidney infection compelling him to leave work for long spells to look after the children. René's family livelihood is one that can most certainly be called vulnerable because his assets and capital are not enough, and the concomitant absence of public action from the local government does not allow resiliency in the face of any critical event, including a disaster.

or supra-national institution has the power to fully operate at the local level. The overlapping of a great number of critical problems, such as cultural segregation and racial discrimination, armed conflict and internal displacement, run-down local economies, environmental problems and related high levels of environmental risk and degradation, and highly vulnerable livelihoods are, as a whole, very complex problems. This must be acknowledged by research approaching the issue of adaptation to GEC and climate change from any single discipline or an area-study related entry point.

Second, the subject of "adaptation" does not make entirely clear who or what has to adapt, or whether the adaptation pertains to a certain subject/unit of analysis or sub-system. The conceptual frameworks used to study complex systemic issues, such as adaptation, come from specific disciplines, or at best, from thematic or area studies. As in the case of this study, these frameworks are limited in their capacity to understand similar phenomena when more complex systems and other units of analysis are taken into consideration. This is to say that what seems useful for the analysis of a household's vulnerability may well be rather useless at the city or regional level. This has to do with epistemological problems related to the issue of scale and the way we conceptualise and represent reality for analytical and policy purposes (Manson 2008). Human-environmental interaction happens at different levels of complexity and what could be very positive for one sub-system, say the poor in a city if they are granted more material well-being, could be detrimental at another level, that of the broader ecosystem and regional sustainability (Wilbanks 2007). This is a simple example that draws on general ideas already well-established in the areas of human ecology, complexities and environmental studies.

Third, as the study of adaptation to GEC and climate change faces a number of problems of scale, it will have to combine developmental dimensions (environmental, social, cultural, etc.) across units of analysis (households, communities, cities, regions, ecosystems). It is imperative to produce new knowledge on adaptation beyond modifying current discourses of development and established frameworks. Furthermore, finding new forms of more inclusive governance capable to face overly complex issues must give space and a voice to a greater number of actors. The case study of Tumaco, where low-income groups are largely excluded from political and decision making processes, illustrates the central importance of urban governance, democracy and participation in the broader debates of adaptation to GEC and climate change. There seems to be much support for the argument that adaptation to GEC and climate change in cities of developing countries is only viable if communities and institutions participate in the policy process that has an even power balance.

With respect to the case study presented here, evaluating existing constraints to people's livelihoods towards adaptation to climate change is an important first step to produce locally-based knowledge on these highly complex issues. That is, one must begin to analyze the linkages existing among issues of human security, vulnerability and the conditions producing risk.

The references for this article are available on our website: http://ugec.org/docs/ViewpointsIssue3References.pdf

Future plan and model of the Sino Singapore Tianjin Eco-city

Urbanization and Global Environmental Change and Its Implications for China's Future Urban Socio-Economic Development Strategy

Yangfan Li & Xiaodong Zhu

Urban areas are hot spots that drive environmental change at multiple scales. Just as land change occurs as cities are built and must support the demands of their urban populations, cities also drive other types of environmental change (Grimm et al. 2008). The irreversible transition to urbanization has, since 2008, led to more than half of the world's population (approximately 3.3 billion people) living in urban areas and it is projected that 60% of the population will be living in urban areas by 2030 (Sanchez-Rodriguez et al. 2008). Furthermore, 90% of the world's future population growth is expected to occur in urban areas, mainly in developing countries.

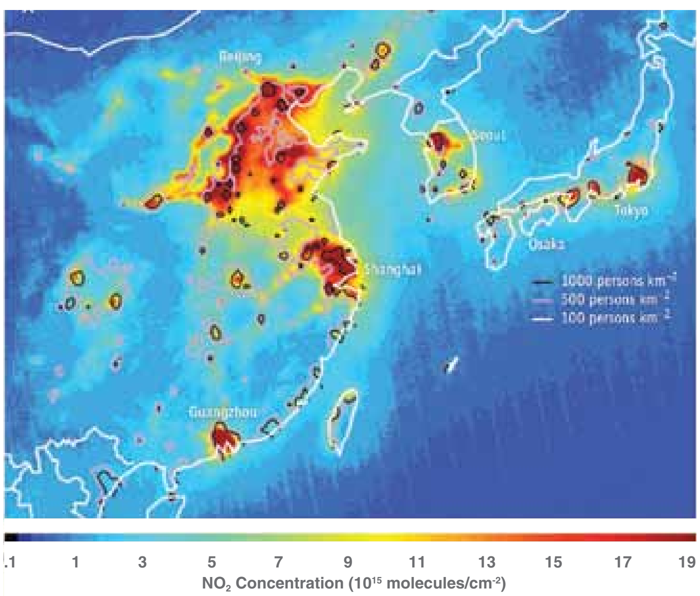
China is vastly becoming more urban (Liu and Diamond 2005). Between 1949 and 2008, while its total population more than doubled, its proportionate urban population increased from 7.3% to 45.7%. The number of cities increased fourfold to more than 655 (including 122 cities with at least one million residents compared to ten in 1949) and the size of existing cities grew immensely. Consequently, problems have arisen such as the decrease of farmlands, a huge increase of motor vehicle use and public health issues.

Within global environmental change (GEC) research, cities and urban living are now considered to be important factors in many environmental burdens including the greenhouse effect, air and water pollution (Li et al. 2008). In this context, urban development policies and strategies should take the positive effects of urbanization into consideration, as well as the potential and ability of mitigating the negative impacts of environmental change in cities. We suggest that China's future urban socio-economic development strategy should highlight innovations in response to severe challenges of urbanization and global environmental change (UGEC) including: (1) adaptive evaluation of urban vulnerability and climate change, (2) urban environmentally-friendly planning through ecological design solutions, (3) establishment of low carbon eco-cities, and (4) urban ecological governance.

Urbanization and Global Environmental Change in China

In China, the explosive increase of automotive vehicles and transportation networks has been fueled by rapid urbanization at the expense of arable land, greater dependence on imported oil, and the recently improved, but still poor air quality (Figure 1). Garbage is another negative consequence of urbanization. Unrecycled and unused industrial waste and domestic waste are problems that are increasing, as these wastes are dumped into open fields around most cities, polluting soil and taking over or damaging 100,000 km^2 of cropland. Water pollution has also become a serious issue and worse still, urban development has accelerated the trend of lake eutrophication.

Figure 1 I Centers of pollution: Satellite image of NO_2 concentrations over Asia (Parrish and Zhu 2009)



China is not excluded from the effects of urban vulnerability which is complicated by sea level rise, increased extreme weather events or coastal erosion as a result of GEC. Over the last three decades, China's sea level has risen 2.6mm per year, which is higher than the global average sea level with a significant upward trend in volatility. It is documented that the average sea level of China's coastal provinces rose 60 mm in 2008 alone, compared with the mean sea level (SOA 2009).

Rapid urbanization of China's coastal areas destroys wetlands and affects adjacent areas (Li et al. 2009b) (Figure 2). Thus, it is China's coastal areas, which are characterized by highly concentrated cities in terms of population and high levels of economic development, which are most vulnerable.

Figure 2 I Rapid Urbanization in China's Coastal Cities

Rapid urbanization and wetlands loss, Hong Kong

Rapid urbanization and mangrove wetlands eco-park, Shenzhen

Sea reclamation, Xiamen

Reclaimed coastal marsh wetlands for industrial park, Lianyungang

Source: Yangfan Li 2006

Suggestions for China's Future Urban Socio-economic Development Strategy

With consideration of the current situation of UGEC in China, we put stress on the importance of finding an effective way towards environmental policy that will mitigate impacts of environmental change in cities of China and launch a coordinated strategy that will recognize the relationship between China's urbanization and the environmental changes that are taking place.

Innovations for Adaptive Evaluation of Urban Vulnerability and Climate Change

In the face of continuing urban vulnerability and GEC challenges, there is an urgent need to strengthen ecological security assessments for adaptive management, in order to better understand the types of climate hazards to which various population groups and systems are vulnerable, the causes of vulnerability, and their location (de Sherbinin et al. 2007). The double-effect strategy towards mitigation and adaptation (with emphasis on mitigation) would address the issues identified in an ecological security assessment.

An effective early-warning mechanism is proposed for integration into the future urban socio-economic development strategy of China. Due to their significance in the country, it is especially essential for coastal urbanized regions to have zoning implemented based on degrees of ecological function and an early-warning mechanism for landscape ecological security (LES), including establishing an index system to assess urbanization intensity, city development intensity, landscape fragmentation, the value of ecological services, and ecological resilience; to employ the use of spatial models (e.g., Multi-criteria evaluation (MCE), a method of decision-making analysis for land use suitability evaluation which is used for the evaluation of numerous spatial criteria after data has been normalized); and knowledge classification methods (an early warning classification system including security and degradation, sub-security and slow degradation, sub-security and rapid degradation and insecurity) (Li et al. 2009a).

Innovations for Urban Environmental Planning and Ecological Design Solutions

A higher degree of urban landscape fragmentation is expected to make natural services and biodiversity that humans depend on more and more difficult and expensive to maintain. Thus, a more sustainable future should contain a better understanding of how to design ecological solutions, not only through conservation and restoration, but also by purposeful invention of ecological systems to provide vital services and maintain biodiversity, and designed ecological solutions (which go beyond restoring a system to a past state, but aim to create a well-functioning community of organisms that optimizes the ecological services and biodiversity). The way to design ecosystems is not necessarily based on historical views of ecological structure and function at a given location, as is the case for restored ecosystems such as constructed wetlands surrounding the Taihu Lake and ecological landscape restoration in mining areas. Instead, ecosystems may be designed to mitigate unfavorable conditions by means of blending technological innovations with novel mixtures of native species that favor specific ecosystem functions (Palmer et al. 2004).

