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# ADAPTE: A tale of diverse teams coming together to do issue-driven interdisciplinary research☆

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ABSTRACT

This paper examines the opportunities and challenges faced by ''Adaptation to the Health Impacts of Air Pollution and Climate Extremes in Latin American Cities'' (ADAPTE). ADAPTE is an issue-driven research endeavor that integrates different disciplinary domains to explore the complex nature of urban vulnerability/adaptive capacity to weather and air pollution in Buenos Aires, Bogota, Mexico City and Santiago. The paper also critically reflects on some of the possible challenges to be encountered, along with the benefits to be gleaned, when doing issue-driven research that seeks to be scientifically robust and socially relevant and is defined by such attributes as integration of heterogeneous research domains, interactivity and reflexivity. ADAPTE's efforts to integrate concepts, methods and data from different disciplines were fundamental in the design of a conceptual framework on urban vulnerability. The integrating research question and the use of quantitative and qualitative methods allowed ADAPTE to shed a slightly different light on the nature and interconnections between the different dimensions of urban vulnerability. However, it has proven difficult for us to fully explore the dynamics of urban vulnerability as well as the issues of scale and context. A set of cultural and communication challenges has arisen, not only from the diverse conceptualization approaches, methods, differing terminologies and mechanisms for analyzing and presenting results that ADAPTE has attempted to integrate, but also from institutional and interpersonal issues affecting team interactions.

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## 1. Introduction

Urban populations and activities play a crucial role in the arena of environmental change, not only as sources of atmospheric emissions, but also as hotspots of risk from exposure to climate hazards such as extreme temperatures, hurricanes and changes in the water cycle. Populations in these urban centers are also negatively affected by high levels of air pollution (Bell et al., 2008) and dangerous deficits in health resulting in effects such as high infant mortality rates. Therefore, many urban areas are already constrained in their capacity to respond to changes in the magnitude of hazards (weather extremes) that climate change is expected to aggravate. However, even beyond this agglomeration of individual effects and risks, an additional challenge is given by the fact that environmental problems such as these are complex, i.e., they result from a complicated chain of interactions between atmospheric, meteorological and societal systems, thus their understanding requires the integration of multiple disciplinary domains. Furthermore, a practical understanding of these problems requires a very special collaboration between science, policy making and the broader public aimed at the creation of issue-based and interdisciplinary science (Lemos and Morehouse, 2005).

The call for interdisciplinary or integrated research is receiving more and more acceptance among scholars, scientific foundations and practitioners addressing issues of global environmental change at global, national and regional levels. Yet, there is little agreement on what integrated science means in practice. Within the sometimes differing definitions of this term, integrated research spans a wide range of efforts such as global environmental assessments (e.g., IPCC, GEO Outlook), integrated assessment models (IAMs), and more local integrated and participatory environmental assessments (Lemos and Morehouse, 2005; Robinson, 2008; Brasseur et al., 2007; Rothman et al., 2009).

Drawing on Robinson (2008), a first distinction can be made between ''academic-driven'' and ''issue-driven'' interdisciplinary science. Practitioners of the former are interested in the intellectual questions that inhabit the edge of established knowledge and offer promising potentials for the creation of new understandings that, if fruitful, can result in a new discipline or field of knowledge (pure curiosity driven research, see Fig. 1). Practitioners of ''issue-driven interdisciplinary research'' are primarily driven by the aspiration of engaging with issues that emerge from fundamental societal dilemmas but do not easily lend themselves to responses originated in traditional – disciplinary – methods of analysis. While the former explore the edges of new disciplinary domains, the later explore, in an attempt to transcend, the boundaries between the academic norms and standards and the practical challenges and policies of the larger world. Furthermore, as they try to bridge the divide between science and practice, issue-driven researchers are faced with the twofold challenge of generating salient and scientifically robust knowledge (Fig. 1).

This paper examines the opportunities and challenges faced by ''Adaptation to the Health Impacts of Air Pollution and Climate Extremes in Latin American Cities'' (ADAPTE). ADAPTE is an issue-driven research endeavor that integrates different disciplinary domains to explore the complex nature of urban vulnerability/adaptive capacity to weather and air pollution in Buenos Aires, Bogota, Mexico City and Santiago. The paper also critically reflects on some of the possible challenges to be encountered, along with the benefits to be gleaned, when doing issue-driven research that seeks to be scientifically robust and socially relevant and is defined by such attributes as integration of heterogeneous research domains, interactivity and reflexivity (Fig. 1). It starts with a brief discussion of curiosity- and issue-driven research (Section 2). It then describes ADAPTE's approach to the integration of different disciplinary domains (Section 3) and to the interactivity between researchers and users of scientific information (Section 4).

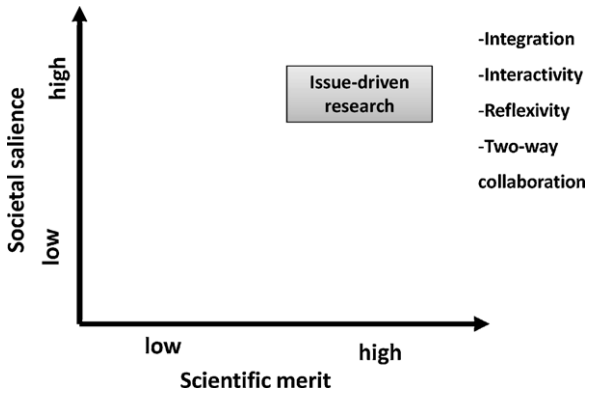


**Fig. 1 – Sustainability science: issue-driven interdisciplinary research.**
***Source:* Romero Lankao and Qin (2011). This figure depicts issue-driven interdisciplinary research across two axes: societal salience and scientific merit. It also lists some of its characteristics (e.g., intragration).**

