

Risk Habitat Megacity

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Preface

The *Risk Habitat Megacity* research initiative reflects the joint work of about forty natural and social scientists and engineers from five research centres of the German Helmholtz Association – the German Aerospace Centre (DLR), the Forschungszentrum Karlsruhe (FZK), the Helmholtz Centre for Infection Research (HZI), the GeoForschungsZentrum Potsdam (GFZ), and the Helmholtz Centre for Environmental Research – UFZ, and four partner organizations in Latin America – Universidad de Chile, Pontificia Universidad Católica de Chile, Pontificia Universidad Católica de Valparaíso and Economic Commission for Latin America and the Caribbean (ECLAC/CEPAL) in the United Nations.

The programme is based on a concept proposal, the result of meetings and discussion in the Helmholtz Association on the possibility of integrating the capacities of the Helmholtz centres into the research on megacities. An evaluation of the concept proposal in 2005 confirmed its strategic relevance. Following endorsement by the Helmholtz president, the preparatory phase got under way in October 2005, with the aim of finalising a full research plan by March 2007. During the preparatory phase, workshops organized in Santiago de Chile (December 2005) and Leipzig (June 2006) brought the research groups from Latin America and Germany together. The teams from both sides, working on individual topics, met frequently.

The research plan is laid down in the following chapters. It explains how the partners of the research initiative intend to put their unique approach to *Risk Habitat Megacity* into practice. The research plan serves two purposes:

- to introduce the *Risk Habitat Megacity* research initiative (2007-2013)
- to apply for additional funding from the Helmholtz Association for the 2007-2010 research period

Chapter I outlines the research challenges along the three central themes of sustainability, risk and governance. It summarises emerging challenges and thus provides the rationale for the research.

Chapter II provides an overview of the research initiative, including its objectives, research approach and programme architecture, its tools for integration of the different research streams, and its choice of geographic focus for the two programme phases between 2007 and 2013. It specifies the implementation of the research for the first phase from 2007 to 2010, including management, time frame, resource provisions for capacity building, and existing networks.

Chapter III outlines the programme of work for the three cross-cutting concepts (III.1-3) and seven fields of application (III.4-10) in the first programme phase (2007–2010). It gives a concise background on the contemporary challenges of each topic, summarizes the current scientific debate, and defines key research questions, activities and outputs. It further outlines the specific work packages, time frame and resources, and lists the scientists and professionals involved.

A separate document with appendices provides additional information on the expertise and infrastructure of the participating Helmholtz centres, and on the partners in Latin America.

I. The *Risk Habitat Megacity* as a challenge for research

1. Mega-urbanization and sustainable development

The year 2007 marks the beginning of an era in which, for the first time in history, more people will be living in cities than in rural areas. The world's urban population, which has quadrupled since 1950, was predicted to reach an estimated 3.17 billion in 2005 out of a total population of 6.45 billion (UN Population Division 2004). The figures for urban dwellers are predicted to rise to five billion by 2030. Cities in the developing world will absorb 95 % of urban growth in the next two decades, and by 2030, will be home to almost four billion people, or 80 % of the world's urban population. As approx. 60 % of urban growth is due to an excess of urban fertility over urban mortality, the population of the world's megacities is rising dramatically – and will continue to do so in the future (Renner 1998). Some cities will reach inconceivable dimensions. Metacities – massive conurbations of more than 20 million people – are now gaining ground in Asia, Africa and Latin America (UN Habitat 2006a).

As human activities shift to cities, the future of the world community depends more and more on urban sustainability (McGranahan et al. 2001). The scale, the speed of change, the growing mobilization of people, information, goods and capital, and the global connectedness of megacities all combine to create new physical, economic and social dynamics, a new complexity, and new dimensions of risk. This places cities at the centre of the challenges for global sustainable development.

Megacities are more than the concentration of people. They absorb resources from all over the world, generate vast amounts of waste and sewage, and contribute considerably to the use of the environment as a sink. The quantity of resources consumed and urban residues produced per capita tends to rise steadily with increased per capita income. Resource demands, measured in terms of the ecological footprint, show that cities take up less than 2 % of the earth's surface, but use 75 % of its resources (BMBF 2004). The growth and spread of cities impacts on complex natural ecosystems and resource regimes on a global scale (Hardoy et al. 2001), as is documented, for instance, in the case of greenhouse gas emissions (World Resources Institute 1996).

Notwithstanding their hunger for resources, megacities are in a position to contribute significantly to their more sustainable use, taking advantage of economies of scale. High density means low per capita costs for the provision of piped water, the collection and disposal of garbage or waste water treatment. The services provided could be both cost effective and environmentally sound (Satterthwaite 1999; UN Habitat 2006a). The concentration of production and consumption offers huge potential for the provision of public transport systems and the recycling of wastewater or solid waste.

Due to their rapid growth, large cities often fail to satisfy the basic needs of the poor population and are thus confronted with severe problems related to poverty, unemployment and social exclusion. At the same time, they provide the grounds for economic success, as well as for human and social development. Compared to the rural areas, literacy rates average higher and fertility rates lower in the cities (UN Habitat 2006a). Likewise, urban centres accommodate human capital to solve sustainability challenges. The intellectual and scientific communities (research institutions, universities, consultancies) are largely urban. The urban agglomerations further concentrate social resources, such as non-government

organizations and people's associations and their networks. The concentration of social resources also offers political opportunities. The availability of information and ease of communication can expand civic engagement and participation in decision-making, and thus push for good governance and the development of independent control mechanisms.