Innovations for Establishment of Low Carbon Eco-Cities

Based on the concept of low energy consumption, less pollution and low emissions, and the consistence with ecological balance home and abroad, low carbon cities are considered to be environmentally friendly pioneers. Low carbon cities can be classified by four types: technological innovation-oriented eco-cities (e.g. Solar Energy Technologies Program); livable eco-cities (e.g. green and open space, green infrastructure); evolutionary eco-cities (co-evolution of nature and humans in urban areas); and post-disaster reconstruction-oriented eco-cities (e.g. Wenchuan, the post-earthquake reconstruction). The potential technologies and related methods include: solar roof program, low-impact modes of development, water recycling program, technology to ecologically restore water bodies, distributed energy systems combined with green buildings, green transportation dominated by transit-oriented development (TOD), domestic garbage recycling use and separate collection, and dynamic monitoring and evaluation of CO_2 emissions of each building (Qiu 2009).

One example is the newly constructed Sino-Singapore Tianjin Eco-city (http://www.tianjinecocity.gov.sg/). This city provides the application of low carbon ideals including a scientific index system of 26 Key Performance Indicators (KPIs), which has been selected for the Eco-city to guide its planning and development into a model city for sustainable development (the four qualitative KPIs include (i) good natural environment, (ii) healthy balance in the man-made environment, (iii) good lifestyle habits, and (iv) developing a dynamic and efficient economy). The city has specific targets for renewable energy usage, usage of water from non-traditional sources such as desalination and recycled water, and for the amount of R&D scientists and engineers employed in the Eco-city workforce. The city also takes measures to ensure no net loss of natural wetlands, optimizes ecological patterns by designating specific amounts of per capita public green space, utilizes green transportation, and has stricter standards governing acceptable levels of water, air, and noise pollution.

Innovations for Urban Ecological Governance (UEG)

Global environmental change creates major challenges for societies, but it also opens opportunities for rethinking current patterns of growth, confronting deficiencies in planning, governance, management and functioning of urban areas, and reconsidering structural contradictions and inequalities in societies (Sanchez-Rodriguez et al. 2008). In response to China's contradiction between economic development and environmental pressure, urban ecological governance - of urban biodiversity, natural resources, energy, wastes and ecological quality - is an effective tool for integration with eco-cities and sustainable development, and for the coordination among central government, local governments and NGOs (Li et al. 2005).

For example, the creation of an eco-region in Jiangsu Province improves quality of life through ecologically responsible guidelines at the level of national eco-cities (counties), towns, eco-demonstration zones and eco-villages. The creation of these jurisdictions switches from a consequence-oriented management mode to one that takes a precautionary measure; this is an important application of UEG that could potentially reduce the risk of urban diseases, preserve regional ecology, maintain population health, and avoid regional environmental risks (Li and Zhu 2009).

Conclusion

Global environmental change is not only an environmental problem; it is a major challenge for development. The challenges of GEC for China are now clear, i.e., development near sea level, in flood plains, and deltas; declining water quality; water shortages; heat and cold waves; health risks; weak or outdated infrastructure; urban land use; and urban growth induced climate change. But also, a better understanding of the country's socioeconomic and institutional framework can reveal opportunities for sustainability, such as leap-frog technology; energy efficiency potential; increased urban density and land-use efficiency; and increased public transportation (Seto 2008).

Against the background of UGEC, China's social and economic development, together with sustainable development, have been severely hindered by increasingly prominent pressure on the environment including an increase of urban vulnerability. In order to realize comprehensive sustainable development and mitigate environmental pressures at the source, there is an urgent need to promote ideal innovations for China's urban future socio-economic development strategy. If China can face the challenge and seize the opportunities associated with climate change and other global environmental changes with the help of the international community, it could become the world leader in sustainable development throughout the 21st century. (Zeng et al. 2008)

The references for this article are available on our website: http://ugec.org/docs/ViewpointsIssue3References.pdf

Acknowledgements

We are very grateful to our funders of this research which includes the National Natural Science Foundation of China (NSFC) grants 40901081 and 40976021, the Soft Science Project of the Ministry of Housing and Urban-Rural Development of China (2009-R2-40), and the Foundation of the State Key Laboratory of Pollution Control and Resource Reuse of China (Nanjing University). We also thank Hu Zhang and Xiao Yang for help with collecting materials.

Whitewater on Russell Street, Melbourne, Australia

Perspectives on Climate Change Adaptation Policy "Down Under": A Change of Course for Australia?

Darryn McEvoy & Jane Mullett

The Discordant Emergence of Australian Climate Policy

The election of the Labor Party in November 2007 not only brought the 11-year reign of the previous Australian Government to an end, but by immediately signing on to the Kyoto Protocol, the Prime Minister, Kevin Rudd, also signified a new commitment to engage more constructively with the international climate change community. However, all has not gone according to plan, as evidenced by the protracted and often highly charged debate that took place in the Australian Federal Parliament in 2009. Heated discussions centred on the proposed introduction of a new carbon trading mechanism, the Carbon Pollution Reduction Scheme (CPRS),with the opposing Liberal Party (including several prominent and highly vocal climate sceptics) managing to mobilise enough support to block the progress of the legislation. In the process, the Liberal Party also replaced their "pro-minded" leader; however, it is arguable whether this had to do with the merits of the CPRS, rather than a scheme to conveniently trigger an internal clash of competing political camps.

These latest political developments tend to suggest a reinforcement of the recalcitrant image of Australia with regards to climate policy, as seen through many international eyes. This negativity stems from the country's reluctance to engage in any meaningful way with the Kyoto Protocol, meaning that a post-1997 Australia has found itself aligned to a small grouping of nations often on the receiving end of widespread condemnation for failing to play a meaningful role in the emerging coalescence of an international community to deal with the causes and consequences of a changing climate. What is perhaps less well known is that it was originally intended that Australia would become a signatory, but this undertaking was overturned in 1998 when the newly elected Liberal-Coalition Federal Government refused final ratification, citing the non-participation of the US, China, and India, as justification. However, other domestic issues such as an economic downturn at the time and intensive lobbying by those representing primary industry interests have also been noted as important influences. This fracture in international relations intensified further when Australia was party to the establishment of the 2005 Asia-Pacific Partnership on Clean Development and Climate (AP6) - an agreement between the major non-signatories of the Kyoto Treaty.

However, we argue that these events are not wholly representative of antipodean attitudes and action to tackle the climate change issue. During the 1980s and 1990s for example, Australia was considered one of the world leaders in climate change research and policy development. In the scientific realm, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) was engaged in early and ground-breaking research activity for better understanding the causal links between greenhouse gases and anthropogenic forcing of climate change, with these scientific foundations subsequently helping to underpin the political developments that occurred during this period. The most important of these was the signing and ratification of the United Nations Framework Convention on Climate Change (UNFCCC) by the Labor Federal Government in 1992.

Domestic activity was also being undertaken in tandem with this international outreach activity, with vertical integration and cooperation promoted between the three different tiers of Australian government (Federal, State and Territory, and local government) in order to develop and launch a National Greenhouse Response Strategy. The main aims of this pioneering strategy were to improve understanding of "greenhouse issues", to limit emissions, and lastly but significantly, to develop adaptation responses. It seems remarkable looking back to the 1990s that adaptation was being given such explicit consideration so early in the policy process, and that the Federal Government was attempting to promote a holistic approach to Australia's response at this time. It is also noteworthy that although the Liberal-Coalition Federal Government refused to sign up to international obligations, it continued to support substantive national initiatives, in particular allocating significant funding to establish the Australian Greenhouse Office (AGO). This built on the previous government's National Greenhouse Response Strategy and whilst much of the agency's emphasis was on mitigation, numerous reports were also produced to disseminate "state of the art" knowledge on topics ranging from risk assessment methodologies to the potential climate impacts on critical urban infrastructure and buildings, with their 2005 report to the UNFCCC explicitly addressing vulnerability assessment, impacts, and adaptation.

Australia: A Landscape of Contradictions

The contradictory nature of Australia's response to climate change is not only inherent in the chequered development of climate policy, it can also be detected in how different communities across the country perceive the risks posed by climate change, and as a consequence, the urgency that has been placed on the need for adaptation. Geographically, the continent covers 7.6 million km^2 and is often referred to as the hottest and driest on earth. Most people would associate drought as the most common defining climate feature, however, the sheer size of the country means that climate regimes range from tropical monsoon in the northern reaches, through the dry desert central belt, to the milder temperate climate found in the south. Given the history of flooding and cyclonic storm damage in the north and drought conditions experienced by many regions, it is perhaps of little surprise that Australian communities have become accustomed to coping with weather-related challenges; though interestingly, in the past, those affected have tended to frame the occurrence of extreme events in the context of natural variation rather than as part of a longer term climate change trend. It is this past experience of coping with nature that at least partially explains a perceived public reluctance to engage fully with the emerging climate change agenda; although in reality, Australian communities have considerable practical experience in dealing with the vagaries of the climate.

Recent experiences of extreme weather events, which have increased in frequency and intensity (and media coverage), have begun to alter the perceptions of many in Australia. For example, for those in the northern State of Queensland, flooding episodes and storm damage are recent events of note (concerns are reinforced by the predicted southwards shift in cyclone tracking); whilst at the other end of the country, the State of Victoria is about to enter peak fire season one year after 173 people died in bushfires in the peri-urban areas surrounding Melbourne ("Black Saturday", 7th of February 2009). Whilst these rapid-onset extremes make the international headlines, other critical long-term issues are also rising up political agendas. Sea level rise and storm surges are increasing concerns for each of the major Australian cities (which are all coastal settlements), whereas arguably the most pressing sustainability issue for all

States is the future availability of water (perversely, many cities have committed to energy intensive desalinisation plants in the near future).