## 2. Attributes of issue-driven interdisciplinary research

The distinction between multi-, cross- and trans-disciplinary scholarship was first articulated by an influential OECD publication on interdisciplinarity in 1972 (cited in Robinson, 2008), which suggested a hierarchical typology. According to it, multi- and cross-disciplinary scholarship is situated at the bottom of the hierarchy, and corresponds to work that simply combines, without integration, more than one form of disciplinary expertise; interdisciplinary research, at the next level, entails some integration of disciplinary work; and transdisciplinary scholarship, at the top, engages in the creation of new conceptual frameworks that provide a novel synthesis of ideas and methods.

Rather than joining in the debate regarding levels of interdisciplinarity and the co-production of science, here we will refer only to the actual experience of designing and implementing ADAPTE and to attributes of issue-driven science that are of relevance to this special issue.

Scholars tend to agree on a set of attributes defining issue-driven interdisciplinary research. It should be sensitive to the context where knowledge is developed and applied, transdisciplinary, integrative, collaborative and reflexive (Lemos and Morehouse, 2005; Robinson, 2008; Bizikova et al., 2010). This raises a number of requirements and challenges. For instance, this research needs to bring together scholars with very different mental models, conceptual frameworks and methods with the goal of creating new ways of doing science. However, problems of communication, real integration and sharing of knowledge between disciplines can be source of frustration. Furthermore, there is a need to choose research areas that are both academically exciting and socially fruitful, which gives rise to some challenges. It is difficult to create a balance between the academic need to contribute to the literature by bringing forth new theories, methods, tools and insights and the need to do research from which a social benefit may be derived. The second challenge revolves around questions of how to achieve equity of opinions between the scholars and the practitioners and communities who participate in the research; whether scholars' positions should, of necessity, be given more weight, than those of the non-scholars, as it is frequently assumed by many scholars to be the case, and if so, whether the research is truly participatory. Conversely, the pendulum can sometimes swing too far in the other direction. Therefore, issue-driven researchers need to find ways to keep their efforts from degrading into mere consulting or pure advocacy work, even as they strive to fulfill societal needs and to create value, salience and interest beyond the academy.

Issue-driven research is highly participatory and iterative. Because it emphasizes involvement with non academic actors and organizations, it faces the requirement of being socially salient, accountable, and reflexive (Mitchell et al., 2006). The fulfillment of this attribute is not exempt of challenges. The first of these challenges arises out of differences in the culture and priorities of researchers and stakeholders. Researchers frequently approach assessments with a single-focus, for instance, in the arena of climate change the emphasis can be upon cutting carbon emissions, or adapting to climate change impacts. However, stakeholders, whether on an individual or institutional level, have multiple competing goals. While the stakeholders may subscribe to the climate change narrative and 'cause', they also seek to balance multiple and differing goals in the near, medium, and long-term (e.g., build roads and provide housing, profit from a business and make a livelihood). The scale of the climate change challenge, and the frequent lack of obvious, 'win–win' solutions, means that the shorter term, more tangible goals take priority, and perceived longer term goals, such as mitigation and adaptation are often dropped or down-played (Carney and Shackley, 2009).

Another challenge is created by sociological and political issues that arise at the intersection of science and society as issue-centered research places more emphasis on science as a societal endeavor. Issues arise such as which stakeholders should be involved in the coproduction of knowledge (e.g., governmental agencies, private enterprises, community based organizations, grassroots, communities); who should be involved in what deliberative processes (citizen panels, citizen juries, consensus conferences, ombudspersons, citizen advisory commissions); to what extent scientists should reach out to stakeholders; and how much consideration should be given to issues of equity, unintended uses and positive or negative consequences to stakeholders (Lemos and Morehouse, 2005; Carney and Shackley, 2009). Of course, all of these considerations will have profound political ramifications, and how researchers answer these questions will affect the outcome of the research and the way it will be viewed and used by the society with which it attempts to interact.

## 3. ADAPTE's experience

Urban populations in Latin America are at risk from weather extremes and air pollution, which are expected to be aggravated by climate change (Magrin et al., 2007). Scholars have explored the linkages between mortality and air pollution and weather (O'Neill et al., 2005; Bell et al., 2008). However, there are few studies on who is currently vulnerable to the interaction of these hazards, and what environmental and societal factors explain differences in vulnerability and adaptive capacity across and within Buenos Aires, Bogota, Mexico and Santiago. ADAPTE seeks to cover this research gap by: (a) exploring the impacts of air pollution and weather on human health; (b) developing a geo-referenced understanding of vulnerability and adaptive capacity, i.e., of how socio-economic factors such as income, education, overcrowding and age affect mortality differences across cities and between neighborhoods; and (c) performing an assessment of adaptive capacity and adaptation, i.e., of how urban populations and authorities perceive and respond to these risks (this stage is currently underway).

As an issue-driven endeavor, ADAPTE reaches across different disciplinary, theoretical and methodological domains to explore the nature and interaction of key dimensions of health risks (e.g., exposure to hazards, sensitivity, and adaptive capacity. See Fig. 2). Urban vulnerability, or the potential for people in urban areas to be negatively impacted by climate change, is a function of: (a)

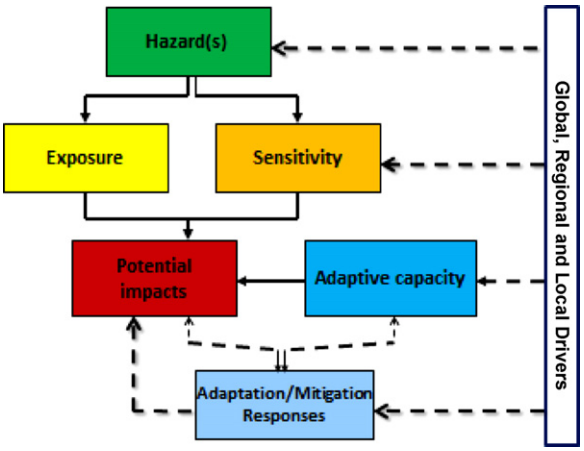


**Fig. 2 – A conceptual framework of urban vulnerability to global climate and environmental change.**
***Source*: Romero Lankao and Qin (2011).**

*hazards*, (i.e., probable or looming s perturbations and stresses[2] to a system); (b) *exposure*, i.e., the extent to which urban populations are in contact with, or subject to hazards; (c) *sensitivity*, i.e., the degree to which subsets of urban populations are susceptible to hazards with patterns of susceptibility often based on demographic characteristics or medical conditions; and (d) *adaptive capacity*, or the ability to avoid or lessen the negative consequences of climate change based on access to resources, assets and options people draw on to moderate potential damages, to cope with the consequences, or to introduce policy changes to expand the range of variability with which it can cope. Adaptive capacity is different from actual coping and adaptation actions (UN-ISDR, 2009; O'Brien, 2007; Gallopín, 2006; Birkmann, 2006; Romero Lankao and Qin, 2011, see Fig. 2). Each of the dimensions of urban vulnerability has different components, determinants or factors. For instance, hazards are defined by such components as their magnitude, and frequency, while sensitivity and adaptive capacity are defined by such factors as age, pre-existing conditions, income, dwelling type and quality and access to social networks and health services.

### 3.1. *Integration: balancing individuals' goals with institutional factors*

To fulfill its goals, the designers of ADAPTE sought the collaboration of a multidisciplinary group of PIs, postdoctoral researchers and students trained in climate and atmospheric sciences, sociology, public policies, public health, statistics and engineering. We aimed to do trans-disciplinary or interdisciplinary and not only multidisciplinary science (see definitions in Section 2). In both of these approaches researchers from different fields come together to address problems whose understanding cannot be achieved by any particular discipline. But, while in the former, the disciplinary theories and methods remain mainly unintegrated, the later implies a novel integration of these (Lemos and Morehouse, 2005; Robinson, 2008). However, our efforts were challenged in different ways.

The design of ADAPTE was shaped by the scope and goals of the Small Grant Program for the Human Dimensions (SGP-HD), launched by the Inter American Institute of Global Environmental Change (IAI) in 2007. The SGP-HD opened for ADAPTE a precious window of opportunity by aiming to promote human dimensions research that built on existing interdisciplinary networks created under the Collaborative Research Network Program (CRN II, IAI 2011). ADAPTE partnered with the project South American Emissions, Megacities and Climate (SAEMC) that seeks to provide climate change scenarios, with emphasis on the evolution of air quality in South American megacities, and on the implementation of coordinated regional chemical weather forecast tools. This meant that some PIs of ADAPTE (physical scientists) were already PIs of SAEMC and challenged the social scientist designers of ADAPTE to design a proposal of interest for both physical and social scientists. This necessitated the creation of a unique set of concepts, methods and tools (e.g., more quantitative in the case of the physical sciences and combining both qualitative and quantitative methods in the case of social sciences).

Two elements worked as additional incentives to this collaboration. The designers of ADAPTE had previously worked with some of the PIs of SAEMC and, as a result, they trusted each other. The designers were able to come up with an integrating question of interest to both physical and social scientists, namely what and how "human" and "natural" dimensions and factors account for the dynamics and differences of *health vulnerabilities* and *risks* within and across the four cities.

This integrating question allowed us to create sub-teams organized around areas of expertise and cities to address the same question from diverse angles. At the same time, it helped to explore the different dimensions of vulnerability to health risks (Fig. 2) and to create knowledge grounded on a very delicate balance between theory and context, given by the specificities of place and the insights of local experts and practitioners (see Sections 3.2 and 4). Regarding the dimensions of urban vulnerability, the sub-team of atmospheric and weather experts gathered, validated and analyzed data on temperature and air pollution (hazards). Health experts and practitioners collected or provided data on all-causes, cardiovascular and respiratory mortality (impacts). Social scientists collected socio-economic data from the census offices to construct measures of adaptive capacity (e.g., education, poverty and overcrowding). These social scientists have been conducting surveys, interviews, meetings and other ethnographic methods to explore how urban populations and decision makers perceive and respond to hazards (adaptive capacity and adaptation at the individual and institutional level, Fig. 2).

Because most of the members of the team had not collaborated before, the integration and coordination of the different sub-teams rested on only few individuals, some of whom had designed the project. Other researchers, that joined the team one year after it started, had the flexibility, paid time and willingness to join the coordinating sub-team and play an active role in selecting and proofing the following methods to explore the connections between the different dimensions of vulnerability: (a) exploratory time series to quantify short-term effects of *exposure* to weather and air pollution on mortality; (b) a generalized linear model (GLM) with Poisson log-linear distribution to estimate the relative risk of being negatively impacted by weather and air pollution; (c) a multi dimensional vulnerability index (MDVI) to map social vulnerability as a multidimensional phenomenon and compare its manifestations within and across cities; and (d) ethnographic instruments to understand how populations and decision makers perceive and respond to these hazards.