The urgency of responding to the water resource issue is exemplified by the Murray-Darling River, a major river basin which extends over 1 million km^2, passes through four States (Queensland, New South Wales, Victoria and South Australia), and is a major source of water for both agricultural and urban inhabitants. A combination of a ten-year drought and an over-commitment of water allocations has put this valuable river system under severe pressure and any future reductions in rainfall will act to amplify problems of natural river flow and water availability for competing States and different water uses. With individual States unable to come to an agreement about maintaining a healthy state of the river, the new Federal Government established the Murray-Darling Basin Authority in 2008 to ensure the future sustainable management of the Basin's water resources. This abridged water narrative provides further evidence of ongoing adaptation activity not necessarily "badged" as such, as well as the considerable institutional challenges posed by climate-related impacts that extend beyond the administrative boundaries of individual Australian States.

A Change of Course?

Although every State and Territory had produced regional climate change plans by 2007, either embedded within the Department of Premier and Cabinet, or linked to the relevant department charged with environmental management, it is clear that this was an important and watershed year for Australian climate policy. With the IPCC 4th Assessment Report providing external stimulus, and a change of government and internal willingness, Australia not only ratified the Kyoto Protocol but also established a new Department of Climate Change (DCC) to address both mitigation and adaptation agendas (an initiative that was actually already in the pipeline under the previous government though not implemented). It was also the year that saw a rapid escalation in the number of published reports, both scientific and policy, on climate impacts and adaptation. The Garnaut Review (2008), which profiled the likely climate impacts across Australia and their potential socio-economic implications, was a particularly notable example of a renewed emphasis on understanding the risks posed by climate change and how best to respond.

In terms of adaptation, a new national body was formally endorsed by the Council of Australian Governments (COAG) in 2007 with the intention of providing a more coordinated approach to national interdisciplinary research. The National Climate Change Adaptation Research Facility (NCCARF), which became operational in 2009, is now in the process of funding projects under its eight thematic strands. It will also host its first international conference on climate change adaptation in June 2010. Activity to support adaptation research is also being mirrored at the State level with Victoria setting up its first adaptation research centre, the Victorian Centre for Climate Change Adaptation Research (VCCAR), in 2009. With a remit to inform policy-making, VCCAR will support a programme of research projects, fund short-term visits by international fellows, and act as a mechanism to build local adaptive capacity through regional think tanks and an annual forum.

As noted, a key challenge will be to negotiate the political tensions operating across spatial scales. This is best reflected by the considerable power vested in State and Territory Governments. For much of the last decade a political party in opposition to the Federal Government was in control of these, giving rise to considerable discord between national and sub-national institutions, a constant shifting of responsibility and operational control of policy portfolios, and as a consequence, an impaired effectiveness of policy development and implementation. However, institutional "fit" is not a problem unique to the efforts of the previous government, and improved cohesion of policy (and research activity) across scales remains an important issue. The integration of adaptation strategies that are able to address national priorities, while engaging specific communities at the level at which they are likely to be affected by changes in the climate, will be a measure of whether Australia is able to develop meaningful responses to climate change in the coming years. Nonetheless, Australia is engaging with both the mitigation and adaption agendas in a much more pro-active fashion than might have been expected from its position only five years ago.

The references for this article are available on our website: http://ugec.org/docs/ViewpointsIssue3References.pdf

Atlanta, Georgia

On the Role of Urbanization in Hydroclimate Extremes: Changing Water Cycle, Record Floods, and More

J. Marshall Shepherd

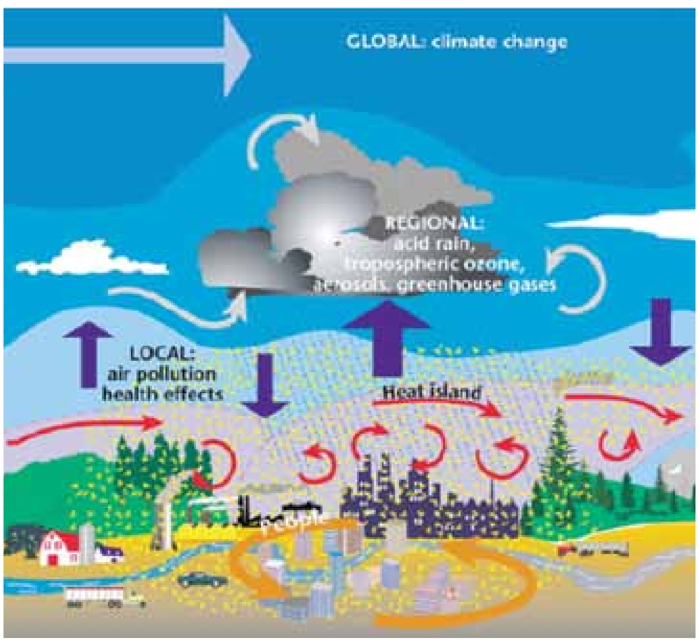
In recent decades, a great deal of attention has focused on feedbacks between human activity and climate at global scales. Anthropogenic-induced climate change is most commonly placed within the context of greenhouse gas (GHG) forcing and rising surface temperatures. Another consequence of a warmer climate is an altered water cycle. If Intergovernmental Panel on Climate Change (Trenberth et al. 2007) projections are accurate, the frequency and severity of extreme hydroclimate events (e.g., droughts, floods) will likely increase in response to the acceleration in the water cycle.

It is increasingly evident that GHGs are not the only significant "human" forcing function on climate. The 4th IPCC Assessment (Trenberth et al. 2007) identified a critical need to understand what role urban land cover/land use and pollution have on climate change. The IPCC has established a separate Working Group on Cities and Climate Change for the forthcoming 5th Assessment (Seto, personal communication, 2009). Human activity in urban environments has signatures at local to global scales by changing atmospheric composition, impacting components of the water cycle, and modifying the carbon cycle and ecosystems (Figure 1). Critical issues at the intersection of urbanization and climate have been discussed recently by two Urbanization and Global Environmental Change (UGEC) project associates (Seto and Shepherd 2009).

Urbanization and the Hydroclimate

Precipitation is a key link in the global water cycle and can be a proxy for changing climate. Therefore, proper assessment of urbanization and its effect on precipitation will be increasingly important in climate analysis, hydrological and energy cycle analysis and modeling, weather forecasting, water resource management, urban planning, and other societal practices. GHG-influenced climate change is, in many ways, an analogue to the urban-regional scale. Society may or may not perceive warmer temperatures due to the urban heat island (global warming), but changes in the water cycle caused by the warming at these scales are already occurring (Brommer et al. 2007, Shepherd 2005). Urban hydroclimate studies will take on greater significance if current projections of global urban growth are accurate. Hand and Shepherd (2009) stated that in 2008, over half the world population lived in urban areas. The United Nations projects that this could reach 81% by 2030 (UNFPA 2007). The 21st Century is likely our first urban century.

Figure 1 I The coupled urban-climate system [Following the Global Atmosphere Watch Urban Research Meteorology and Environment (GURME) programme of the World Meteorological Organization (WMO) as presented in Hidalgo et al. 2008].



Urbanization Affects Precipitation Distribution, Intensity, and Frequency

Studies from as early as the 1920s (see Shepherd et al. 2009b for a historical review) suggested that urban landscape and pollution in cities alter precipitation budgets and distributions, particularly over and 25-75 kilometers downwind of the central business district. This notion gained momentum during the METROMEX studies of the 1960s to early 1980s (Changnon et al. 1981). However, momentum stalled on the topic in the 1980s. Lowry (1998) offered several potential problems with methodology and inferences used in many historical studies of urban-induced precipitation, including METROMEX. Souch and Grimmond (2006) stated that studies using new resources, tools, and platforms have re-invigorated the field of urban hydroclimate study. A review of post-2000 era studies (Shepherd et al. 2009b) reveals that methodological shortcomings during scholarly debates are now being addressed more carefully.

Several plausible hypotheses for urban effects on hydroclimate have emerged within the literature (Shepherd et al. 2009), but there is still no conclusive theory concerning the relevant physical mechanisms, independently or synergistically. There is a flurry of new research and scholarly debate on how the urban environment affects *precipitation variability*. Possible mechanisms for urban environments to impact precipitation or convection include one or a combination of the following:

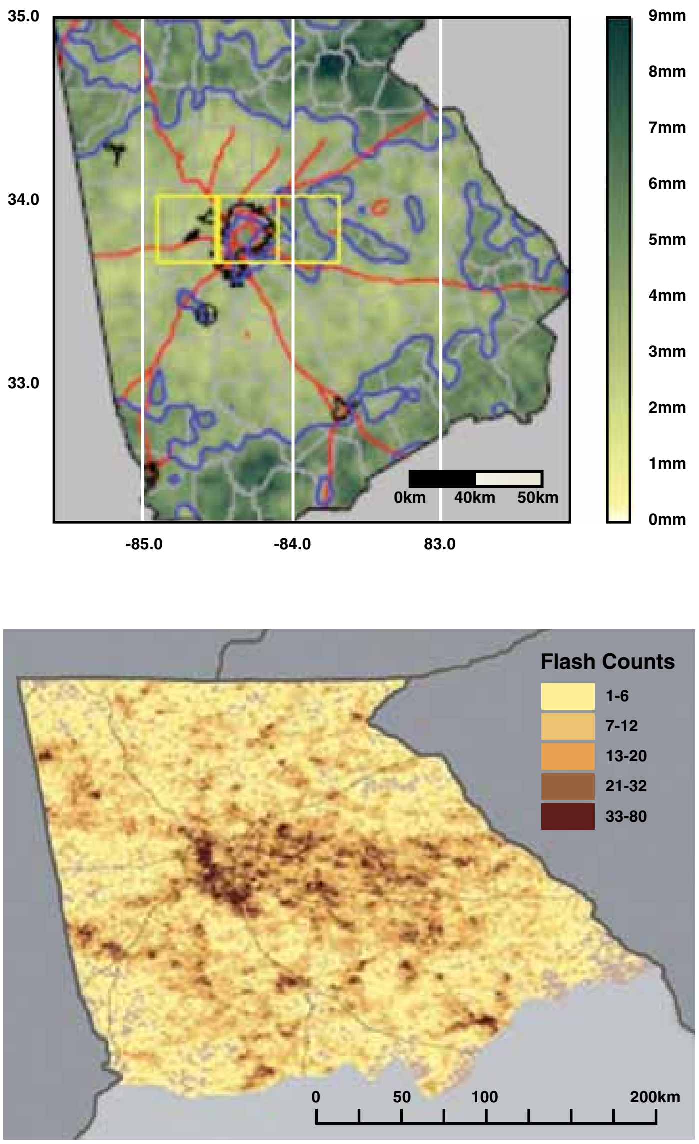
1. enhanced convergence due to increased surface roughness in the urban environment;
2. destabilization due to Urban Heat Island (UHI)-thermal perturbation of the boundary layer and resulting downstream translation of the UHI circulation or UHI-generated convective;
3. enhanced aerosols in the urban environment for cloud condensation nuclei sources or precipitation; or
4. bifurcating or diverting of precipitating systems by the urban canopy or related processes.

Recent studies (Shepherd et al. 2009b, Kishtawal et al. 2009, Shem and Shepherd 2009) provide a comprehensive review of the literature on these mechanisms and findings of investigators.

Uncertainty Remains

Though methods and data availability continue to improve, there is still uncertainty and scientific debate about whether urban environments increase rainfall, decrease rainfall, or have no effect on rainfall. The majority of studies associate rainfall enhancement with urbanization (Figure 2, for example), but a recent collection of work (Trusilova et al. 2008, Kauffmann et al. 2007, Zhang et al. 2009) note precipitation reductions. The studies that found decreasing rainfall around Chinese cities (Kauffmann et al. 2007, Zhang et al. 2009) did not consider the effects of pollution. Smaller cloud droplet size distributions and delayed or suppressed rainfall have been linked to increased aerosol concentrations from anthropogenic sources over and downwind urban areas (Rosenfeld et al. 2008).

Figure 2 | Positive rainfall (top) and lightning flash anomalies (bottom) for the warm season in Atlanta. Rainfall anomalies are presented in Mote et al. (2007) and lightning flash anomalies are presented in Stallins and Rose (2008). These sources should be consulted for further information on methods and data.



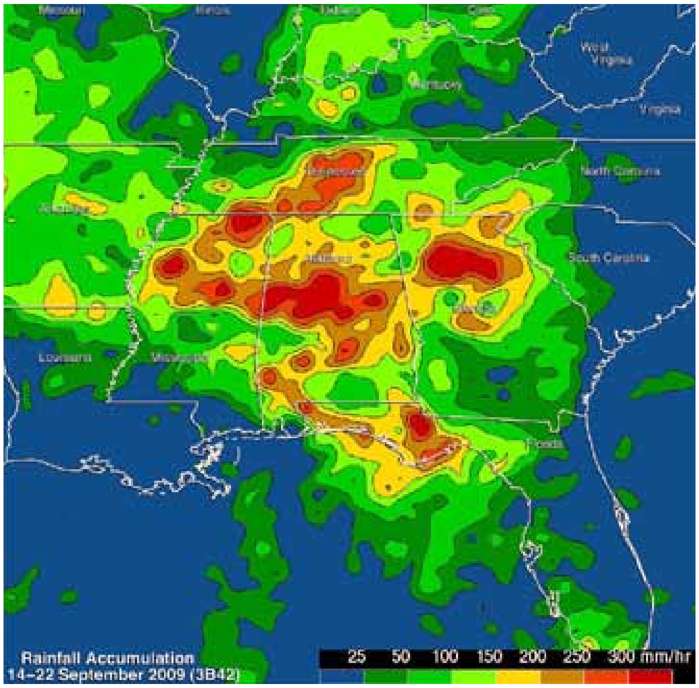
Through a significant body of pattern description, trend analysis and visualization studies around the world, the literature is fairly conclusive that spatio-temporal characteristics of precipitation, lightning, and surface hydrological processes are modified by urbanization. Kishtawal et al. (2009) established that heavy rainfall events are more common in urban areas as compared to rural areas during the Indian monsoon. Hand and Shepherd (2009) found a statistically significant anomaly in heavy rainfall events "downwind" of Oklahoma City. Studies on frequency and intensity are very interesting because they provide a new element to the prevailing thought that urbanization causes a positive anomaly in precipitation amount approximately 25-100 kilometers downwind of the central urban district. These findings suggest that the intensity and/or frequency of events are also changing in response to urbanization. Research going forward must consider intensity and frequency as they are directly related to hydroclimate extreme events like flooding.

Did Urbanization Amplify Historic Atlanta Floods of 2009?

In the developed and developing world, urban flooding is a serious hazard. Damage, loss of life, and costs from flooding continue to rise (Ashley and Ashley 2008). The National Weather Service (NWS) office in Charlotte, North Carolina has expressed an interest in urban-enhanced precipitation events in conjunction with increased impervious surface extent in the Charlotte metro area. There, concern is related to increased heavy runoff/urban flooding events (Quattrochi, personal communication, 2007). Consulting engineers in Philadelphia have similar concerns as they address urban flooding and combined sewer overflows. One of their concerns is the lack of reasonable methods to characterize future urbanization effects on precipitation patterns needed for modeling studies (Reynolds, personnel communication, 2007). Burian et al. (2004) examined the implications of urban-induced precipitation on urban drainage systems. In September 2009, floods of historic magnitude affected the Atlanta Metropolitan area (Figure 3). Preliminary analysis (Shepherd et al. 2010) has established record rainfall intensity and flood levels during the period of September 14th to September 22nd. Meteorologically, a persistent weather pattern called a cutoff-low (Shepherd et al. 2010) established large-scale conditions conducive to flooding: (1) numerous days of sustained rainfall leading to rendered soil moisture nearly saturated and surface storage near capacity and (2) extremely large rainfall rates near the end of the period of interest.

Shepherd et al. (2010) hypothesized that it was plausible that urban land cover may have contributed to the meteorological and hydrological aspects of the event. It is well established that the urban environment affects the hydrologic cycle including runoff,

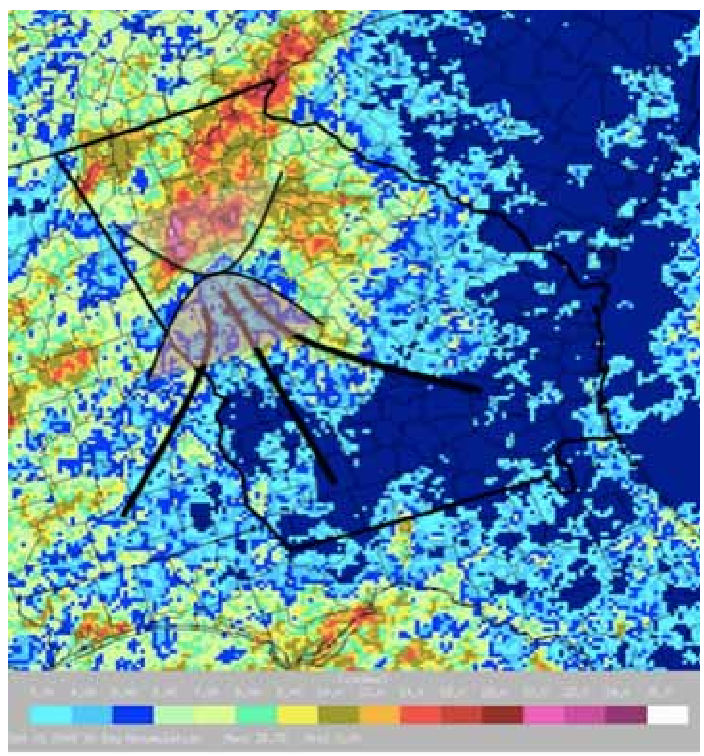
Figure 3 I Satellite-based, near-real time rainfall totals for the 8-day period from September 14 to 22, 2009 show the highest rainfall amounts in central Tennessee, central Alabama, north central Mississippi, and north central Georgia around the Atlanta metropolitan area.



infiltration, evapotranspiration, and precipitation. Reynolds et al. (2008) found that urban impervious surfaces in Houston channeled stormwater to conveyance systems with greater volume over a shorter duration of time. Atlanta's flood event was likely amplified by a similar response. Atlanta impervious surface footprint has increased in recent decades (Shem and Shepherd 2009), so a larger portion of the natural hydrologic system would be affected.