### 3.2. *Opportunities*

The integrating research question and the use of quantitative and qualitative methods allowed ADAPTE to shed a slightly different light on a fundamental question: whether health risks are equally or unequally distributed among urban populations of Bogota, Mexico City and Santiago (Romero

[2] As other vulnerability scholars (e.g., Gallopin, 2006), we distinguish hazards from exposure. Although many of the reviewed papers conflate exposure with the characteristics of climate change hazards, we decided to maintain the distinction (see Table 3).

Lankao and Qin, 2011). This question, which has been the subject of a very rich debate among political ecology scholars and others, at the international level, refers to the famous remark by Ulrich Beck that while poverty is hierarchic, risks are ubiquitous, affect everyone equally and are, presumably, a matter of concern to everyone, a remark that has evolved into his risk-society theory. Political ecology and environmental justice scholars have noted that just as wealth is differently distributed across socioeconomic groups, different capacities to cope with hazards are distributed across socioeconomic groups both within and across cities. As evidence of this, they have pointed to the fact that some groups and districts within cities are more vulnerable than others because they lack the assets and options for risk reduction (e.g., Beck, 1986, 2002; Atkinson, 2007; Morello-Frosch, 2002; Bovenkerk, 2003–2004).

A creative combination of methods and disciplinary insights allowed ADAPTE to find that the risks associated with air pollution are of a nature that is much more complex, nuanced and unexpected than either environmental justice or risk-society theory would admit. As a result of their concentrations of energy use (Grübler, 2004), urban centers overwhelm the atmosphere, especially in the studied urban centers, where high levels of criteria air pollutants were found, compared with World Health Organization (WHO 2005) air-quality guidelines that are based on expert evaluation of current scientific evidence on the health impacts of air pollution (see Fig. 3). Although the monitoring stations with the lowest levels of $PM_{10}$ are situated in wealthy areas, the populations of both the most and least vulnerable districts are at similar relative risk of respiratory mortality from exposure to $PM_{10}$. For example, the relative risks (RR) in Chapinero and Usaquen, two of the least vulnerable districts in Bogota, (RR 1.001 and RR 1.003) are equal and even higher than those of Rafael Uribe (RR 1.001 and 1.00) a relatively more vulnerable district at the industrial area of Bogota.

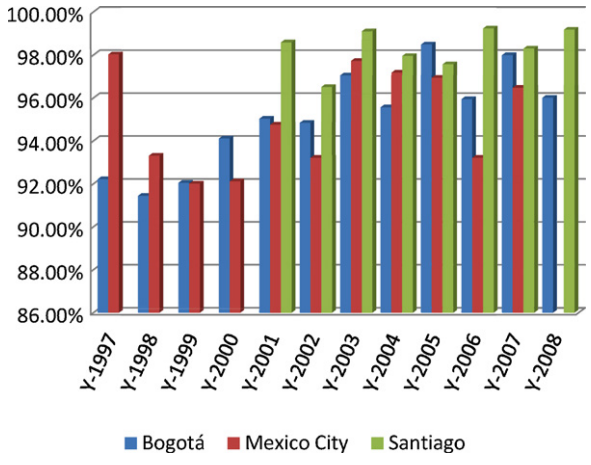


**Fig. 3 – Non-attainment levels for $PM_{10}$.**
***Source*: This figure depicts the percentage of times non-attainment levels for $PM_{10}$ were registered by the monitory stations in the three cities, based on World Health Organization's daily recommendations (50 $\mu g\ m^{-3}$). ADAPTE's calculations based on data from cities' Air Quality Monitoring Stations.**

We also found, however, that *socioeconomic status* plays a complex role not only in explaining urban emissions and mitigation options, but also in affecting and explaining health risks, by interacting in intricate ways with the other dimensions of vulnerability. On the mitigation side and as suggested by political ecology and environmental justice scholarship, the uneven development patterns and distribution of wealth lie behind a process by which economic elites of urban areas are able to monopolize the best land, reap the rewards of local environmental amenities such as clean air, safe drinking water, open space, and tree shade, and create the highest emissions (Bovenkerk, 2003–2004; Morello-Frosch, 2001; Harlan et al., 2006). Mexico City, with a transportation sector that accounts for 34.7 percent of $CO_2$ emissions, offers an example of a socioeconomic gap in responsibility. Private cars contribute 18 percent of the city's daily trip segments but account for 40.8 percent of the $CO_2$ equivalent emissions, while public transport accounts for 82 percent of those trip segments but accounts for 25.9 percent of the $CO_2$ equivalent emissions (Romero Lankao, 2007).

Besides offering opportunities for a more nuanced understanding of the nature and the linkages between the key dimensions involved (e.g., hazards, impacts, adaptive capacities), the collaboration of different disciplinary groups and the participation of students who had more time to continually contribute to the research tasks, has offered opportunities to experiment with various methods. Our work with the socioeconomic determinants of sensitivity and adaptive capacity illustrates this. At first, we wanted to select those indicators with a more significant statistical relationship with air-pollution and mortality. For that we conducted a principal component analysis (PCA) and a Pearson correlation matrix based on Eigen-values and a rotated component plot, to eliminate factors that were not significant ($\rho > 0.05$). We then used a multiple regression analysis (MRA) to model the mean of the response variable (mortality) as a function of the explanatory variables established in the factor analysis. In a third step we used the three most significant SEV factors and calculated the rates for these factors for each individual district.