Shepherd et al. (2010) described how rainfall distribution and intensity could have been affected by Atlanta's urban land cover via previously discussed mechanisms. Shem and Shepherd (2009) and Niyogi et al. (2006) used coupled atmosphere-land modeling and radar-based observations to examine how urban land cover might enhance pre-existing precipitating storms. Bornstein and Lin (2000) and Shem and Shepherd (2009) have found that Atlanta's land can alter precipitation distribution or intensity through enhanced convergence, destabilization due to urban heat island warming, and increased sensible heat flux. Figure 4 (from Shepherd et al. 2010) shows multi-sensor (radar and rain gauge combined) estimates indicating regions of enhanced precipitation. The highest cumulative rainfall spans an arc (light magenta and white) from the northwest suburbs (Douglas, western Cobb Counties) over to northeast suburbs (Gwinnett County). Under the prevailing atmospheric flow for this event (southerly), the downwind region would constitute the northwest to northeast suburbs. Shepherd et al. (2002) and Hand and Shepherd (2009), following work of Changnon et al. (1981), optimized a framework for describing where rainfall might experience urban enhancement under specific prevailing wind flows. While our Atlanta hypothesis is speculative at this stage, several studies (see Changnon et al. 1981, Hand and Shepherd 2009 for historical and current reviews, respectively) have established rainfall anomalies 25 to 100 km downwind of the central business district. It is, however, important to note that large scale meteorological forcing and topography were likely of first-order significance to the Atlanta event.

Figure 4 I Multi-sensor precipitation estimates for (September 2009) with the urban rainfall enhancement framework (Shepherd et al. 2002) superimposed on the image. Black lines represent an approximation of the mean low-level wind flow during the period. The image is courtesy of the National Weather Service, Peachtree City. (Note: 1 inch=25.4 mm) (from Shepherd et al. 2010).



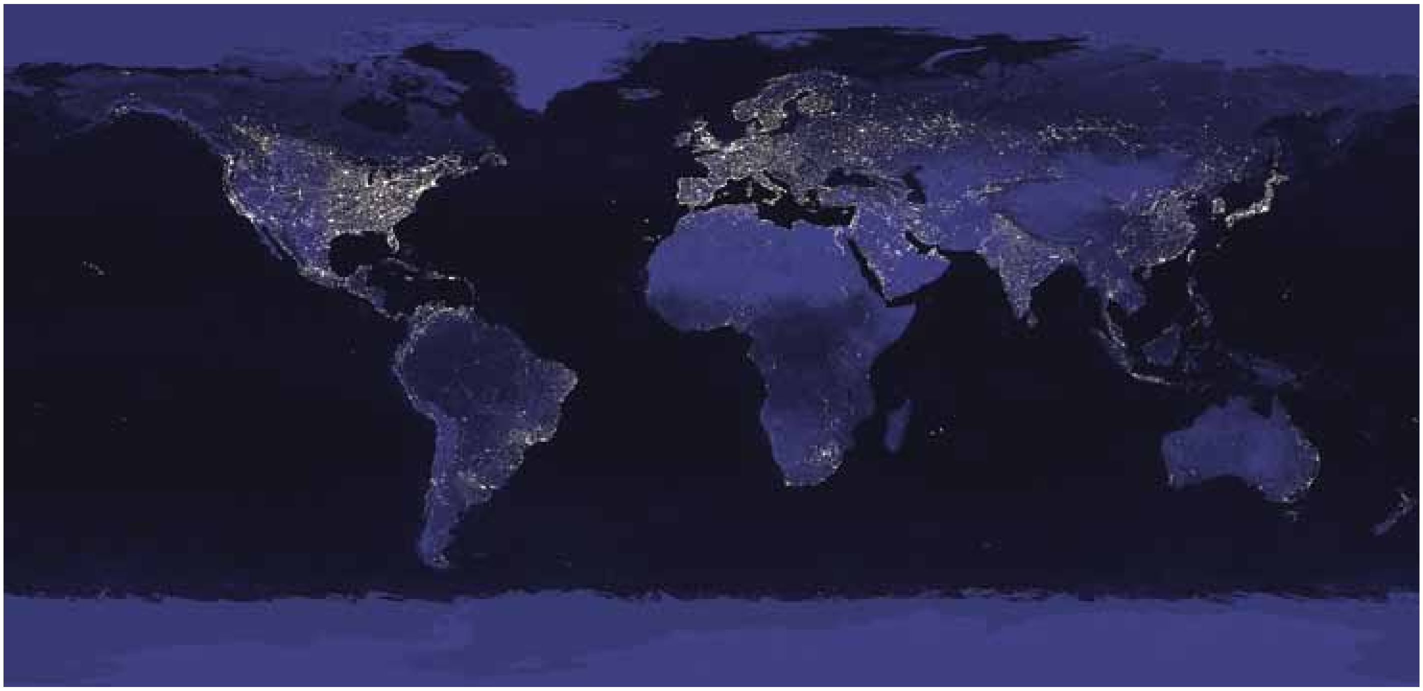
What to Do Next?

The advances in physically based coupled atmosphere-land surface (CALS) modeling work are improving our basic understanding of weather and climate impacts in the urban zone (see Shepherd et al. 2009c). CALS modeling also enables controlled, designed experiments with the ability to replicate various meteorological and land cover scenarios. CALS models essentially solve an inter-related set of equations describing atmospheric motion, heating, and moisture and the interactions with land surface processes. The land surface model represents various land cover and relevant attributes that couple to atmospheric processes. Several recent investigations (Niyogi et al. 2006, Pielke et al. 2007, Shem and Shepherd 2009) have used this approach to study questions concerning physical mechanisms. Shepherd et al. (2009a) even applied urban growth model projections from the UrbanSim model and a weather-land surface model to quantify how future urban land cover might alter Houston's regional hydroclimate in 2025. CALS models, coupled to hydrological models, will be useful for studying possible urban-hydroclimate extremes like the Atlanta Floods of 2009.

Closing Thoughts

Scientific studies have provided compelling evidence that urbanization is shaping the space and time evolution, distribution, and intensity of hydroclimate variables. Placed in the context of the Earth as an "Urban Planet" (Figure 5), it is apparent why Dabberdt et al. (2000) and the IPCC (Trenberth et al. 2007) argued that more resources and time are required for urban weather, climate, and hydrological studies.

Figure 5 | Earth's city lights created with data from the Defense Meteorological Satellite Program (DMSP) Operational Linescan System (OLS) (figure courtesy of NASA).



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An aerial view of Warsaw, Poland

Challenges of Urbanization and Peri-Urban Development in Europe: the Contribution of the PLUREL Project

Thomas Sick Nielsen, Kjell Nilsson

With contributions from: Mark Rounsevell, Sophie Rickebush, Dagmar Haase, Annette Piorr, Nina Schwarz, Ingo Zazada, Jan Peters-Anders

Urbanisation has arguably been the most significant process of land use change in Europe since the Second World War. Over 70% of Europe's population now lives in urban areas, which in turn, have grown in area by almost 80% over the last fifty years (EEA 2006). Urban areas cover approximately five percent of the territory of the European Union (EU25), and are growing more than twice as fast as the European population[1]. A general consequence of the urbanisation trend and increasing wealth and mobility is urban sprawl, as well as the emergence of peri-urban areas.

The peri-urban areas are characterised by scattered built-up areas, dense transport networks, recreational facilities, urban woodlands, and farmstead complexes that have been converted into housing or hobby farms based on the demand from consumers who are attracted by the nature and open space amenities of peri-urban and ex-urban areas; while at the same time take part in an urban economy, and generally pursue urban lifestyles.

Urbanisation, peri-urbanisation and the changing relationships between rural and urban land uses have deep consequences for people's quality of life, for the environment and ecosystem services. These changes are most dynamic, intense and visible in the peri-urban where urban land blends with the rural, and where open space and land formerly used for agriculture undergo permanent changes due to the pressures from urbanisation.

The PLUREL Project

The EU-funded research project, PLUREL[2], aims to achieve a deeper understanding of the changing relationships between urban and rural land use with an emphasis on the dynamic peri-urban areas. As an integrated project in applied research, the project incorporates practitioners and aims to develop tools and methodologies for analysing the environmental, social and economic impacts of land use changes; and to identify potential

1 The extend of urban areas in EU25 grew 0.5% per year through the 1990s - compared to a population growth of 0.2% per year in the same period.

2 PLUREL Peri-urban Land Use Relationships - Strategies and Sustainability Assessment Tools for Urban-Rural Linkages (EC FP6 036921) is a 4 year (2007-2010) integrated research project, funded by the European Commissions sixth framework programme for research – see www.plurel.net.

Figure 1 | PLUREL's case studies

strategies and good practice examples for the promotion of sustainable development of land use systems. The research of PLUREL can be divided into three broad "fields". They are:

1. Land use scenarios for Rural-Urban Regions in Europe, improving the understanding of the economic, social and environmental issues underlying land use dynamics in the urban, peri-urban and rural sub-regions.
2. Analysis, modelling and assessment of relations between land use change and the provision of resources and functions (e.g., residential, transport, environmental and recreational services), as well as environmental, social and economic impact indicators.
3. Analysis of the implications of planning policies and strategies, as well as governance structures on the sustainability of land use, particularly in peri-urban areas by exploring selected case study regions in detail and in collaboration with local stakeholders/practitioners.

In order to adequately identify driving forces and pressures, and to analyse planning policies and governance, PLUREL works at two spatial scales: European and regional. At the European level, typologies of Rural-Urban Regions and future scenarios for spatial development are developed and assessed for sustainability, delivering outputs at NUTS2/3 level across the EU[3]. This allows the variations within the European territory to be addressed by the project and delivered as inputs to policy development in European institutions.

At the regional level, the work of PLUREL focuses on more detailed approaches to the modelling of land use change and assessment of impacts complementary to the research on the European scale, and detailed collaborative case studies of planning, strategies and governance systems in peri-urban regions. For this part of the research, six European case studies were chosen at the beginning of the project to reflect the variability of geographical, economic and social conditions prevailing in Europe, as well as different governance cultures. A Chinese reference study was included to explore the relevance of the results to the very rapidly urbanising areas in Asia (Figure 1).

The following sections present PLUREL's work on land use scenarios and impact analysis.