The selected factors were the number of people with less than a high school education, the number of persons with disabilities, and the number of households with more than 7 members. In Bogota, Mexico City, and Santiago we found that level of education explained, respectively, about 82%, 78% and 25% of the variance associated with cardiovascular mortality and about 88%, 92%, and 30% of the variance associated with respiratory mortality. Number of persons with disabilities explained 92%, 63% and 35%, respectively, of the variance associated with cardiovascular mortality and 93%, 65%, and 46% of the variance in respiratory mortality. And the proxy for poverty explained 27% 67% and 37%, respectively of the variance in cardiovascular and 33%, 86% and 21% of the variance in respiratory mortality.

However, after a couple of rounds of discussion, via Skype, with our local teams and with our health practitioners in Mexico City, we realized that this approach did not allow us to capture the whole set of factors involved and the fact that certain demographic groups can be vulnerable to hazards because of different combinations of such determinants as education, income and overcrowding. For instance, and as can

**Table 1 – Multidimensional vulnerability index in selected comunas[a] of Santiago.**

| Comunas | Financial | Physical | Human | Social | MDV |
|---|---|---|---|---|---|
| Five least vulnerable | | | | | |
| La Reina | 0.29 | 0.32 | 0.15 | 0.26 | 0.33 |
| Vitacura | 0.37 | 0.55 | 0.52 | 0.41 | 0.33 |
| Providencia | 0.58 | 0.68 | 0.65 | 0.81 | 0.35 |
| Maipú | 0.19 | 0.72 | 0.66 | 0.03 | 0.36 |
| Ñuñoa | 0.41 | 0.65 | 0.59 | 0.47 | 0.36 |
| Five most vulnerable | | | | | |
| Cerro Navia | 0.40 | 0.64 | 0.74 | 0.22 | 0.57 |
| Tiltil | 0.34 | 0.62 | 0.67 | 0.49 | 0.59 |
| Padre Hurtado | 0.64 | 0.60 | 0.78 | 0.17 | 0.59 |
| El Monte | 0.54 | 0.19 | 0.96 | 0.18 | 0.61 |
| Curacaví | 0.20 | 0.33 | 0.92 | 0.44 | 0.62 |

*Source*: ADAPTE's own calculations.

[a] Comunas are districts or municipalities within Santiago with their own local governing body (see also Table 2).

be seen in Table 1, even though wealthier comunas of Las Condes and Vitacura in Santiago have the income and education to respond, other factors can be a source of vulnerability.

This insight led us to change gears and draw on the livelihoods approach (Moser and Satterthwaite, 2010; Baud et al., 2008, 2009), to develop a multidimensional vulnerability index (MVI) that acknowledges the multifaceted nature of vulnerability and the capacity to adapt to environmental hazards and stresses; the fact that certain demographic groups are particularly vulnerable to hazards not only as a result of age or existing health conditions, but also because they have or lack the individual/household assets to respond. We built a multi-criteria model of socioeconomic vulnerability based on four different types of capital generally used in the asset-based framework of deprivation: social, human, physical, and financial capitals (Baud et al., 2008). Each dimension of socioeconomic vulnerability was measured by relevant indicators constructed from census data of study cities.[3]

All of the indicators were first normalized based on the method in the UNDP's Human Development Index (UNDP 2002). The values of each variable were normalized to a range between 0 and 1 by applying the following formula:

$$\text{Index value} = \frac{\text{actual value} - \text{minimum value}}{\text{maximum value} - \text{minimum value}}$$

In some cases (e.g., % of houses occupied by owners and income per capital), we reverse the index values by using [1 − index value]. This reversal is necessary to ensure that high index values indicate high vulnerability in all cases. We constructed a sub-index for each of the four dimensions of socioeconomic vulnerability using the average value of relevant normalized indictors. The final index of socioeconomic vulnerability (MDV column in Table 1) is calculated as the average of the four sub-indices (social, human, physical, and financial).

On the adaptation side, the populations in the wealthy districts have access to a broader set of assets and options to cope and adapt to the impacts of weather and air pollution. Yet, the index we built resulted in unexpected findings. For example, populations of La Reyna and Las Condes, two wealthy ''comunas'' in Santiago score relatively low in some of the components of socioeconomic vulnerability measured by the MVI index, but not in all. While it could be said that the least vulnerable comunas have lower scores in their human development (0.14 and 0.10) and financial (0.25 and 0.01) capitals, they have high scores in other components (see Table 1). A possible explanation for this can be that ''comunas'' hide finer spatial differences in socioeconomic status that we can only track using data at a finer level of resolution (census track).

### 3.3. *Challenges*

The integration of concepts, methods and data from different disciplinary domains was not exempted from challenges, however. The different sub-teams had diverse approaches to the conceptualization of problems, and to methods as well as differing terminologies and mechanisms for analyzing and presenting results. Some members of ADAPTE, belonging to an *impacts tradition*,[4] prefer quantitative methods such as the generalized linear model (GLM) to explore how a change in the magnitude of temperature and air pollution (hazard) relates to fluctuations in mortality (impact); and how such compounding factors as age and gender affect the relationship between the hazard and the health impact. Others, belonging to an *inherent vulnerability* tradition (Footnote 5), prefer to work with qualitative methods and less frequently to combine qualitative and quantitative methods to understand how and why populations are differentially affected by hazards within and across cities; whether local stakeholders and populations are receptive to adaptation options and motivated to make the

[3] The indicators include (a) for *Mexico City:* Social: *% of houses occupied by owners*; Human: dependency ratio (ratio of people aged 0–14 and 65+ and people aged 15–64), % of population 5 and older illiterate; Physical: % of households with more than 7 members, *number of health care facilities per 10,000 persons;* Financial: *income per capital,* % population with 2 minimum wages; (b) for *Bogota:* Social: *% of houses occupied by owners;* Human: dependency ratio (ratio of people aged 0–17 and 65+ and people aged 18–64), % of people with less than high school education; Physical: % of households with more than 7 members, *number of health care facilities per 10,000 persons;* Financial: % population living below the poverty line, % persons living below misery level; and (c) for *Santiago:* Social: *% of houses occupied by owners;* Human: dependency ratio (ratio of people aged 0–17 and 65+ and people aged 18–64), % of people with less than high school education; Physical: % of households with more than 7 members, *number of health care facilities per 10,000 persons; and* Financial: % population living below the non-indigent poverty line, % persons living below indigent level.

[4] Coming out of the natural hazards tradition, research on *urban vulnerability as impact* conceives vulnerability as an outcome determined by *exposure* to *hazards* such as temperature, *sensitivity* of urban populations and the resulting or potential *impacts*. Drawing on a political economy approach, a research program on *inherent urban vulnerability* sheds light on additional dimensions creating differences in vulnerability and *adaptive capacity* among urban populations, such as: (a) the assets available to urban residents, and their age and gender; (b) the capacity of urban populations to foresee, resist, react to, recover from, cope with, and take advantage of hazards and stresses; and (c) the way in which governance and policies (e.g., infrastructure provision, health and education) influence those characteristics and adaptive capacities. For a characterization of this and other research lineages see Romero Lankao and Qin (2011).

**Table 2 – Definitions of administrative levels and cities' boundaries.**

| USA | Colombia | Chile | Mexico | Buenos Aires |
|---|---|---|---|---|
| National | National | National | National | National |
| States | Department of Cundimarca | Six provinces | States of Mexico and Federal District | Province and City of Buenos Aires |
| Counties | 20 Localities | 52 Comunas | 16 Delegations and 36 Municipalities | Plus 24 Municipalities |
| Census track | UPZ | Districts | Geo-statistic Basic Areas (AGEB) | Census Radio |

*Source*: ADAPTE's own elaboration.

necessary changes; whether they possess the necessary skills, awareness and resources to be able to adapt; and how their potential adaptation choices are constrained by the social, economic, political, and environmental circumstances in which they live and operate.

Although the coexistence of these different approaches offered opportunities for generating more nuanced understandings of the nature of and the linkages between the key dimensions of vulnerability to the impacts of air pollution and weather, it was also a source of a set of cultural and communication challenges, given not only by the different mental models participants brought to the project, but also by personality issues and personal problems affecting team interactions. Because economic constraints only allowed for one kickoff workshop, a couple of webinar interactions and many Skype calls, face-to-face meetings could not be used to enhance the level of trust and sense of common goals in order to lessen the interpersonal and interdisciplinary impasses and frustrations inherent in any attempt to create a fully integrated set of concepts, methods and tools. Many PIs also had additional responsibilities (e.g., other projects, teaching, outreach and institutional commitments) that did not leave them the time, flexibility and resources necessary for their full participation in the weekly Skype calls and it was often only their students who could join the calls. In short, financial and human constraints, together with the actual structure of incentives of research prevalent in our academic world (which for instance emphasis publishing over permanent involvement with the broader public in the coproduction of science), constrained ADAPTE's possibilities to embark in a sustained interaction aimed at enhancing communication and exploring ways of achieving a more constructive synthesis and convergence.

We faced difficulties in exploring the issues of scale[5] and context. For instance, we intended to work with shared definitions of cities and their administrative subunits (e.g., municipalities, comunas) as our spatial levels of analysis; however, we were constrained by a lack of data at the finer level of resolution (census track) as not all the cities had census data at that level. Therefore we decided to leave this to future research.

We were also constrained by the fact that rather than being determined according to universally agreed upon criteria, cities and their administrative boundaries are set based on local and national criteria and histories, which differ from nation to nation, as can be seen in Table 1. For example, a comparison of Santiago, Buenos Aires and Bogatá, all defined as large cities, illustrates how different administrative divisions and city boundaries may be across cities. The Gran Buenos Aires includes the federal capital plus 24 municipalities within the province of Buenos Aires; and the Metropolitan Region of Santiago contains six provinces and 52 comunas (Table 2), while Bogotá consists of 20 localities with urban and rural characteristics.

Furthermore, cities constantly change in space and over time. For instance, in the 1950s, Mexico City, was limited to the inner city or core area (four central delegations within the Federal District or FD); in the 1980s, however, it became the Mexico City Metropolitan Area (MCMA) including the FD with its 16 delegations and 35 surrounding municipalities which are part of the State of Mexico; and it is currently a megalopolis with corridors connecting it to the cities of Cuernavaca, Toluca, Puebla, Queretaro and Pachuca. In fact it has grown to encompass such a large geographical area that similarities now exist between Mexico City and such megacities as Tokyo, Beijing and Paris.

These differences and the fact that we lacked comparable data at the census-level track, led us to only include data at the municipality and city level. City level data included 20 municipalities of Bogota; 16 delegations and 35 municipalities of Mexico City; 52 ''*comunas*'' within the so-called ''Gran Santiago''; and the city of Buenos Aires plus its 24 municipalities.

As for the temporal scale, the understanding of the dynamics of vulnerability and risk was constrained by the lack of data covering long periods of time. This was especially the case in Buenos Aires, where there has been only one monitoring station working for the last two decades, collecting CO and $NO_X$ data, and three more stations have been recently installed by the City Government. Thus air pollution data do not cover time periods long enough to run time series analyses.