Land Use Scenarios

Four scenarios of global trends with relevance for Rural-Urban Regions provide the framework for the study of future trends in land use in Europe and its related functions, including risks and opportunities for sustainable development. PLUREL's scenarios are based on the IPCC Special Report on Emissions Scenarios

3 NUTS: Nomenclature of Territorial Units for Statistics are established by Eurostat and used for statistics as well as for legislative purposes. NUTS5 corresponds to municipalities, while NUTS0 corresponds to the Nation-states that are part of EU. NUTS 2 and 3 are regional units consisting of several municipalities – see http://ec.europa.eu/eurostat/ramon/nuts/introduction_regions_en.html.

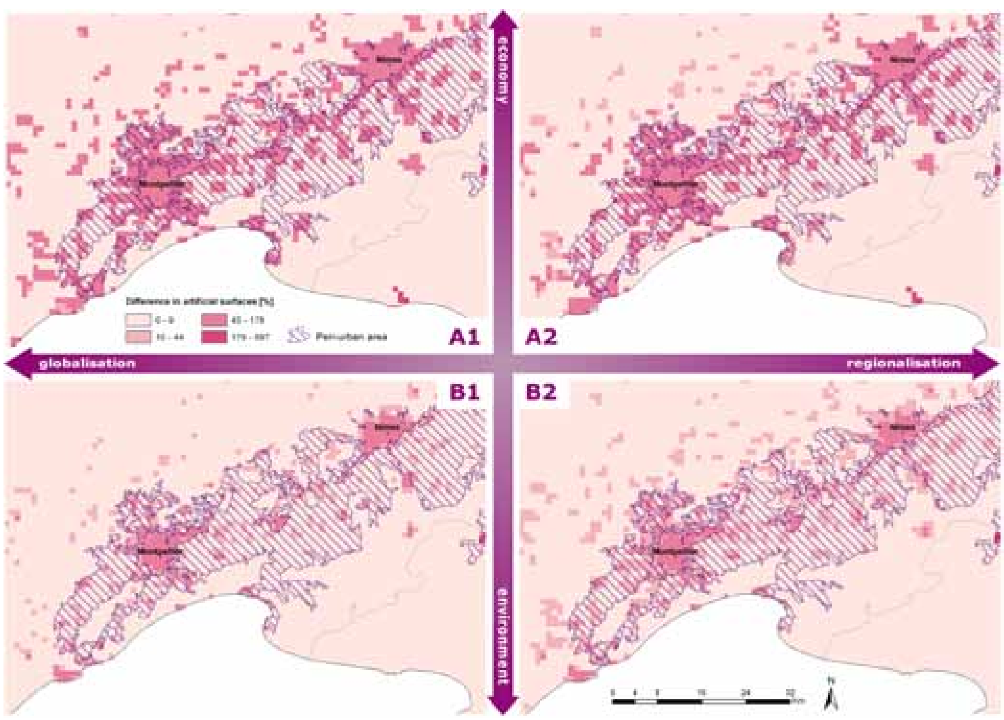
(SRES) that are given a regional interpretation: A1 (*hyper-tech*), A2 (*extreme water*), B1 (*peak oil*) and B2 (*social fragmentation*). Four related narrative storylines are used for the modelling of economic, demographic and environmental futures, and the development of built up areas.

The scenarios of the location of built-up areas can help understand how people might change European landscapes in the future. Although there are big differences in built-up areas between countries, trends in urban patterns emerge from different scenarios, including sprawl into peri-urban and rural areas or concentration in cities. Future land-use patterns in peri-urban areas, PLUREL's main focus, depend largely on changes in the density and location of artificial surfaces[4]. Where will these changes occur? How can they be influenced by planning policy and household preferences? What is the role of technological development in the transport network? These are some of the questions that are addressed in the scenario analysis of urban land-use change in Europe using the regional urban growth model (RUG).

Changes in built-up areas in the four PLUREL scenarios have been simulated for all of Europe, delivering results as urbanisation land cover percentages for cells of a 1 km grid. The scenario storylines affect some of the input data directly. For example, future travel times will vary with the technological change associated with each scenario. Other factors such as the distance from the coast do not vary, but the scenarios determine the importance of coasts in influencing household location preferences. The scenarios also influence model parameters which are used to reflect alternative land-use planning strategies (e.g., "laissez faire" policy versus compact development enhanced by strong planning regulations).

The differences between scenarios for the urban & peri-urban to rural ratio are not significant, but as this ratio generally increases, we can conclude that the current trend for slower growth, in terms of new buildings in rural areas (compared to urban and peri-urban areas), will continue whatever the scenario. On the other hand, the urban to peri-urban ratio does show significant differences, at least between the A (*hyper-tech* and *extreme water*) and B (*peak oil* and *social fragmentation*) type scenarios. This indicates that the scenarios differ mostly in the distribution of new artificial surfaces within the urban/peri-urban areas.

Figure 2 | Sample of PLUREL's European land use scenarios. Difference in artificial surfaces, as a percentage of the current coverage in the Montpellier region, by 2025, for scenarios A1-hyper-tech, A2-extreme water, B1-peak oil and B2-fragmentation. The hatching shows the areas classified as peri-urban (Rickebusch and Rounsevell 2009).



4 CORINE land cover level 1, class 1 – see http://www.eea.europa.eu/data-and-maps.

European land use scenarios (see example in Figure 2) provide inputs for impact analysis with European coverage. At the regional level, more fine grained modelling approaches are applied to develop land use scenarios that are more sensitive to context and include regionally adapted policy dimensions in the scenario specifications.

Impact Analysis

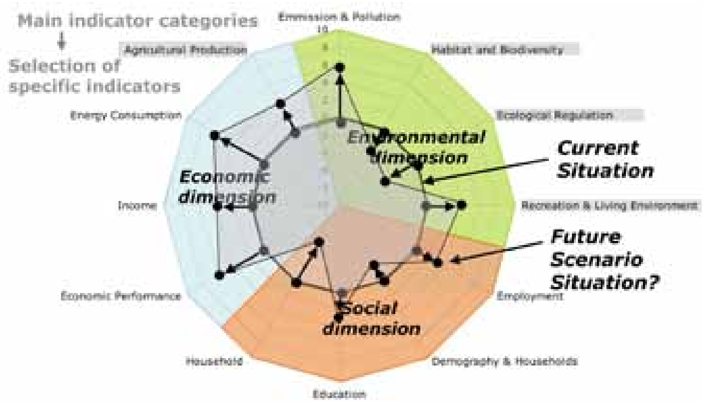
The economic, social and environmental impacts of land use scenarios are evaluated using a range of indicators (e.g., as proposed in Schetke and Haase 2008, Haase and Schetke 2009, Burkhard et al. 2009), and a range of methodologies adapted to the indicator issue and the spatial scale of the output. All impact analysis components are synthesized into one tool: integrated Impact Analysis Tool (iIAT). The iIAT is a tool for an integrated result presentation of a broad impact analysis (IA) and is multipurpose and interactive in nature. It allows for integration of manifold aspects of problems of land use and its functions and services related to urbanisation and considers conflicts of interest of different stakeholders (e.g., residents, planners, developers) within a planning process (Nijkamp et al. 2002, Nijkamp and Vreeker 2000). It covers the three dimensions of sustainability, namely the economic, the social and the environmental (Schetke and Haase 2008).

The PLUREL iIAT consists of two modules – corresponding to the two spatial scales of the project: the iIAT-EU and the iIAT-Region. The iIAT-EU shows how the impacts of urbanisation under future scenario conditions will differ from the current situation (Nielsen et al. 2009). The initial situation 2000 (baseline) can be compared to four scenarios of future development (Ravetz et al. 2008) for the two time slices 2015 and 2025. The main purpose of the iIAT-EU is to create awareness around how sustainability trends develop at different scales for different types of regions and where policy action might be necessary, thematically and spatially (see Figure 3). The iIAT-Region approach allows for selecting or adapting indicators, their weights, the scale, and thresholds or to determine target values for single indicators on which the system will display the reciprocate effect on the other indicators, as calculated by the MCA (Multi-Criteria Analysis) tool.

PLUREL XPLORER

As one of its main end-products, PLUREL will present its evidence on peri-urban land use relationships and sustainability effects; and provide access to a map portal and interactive tools for impact analysis (iIAT), land use scenarios, and Quality of Life effects – through the PLUREL XPLORER. The PLUREL XPLORER

Figure 3 I Sustainability spiders provided by the iIAT EU-27: integrated analysis of urbanisation impacts on sustainability, Level 1 indicators.



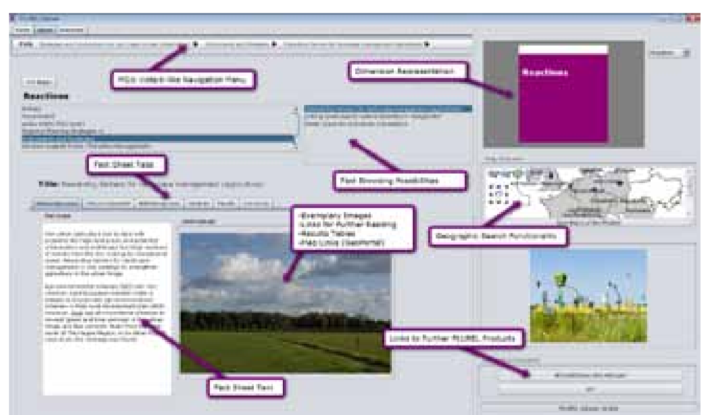
Source: Zasada et al.2009

(Figure 4) will be an online tool allowing the user to browse the evidence based on issues or keywords, to get information in a short form, and to download more elaborate information and/or be linked to additional tools and information systems.

The PLUREL XPLORER and the associated interactive tools will be supplemented by book and brochure publications addressing the issue of sustainable peri-urban development geared towards regional level practitioners or policymakers, and respectively European Commission policy makers.

2010 will be the final year of the PLUREL project and the aim is to present all main results and products at the international conference "Managing the Urban-Rural Interface" in Copenhagen, October 19-22, 2010[5].

Figure 4 I Web-based Graphical User Interface (GUI) of PLUREL XPLORER.



The references for this article are available on our website: http://ugec.org/docs/ViewpointsIssue2References.pdf

5 "Managing the Urban-Rural Interface" conference webpage: www.plurel.net/conference.

A new quarter at Khartoum's western periphery

Thirsty Capital: Urban Growth, Water Management and Infrastructure Investments in Khartoum

Salma Abdalla, Anne-Sophie Beckedorf, David Blanchon, Martin Doevenspeck, Detlef Müller-Mahn

Water supply and distribution are becoming increasingly problematic in many of the rapidly growing cities in the developing world, especially in arid areas. However, critical water supply is seldom simply a problem of physical scarcity, but of management, social organization and power. Infrastructure investments in urban water supply systems often do not primarily reflect people's needs, but rather the economic interests of the investors. In that respect, Sudan's capital Khartoum presents a typical case to study social water scarcity, but at the same time it is quite particular because of a number of the country's peculiarities. The city is located in an arid environment at the edge of the Sahara desert, but it benefits from an abundant water supply at the confluence of the Blue and White Nile with mean annual discharges of 25 and 50 million km^3, respectively (Walsh and Musa 1991: 48).

In addition, groundwater resources in the city area are estimated at 85 to 300 km^3 (Musa and Musa 1991: 70). Despite the abundance of water resources, there is a critical shortage of potable water in Greater Khartoum. The estimated current demand amounts to more than one million cubic meters per day. Around two-thirds of the city is currently not supplied with water through the state owned network. This results in water prices that in some unserved neighbourhoods exceed those in Paris or Berlin.

Recent developments in Sudan have been quite spectacular, but political attention and scientific research in the West have been largely absorbed by the Darfur crisis and related problems. As a consequence, Sudan became a "pariah state", politically marginalized and widely ignored by the international research community. This article presents some preliminary findings of the French-German-Sudanese "Water Management of Khartoum International Research Project" (WAMAKHAIR) that is jointly financed by the German Research Foundation (DFG) and the French Agence Nationale de Recherche (ANR).

Flows of Water, Flows of Power: Theoretical Framework

In order to understand how urban dwellers manage to get access to water under conditions of economic liberalization, growing social differentiation and the hegemony of neo-Islam, WAMAKHAIR builds upon theoretical debates conducted by scholars such as Eric Swyngedouw (2004) and Anthony Turton (2002), who have focused on the links between the control of water and power structures. We link the outcomes of this work to approaches that are informed by the theory of regulation (Barraqué 1995, Lorrain 2001, Jaglin 2005), in order to illustrate different processes of commodification of water in the context of economic liberalisation, privatization and the general retreat of the state. Another objective of the research project is to understand the socialization ("*Vergesellschaftung*") of nature and the transformation of the particular nature-society relationship, which is an essential element of the inner dynamics of society itself. Thus, urban water management is used as an entry point to understand societal changes and to unveil the networks of power that are shaping the urban fabric.

The Political Economy of Water Management in Khartoum

As defenders of the Islamic ideal, the Government of the National Salvation Revolution (NSR) came into power through a military coup in 1989. The new rulers launched a policy of total control and mass mobilization to forge a new Islamic identity. At the same time, the government implemented a radical neo-liberal structural adjustment program aiming at price liberalisations and privatisation. This development is paradoxical in so far as it was brought about without the usual interference of the Bretton Woods institutions, as is the case in most other developing countries, but with more or less the same effects. Due to the international isolation of Sudan, structural adjustment was not enforced by the international finance organisations, but it was legitimated by Islamist reformism. When relations with Western countries deteriorated and foreign development assistance from important international donors was reduced to humanitarian aid in the 1990s, the regime turned towards investors from China, India and Malaysia and continued the structural adjustment policy.

The shift towards privatization entailed huge water sector reforms in the 1990s. Until then, water supply had been centralized within two governmental institutions, the rural and the urban water corporations. Both institutions were dissolved through a presidential decree and new state water corporations were established, the most important one being the Khartoum State Water Corporation (KSWC). The new corporations were intended to be run as cost-efficient governmental companies with private sub-contractors. No budgets were allocated from the federal government. Instead, the state water corporations were supposed to apply the principle of cost-recovery through collection of fees and water bills. Thus, the water consumers were transformed to customers, and the water corporations to companies that sell water for a specific price.

In practice, however, the shift from water consumers to customers and from a public institution to a governmental company

The carro system of water supply

has faced many problems. As the amount of collected water bills and the price for water is too low, the objective of cost-recovery has not been achieved thus far. While the recent boom of the Sudanese economy (mainly due to growing oil exports since 1999) has led to increased investments in construction and industry in the capital area, the development of the water supply system is still lagging behind.

Population Growth and Urbanization

Recent urbanization processes of Khartoum are characterized by rapid growth, spatial disparities, and socioeconomic disruptions. Due to a massive growth of the number of inhabitants from 0.5 million after independence in 1956, to an estimated 5.3 million in 2008, Khartoum has become the fourth largest city in Africa. In the 1980s the city experienced an exceptionally high annual population growth of 10-12% and accelerated urbanization, mainly because of internal displacement and political unrest in the South (Figure 1). According to the latest census data, growth has slowed down from 4.5 % per year in the 1990s to 2.4 % during the 2002-2008 period, however, it is regionally concentrated and continues to be high in the western periphery of Omdurman and in the southern suburbs of Khartoum. This poverty-led growth on the outskirts of the city is contrasted by a completely different example of urban development in a large-scale construction scheme financed by Arabian and Asian investors. The new Dubai-style business centre presently under construction in a prominent location near the confluence of the two Niles is associated with upper-class residential areas (Crombé 2009), and it may eventually challenge the majority of Khartoum's inhabitants who are coming from rural backgrounds and are living under conditions of scarcity.

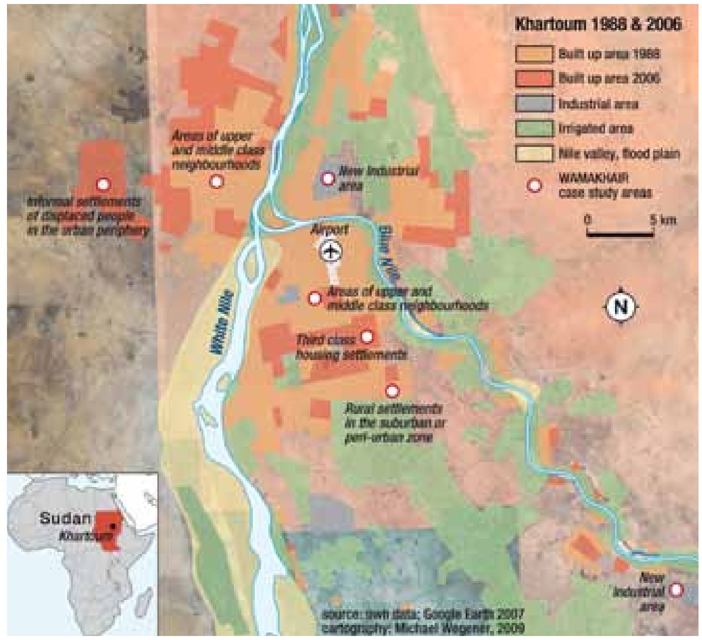
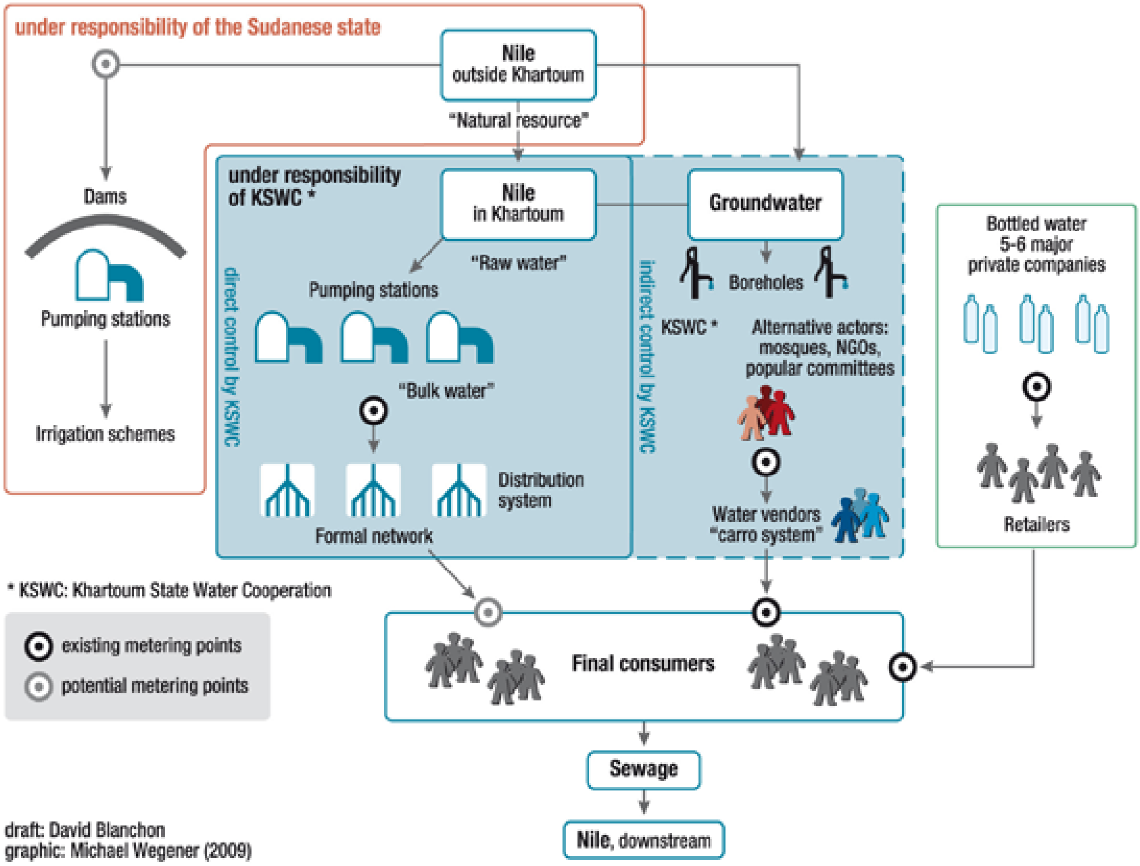