Data on temperature, air pollution and mortality covered different time periods (e.g., 2002–2006 in Buenos Aires; 2003–2006 in Bogota; 2000–2004 in Mexico City; and 2001–2005 in Santiago), while census data on socioeconomic vulnerability only covered one year (e.g., 2002 in Santiago, 2003 in Bogota, in Buenos Aires and 2000 in Mexico). As a result, we were faced with temporal mismatches between air pollution and mortality data on the one hand and socioeconomic data on the other. And we were only able to capture a snapshot of the risk dynamics we wanted to explore.

All these limitations have made it harder than expected to draw patterns of causation across cities and at the same time to represent the richness and importance of context specific situations, particularly without the financial and human resources necessary for this effort. Yet, ADAPTE's team has worked hard to overcome these and has produced a quite innovative set of scientific insights.

Although the use of quantitative methods was fundamental for a careful consideration of the nature of risks, we were aware of the fact that neither aggregate analysis nor

[5] Scale is defined as ''the spatial, temporal, quantitative, or analytical dimensions used to measure and study any phenomenon'', while levels are ''the units of analysis that are located at the same position on a scale'' (Gibson et al., 2000).

quantitative data derived from governmental statistics fully captured perceptions, within a population or by individual decision makers, of risks or capacities to respond to those risks. For instance, the quantitative analysis is insufficient to explore whether urban populations actually cope with and adapt to heat/cold stress and air pollution and, if they do, what assets, options and safety nets are available to them. Further, these generalized data and analyses cannot help determine whether warning systems, health services and other governmental actions actually help reduce the impacts of those hazards on the health of the affected populations. Therefore, it was necessary to supplement the quantitative analysis undertaken so far with qualitative instruments to analyze not only perceptions but also governmental actions and public health programs, adaptive capacities and adaptation actions taken by urban populations.

During the design of our interviews and surveys we worked to overcome some of our constraints and challenges. Although we do not have enough financial resources to apply surveys to a statistically representative sample of the populations, we applied some questionnaires to capture the dynamics of adaptive capacities, perceptions and responses at the institutional and individual levels (see Fig. 2). In doing so, we are capturing some elements of the dynamics of vulnerability and adaptive capacity as well as some of the relationships between hazards and coping/adaptation strategies.

## 4. Stakeholder involvement

When engaging stakeholders in *issue-driven* research, it is important to understand why we are doing so. These purposes, which are not always explicitly stated by the researchers involved, among others may include: gaining compliance with a funder's request; adding legitimacy to the assessment; helping to influence agendas; building new knowledge; extending capacity in the project; incorporating the values of people who in some way 'represent' (a section of) the wider public; producing high quality academic outputs; and reducing stakeholder scepticism, when forming, assessing and disseminating assessment findings (Carney and Shackley, 2009).

Stakeholder engagement is most evidently required where, as it is the case with ADAPTE, problems are complex and uncertainty levels high. This is the case, for instance, where it is not possible to quantify uncertainty using established techniques, or it is difficult or impossible even to characterize uncertainty due to ambiguity, indeterminacy or ignorance. ''High ambiguities require the most inclusive strategy for participation, since not only directly affected groups but also those indirectly affected have something to contribute to this debate. Resolving ambiguities in risk debates requires a participatory discourse. Available sets of deliberative processes include citizen panels, citizen juries, consensus conferences, ombudspersons, citizen advisory commissions, and similar participatory instruments.''[6]

When done well, appropriate stakeholder engagement can provide highly effective co-production of knowledge, whereby various actors may learn from each other and, potentially, learn how to better communicate with each other. But again there are many lessons to be gleaned from the practice of stakeholder involvement. ADAPTE has had to face the challenge of deciding who should be involved in the production of this interdisciplinary research, made worse by the fact that scarce financial and human resources, which had to be allocated to four cities, did not allow our team to commit enough time and effort to recurrently involve all the relevant decision makers and communities in advisory groups and round tables (Robinson, 2008; Lemos and Morehouse, 2005). ADAPTE has, therefore, taken an ad hoc approach to involving health practitioners and environmental authorities; to presenting our research findings in different academic and science–policy events; to designing and implementing our interviews and surveys in conjunction with local authorities of the cities; to discussing results with authorities, academics, and community leaders; and to holding workshops to enhance a dialogue between all these sectors.

Our efforts have not been undertaken in a political vacuum, but rather in a Latin American institutional, societal and political context. With all their dynamism, high levels of integration in the global economy and presence of a strong and creative middle class, Latin American cities are still faced with significant levels of poverty, indigence and informality (Eakin and Lemos, 2010; Hardoy and Romero-Lankao). They have experienced a profound state reform given by contested and contradictory processes of democratization, retrenchment of the state, decentralization and increased participation of the private sector and civil society organizations. In some cases, these transformations have opened opportunities for societal participation and entrepreneurial ingenuity in the design of inclusive processes such as issue-driven science. However, in many cases they have been accompanied by losses of governmental capacities to respond, particularly at the local level, have created greater inequalities in the distribution of individual assets and entitlements, and have reduced the possibilities for inclusive science–policy interfaces (Aragon-Durand, 2007; Lemos, 2008; Eakin et al., 2010; Romero Lankao, 2010).