Figure 1 I Urban extension in Khartoum and case study areas of WAMAKHAIR

The Water Distribution System in Greater Khartoum

Until today, the waterscape of Khartoum (Figure 2) is characterized by the coexistence of two separate systems that underwent different developments over the past two decades. At the beginning of the 1990s, the central water distribution system in Khartoum was close to collapse. The ageing Nile pumping stations had a capacity of only 114,000 m^3/day, and the total capacity was less than 75 litres per capita and per day (270,000 m^3 per day for the whole city). One million people, mostly in the internally displaced person (IDP) camps, were consuming less than 20 litres/person/day (Musa & Musa 1991: 68-75). Only in 2001 did the KSWC launch a major investment plan amounting to 150 million Euros that aimed to upgrade the old existing pumping stations and construct new ones, and to drill new boreholes. By 2008, the total capacity of the system had grown to750,000 m^3/day. But despite this substantial progress (+114% in ten years), water supply in Khartoum is still largely insufficient. By now, seven Nile stations provide water through centralized networks to 438,000 households (approximately two million inhabitants) in the central parts of the city. However, most of the remaining population depends on 1,386 boreholes, which are controlled by the KSWC and operated locally by Popular Committees, NGOs, and private entrepreneurs. Here, water is distributed from the boreholes by donkey carts locally called *carros*. The number of carros that serve Khartoum's periphery is estimated at 30,000 to 40,000 (Abdel Gadir 2006: 5). The final price to be paid by the households is subject to strong fluctuations and depends on the distance from the borehole. It ranges generally between 0.8 and 2 Euros per cubic meter.

Figure 2 I Waterflows in Khartoum (from a water supply point of view)



Current Changes in Khartoum's Water Policy

Since its establishment in 1994, the main task of the KSWC had been the provision of water for a rapidly growing population through modern water treatment plants that produce about 200,000 m^3 per day at Soba, Manara (to be finished in April 2010) and Abu Zeid (planned). However, the responsibility for water supply was transferred to the regional states in 1994 without the allocation of sufficient funds. Therefore, the financial resources of the KSWC remained so inadequate that the corporation had to dramatically increase its efforts to gain access to capital. First, since 2001, private companies have been sub-contracted in order to reduce the amount of money spent on labour and equipment within the KSWC. Second, a new billing system and a customer database have been recently established in order to increase the amount of customers who pay for water. Third, efforts to attract foreign investment have been strongly pursued, further facilitated by the peace agreement of 2005. One example of a successful attraction of foreign investment is the Manara water treatment plant, currently being built by a British company. However, this example highlights that the process of economization of water supply clashes with existing structures within the water supply system. Theoretically, the Manara project will extend the water network in order to connect new customers (and thus generate new revenues); according to the economic paradigm, however, the priority of the KSWC is to further improve water supply in areas that are already connected to the water network. This example shows that the current water policy of the KSWC is composed of different rationales that may be described as economic, technical, political and clientelistic, which constantly overlap, co-exist or clash.

Conclusion

First results of the research that is presently being conducted within the various neighbourhoods of the Sudanese capital give evidence of a number of processes that at first sight, may seem to be rather contradictory. At the macro level of metropolitan development there is a strong political impetus by governmental organisations

(KSWC) and NGOs to upgrade local borehole supply systems in poor, peripheral and peri-urban areas, to gradually link these areas to the centralized network based on Nile water purification stations, and to improve water supply for poor households. At the local level, however, the situation remains highly differentiated and disparities are ever increasing. An indicator for uneven development and fragmentation is the effective water price. Poor households generally pay the highest price per unit (often more than 50% of their income) when they buy water in relatively small quantities per head from private water vendors, whereas households in middle and upper class neighbourhoods benefit from the improvements of the centralized network of piped water supply. Attempts of homogenization at the macro level and the persistence and increase of disparities at the local level can be interpreted as expressions of the current social transformation in greater Khartoum, which contains contradictory tendencies of cohesion and fragmentation.

The rural within the urban, view from Tuti Island, Khartoum

The references for this article are available on our website: http://ugec.org/docs/ViewpointsIssue3References.pdf

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Urbanization and Global Environmental Change
AN IHDP CORE PROJECT

The Urbanization and Global Environmental Change (UGEC) project is a science project that targets the generation of new knowledge on the bi-directional interactions and feedback loops between urban areas and global environmental change at local, regional and global levels. It follows a multi-disciplinary approach and utilizes an innovative framework for the comprehensive understanding of the driving and resulting economic, political, cultural, social and physical processes. An important feature of this core project is the explicit commitment to translate abstract knowledge about GEC into local decision-making contexts. The project is expected to provide a platform for close interaction between practitioners, political decision-makers and researchers and targets a stronger coordination and collaboration between academics, political decision-makers and practitioners working on urban and environmental issues. The UGEC project is currently engaged in ongoing efforts to expand its regional and thematic networks.

Our website provides links to the UGEC Science Plan, information on how researchers can join our network as project associates, and how research projects and agencies can get their projects endorsed by UGEC (www.ugec.org). You can assist us in achieving our goals by forwarding this newsletter to any potentially interested party. Visit www.ugec.org for more information.

IHDP
International Human Dimensions Programme on Global Environmental Change

The International Human Dimensions Programme on Global Environmental Change (IHDP) is an international, interdisciplinary science programme, dedicated to promoting, catalysing and coordinating research, capacity-development and networking on the human dimensions of global environmental change. It takes a social science perspective on global change and works on the interface between science and practice. IHDP is a joint programme of the International Council for Science (ICSU), the International Social Science Council (ISSC) and the United Nations University (UNU).

IHDP was founded by the International Council for Science (ICSU) and the International Social Science Council (ISSC) of UNESCO in 1996, and has been a key programme of the United Nations University (UNU) since January 2007. Financed by a broad range of agencies from different countries, IHDP's research programme is guided by an international Scientific Committee made up of reputable scientists from various disciplinary and regional backgrounds.

IHDP fosters high-quality research. The dynamics of climate change, land-use and land-cover change, interactions between institutions and the global environment, human security, sustainable production and consumption systems as well as food and water issues, urbanization and the global carbon cycle are investigated in the context of global environmental change. Visit www.ihdp.unu.edu for more information.

ASU Global Institute of Sustainability
Arizona State University

The Global Institute of Sustainability is the hub of Arizona State University's (ASU) sustainability initiatives. The Institute advances research, education, business practices, and the University's operations for an urbanizing world. Its School of Sustainability, the first of its kind in the US, offers transdisciplinary degree programs that explore and advance practical solutions to environmental, economic, and social challenges.

With over 30 years of environmental research conducted by ASU's Center for Environmental Studies, in 2004, it evolved into the Global Institute of Sustainability established by Julie A. Wrigley. In 2007, the School of Sustainability was formed, offering undergraduate and graduate degrees in sustainability.

The Institute has a comprehensive sustainability research portfolio with a special focus on urban environments. More than half of the world's population lives in cities: global sustainability cannot be achieved without making cities sustainable.

Call for Abstracts

"Opportunities and Challenges for Sustainability in an Urbanizing World"

We have the pleasure to invite you to submit an abstract for the **International Conference on Urbanization and Global Environmental Change** organized by the UGEC project (www.ugec.org). The conference will take place from October 15th – 17th, 2010 at Arizona State University, located in Tempe, Arizona, USA. This conference is organized in close cooperation with the Global Land Project – a joint project of the IHDP and IGBP (GLP will hold its 1st Open Science Meeting between the 17th and 19th of October, with October 17th organized jointly by the two projects).

The conference is an international effort to bring together scientists, practitioners, policy makers, and stakeholders whose research and work addresses the multi-faceted interactions between urban areas and global environmental change. The conference seeks to build a forum for reflection, exchange of knowledge, experiences, lessons, ideas, and information, contributing to the creation of efficient strategies for urban sustainability. The structure and approach of the conference is specifically designed to foster the dialogue among participants. Oral presentations and posters are encouraged to discuss the knowledge and lessons learned from research projects and practices.

Call for Abstracts

Abstract submission has now been extended until April 15th, 2010. We invite you to submit abstracts under one of the main themes listed in the Concept Note which can be found on the conference website www.ugec2010.org. Information on abstract submission as well as other details regarding the conference can be found on the conference website. Expected registration costs are $120 Student, $200 Early Bird, $280 Standard (registration will open soon and a registration option for those who want to attend both conferences will be provided). For any questions, comments and suggestions please email: ugec2010@asu.edu.

Come join us in Tempe, Arizona this coming October!