All of the constraints that our ADAPTE team has faced within a Latin American socioeconomic and institutional context have challenged our ability to fulfill the requirement of creating iterative processes salient to multiple audiences representing the stakeholders involved. As can be seen in Table 3, where we map out the relevant actors in Buenos Aires and Mexico City, our relevant stakeholders include governmental and non-governmental organizations operating at national, state and local levels. Of all the relevant stakeholders listed, however, we have only been able to work with health, civil defense, environmental and housing authorities as well as with the academic sector. We have broaden our stakeholder participation during the current project-stage of interviews and surveys and get a better sense of how NGOs, the private sector and individuals perceive and respond to this issue. We held local workshops in each city to share preliminary results of our survey and prior work with decision makers, scientists, NGOs and community leaders. We will hold a final workshop in February 2012 in Mexico City where we will discuss the results of our work with a handful of city authorities. Only in this way, will we will be able to assure that our research is

[6] Renn 2009: 244–245 cited by Carney and Shackley (2009).

**Table 3 – Relevant governmental and non-governmental actors in Buenos Aires and Mexico City.**

| City | Level | Governmental | Academic | NGOs, church, grassroots | Private |
|---|---|---|---|---|---|
| Buenos Aires | National | • Climatic Change Direction<br>• Water National Institute | • Bariloche Foundation | | |
| | State | • S. Social Welfare and Public Health<br>• S. Planning and Environmental Management<br>• S. Public Infrastructure<br>• S. Housing and Urban Development<br>• Agency Sustainable Development<br>• Civil Defense<br>• Housing Institute | • Buenos Aires University: Climate Center and Natural Resources Research Programme<br>• San Andres University | | • Real state organisms |
| | Local | | | • Clubs<br>• Health centers | • Real state organisms<br>• Shipyards<br>• Health centers |
| México | National | • S. Environment<br>• National Water Commission<br>• S. Health<br>• National C. for Disasters Protection (CENAPRED)<br>• National Institute of Ecology | • UNAM: Atmospheric Sciences Center<br>• National Public Health Institute<br>• UAM<br>• COLMEX | • Green Peace | |
| | State | • S. Health<br>• S. Environment<br>• S. of Civil Protection | | | • Real state organisms |
| | Local | • Directorate Environment and Sustainable Development<br>• Environmental Planning and Sustainability<br>• Civil Protection<br>• Coordination of Territorial Planning<br>• Health centers | | • Neighbors Committees<br>• Firemen | • Health centers<br>• Real state organizations |

*Source*: ADAPTE's own elaboration.

legitimate in the eyes of multiple audiences, and be better able to respond to the two questions that all issue-driven research needs to ask: what stakeholder's needs should the science thus produced serve; and what knowledge can we gain that will benefit both researchers and users?

## 5. Concluding remarks

This paper has used the experience of ADAPTE to critically reflect on the potentials and challenges of fulfilling such requirement of issue-driven interdisciplinary research as sensitivity to context, integration of different disciplinary domains and active collaboration with representatives of the broader public. From its inception, ADAPTE has sought to be an issue-driven interdisciplinary project. Toward that end, it designed a proposal and an integrating question of interest to both physical and social scientists, which revolved around the ''human'' and ''natural'' dimensions and factors accounting for the dynamics and differences of *health vulnerabilities* and *risks* within and across the four cities.

This strategy offered diverse advantages. It permitted ADAPTE to create sub-teams around areas of expertise and cities to address the same question from diverse angles. It helped to explore the different dimensions of urban vulnerability (Fig. 2) and to create knowledge grounded on a very delicate balance between theory and context, given by the specificities of place and the insights of local experts and practitioners. The integrating research question and the use of quantitative and qualitative methods allowed ADAPTE to shed a slightly different light on the nature and interconnections between the different dimensions of risk which are not straightforward, but rather quite unexpected. Therefore, as suggested by Risk Society theory, at these high levels of pollution, atmospheric hazards affect both the most and least vulnerable districts alike. However, *socioeconomic status* plays an important yet nuanced role, as populations in the wealthy districts have access to a broader set of assets and options to cope with and adapt to the impacts of weather and air pollution. The participation of students who had more time to continually contribute to the research tasks, has also offered opportunities to experiment with various methods. The creation of a collaboration between local scientific teams became fundamental in building capacity.

Yet, ADAPTE's efforts to integrate concepts, methods and data from different disciplines have been faced with many challenges. It has proven difficult for us to fully explore the dynamics of health risks as well as the issues of scale and context. A set of cultural and communication challenges has arisen, not only from the diverse conceptualization

approaches, methods, differing terminologies and mechanisms for analyzing and presenting results that ADAPTE has attempted to integrate, but also from interpersonal issues affecting team interactions.

Our attempts at a sustained interaction that achieved a more constructive synthesis and convergence were constrained by a series of factors. Most of the members of the team had not collaborated before. Because of economic constraints, only sub-teams could hold face-to face workshops. PIs had additional responsibilities (e.g., other projects, teaching, outreach and institutional commitments), and only students participated in the weekly meetings held via Skype. As a result, the integration and coordination of the different sub-teams rested on only few individuals. Last but not least, rather than being able to create iterative processes salient to multiple audiences, ADAPTE has taken an ad hoc approach to linking science with policy, where stakeholder involvement is driven by the needs of the research as those needs arise. Thus far in this approach, we have: involved health practitioners and environmental authorities; presented our research findings in different academic and science–policy events; created a unique combination of methods and tools or relevance for practitioners and decision makers; and designed and implemented our interviews and surveys in conjunction with local authorities of the cities. While there are certainly limitations to this approach, it has allowed ADAPTE to develop novel ideas to issue-driven interdisciplinary research under severe funding constraints.

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