Megacities are powerhouses of global change. As centres of trade, culture, information and industry, they are characterized by a concentration of firms, corporate headquarters, banks and services, often mediating major functions of the global economy (Sassen 2005; Korff 1996). At the same time, megacities bear the cumulative effects of globalization. Due to changing environmental conditions, megacities increasingly face new and highly dangerous environmental problems. The emergence of new economic production patterns changes the spatial structure of cities and results in new socio-spatial topographies. As globalization generates the migration of vast numbers of people across borders on a mammoth scale, it speeds up processes of urban multi-ethnic co-existence (UN Habitat 2004a).

2. Megacities: spaces of opportunity and risk

Megacities are laboratories of change, representing both "a space of opportunity and a space of risk" (Heinrichs/ Kabisch 2006). On the one hand, they are the engines of global economic growth. Several major cities play leading roles in global networks, not merely producing goods and services, and hosting institutions, but creating related economic and societal structures in other cities (Sassen 1991). Megacities in developing countries have so far not played a prominent role in this global geography (Beaverstock et al. 1999; GAWC 2006). They do, however, generate a huge share of the gross domestic product of their respective countries and provide extensive opportunities for employment and investment (World Bank 2000a). Mexico City and Buenos Aires contribute approx. 50 % of the wealth created in their countries. Furthermore, "World City" status in the urban millennium is beginning to extend to several key cities in developing regions as well. The competition between megacities as World Cities will intensify (UN Habitat 2006a).

On the other hand, the development of mega-agglomerations causes a number of risks and dangers for the inhabitants and for protected goods. Victim and culprit at the same time, these agglomerations not only face but also produce and reinforce these risks and dangers (Mitchell 1999a). "Urbanization affects disasters just as profoundly as disasters can affect urbanization" (Pelling 2003, 7). Most of the world's largest cities are concentrated in areas where earthquakes, floods, and landslides are most likely to happen (UN Office for the Coordination of Humanitarian Affairs 2005). Some 75 % of the world's population lives in areas that were affected at least once by an earthquake, a tropical cyclone, floods, or drought between 1980 and 2000 (UNDP 2004).

At the same time, changes in land use often exacerbate the risk of floods, while interference with water catchments increasingly jeopardizes the water supply, both in quantity and quality (UN World Water Assessment Programme 2006); conversion of agricultural land bears the risk of crisis in the food supply chain for the urban population (UN Habitat 2006a); uncontrolled waste disposal results in environmental deterioration and health risks for urban dwellers, in particular those living in precarious locations; household leakages, and industrial and toxic waste pollute the groundwater (UN Habitat 2006a); high amounts of untreated sewage restrain the usage of surface water downstream the cities; and mounting traffic contributes greatly to worsening air quality. In Mexico City, for example, approximately one million people suffer from respiratory conditions.

The range and linkage of risks and dangers highlight the complexity of the *Risk Habitat Megacity*. Risk factors and risk trends do not exist in isolation, but frequently reinforce each other. Their interaction can create risk dynamics with significant effects that are hard to predict. In addition to the greater exposure of human lives and protected goods to natural hazards, megacities obviously produce conditions that permanently endanger the cities' vital processes and infrastructures. Growing densification in large agglomerations leads to the co-existence and close interaction of different technical and socio-technical systems, and leaves the latter more and more exposed to systemic risks "...that affect the systems on which society depends – health, transport, environment, telecommunications, etc." (OECD 2003, 30).

Mega-urbanization likewise brings with it intensive social and economic problems that compound other factors, such as poverty and social exclusion (World Bank 2000b). For the affected population, dangers take the form of insecurity in relation to food, for example, or tenure (UN Millennium Project 2005). Insecurity of tenure manifests itself in the eviction rates of informal or illegal dwellers, which have risen dramatically in recent years (Centre for Housing Rights and Eviction 2003). Crime is a further challenge (Worldwatch Institute 2005). Approximately 70 % of urban dwellers in Latin America and Africa were victims of crime between 2000 and 2005 (UN Habitat 2006a). Although there is no simple or immediate causal relationship, inequality does appear to aggravate the likelihood of violent crime. Cities where inequalities are most stark also appear to be more vulnerable to insecurity.

Whether and to what extent hazardous events, accidents or systemic risks turn into disasters depends on the vulnerability of the exposed system and population. The analysis of past events shows that the capacity to anticipate or cope with risks, and to resist and recover from the impact of disasters differs from one megacity to another (UNU-EHS 2004). Vulnerability first of all occurs in the context of increasing social inequality. The World Bank estimates that by 2035, cities will become the predominant site of poverty (Ravallion 2001). Even today, poverty levels in the megacities of Latin America and the Caribbean are higher than in rural areas. Similarly, income disparities have grown substantially in recent years (ECLAC/CEPAL 2005a). There is a growing concentration of poverty in particular neighbourhoods, with racial minorities in some structures and international immigrants in others (UN Habitat 2004a). Hence, vulnerability to the dangers associated with environmental degradation, poor housing and sanitation or the lack of access to basic services differs significantly across locations (Puente 1999; Munich Re Group 2004), as well as across social groups (UN Habitat 2006a; Wisner 1999). People in slums, on average, have worse health outcomes and are more vulnerable to disasters such as floods. The most vulnerable of all are women, the elderly and children. The child mortality rate in the slums of Rio de Janeiro is three times higher than in non-slum areas (UN Millennium Project 2005).

However, not only people are susceptible to the multitude of risks concentrated in megacities. Risks also affect megacities at large and, on a broader scale, even national economies. Crime, for instance, renders urban economies less competitive. Likewise, the impact of disasters can be devastating to the economy beyond the level of cities. Between 1990 and 2000, natural disasters resulted in damages constituting between 2 and 15 % of the affected countries' GDP (UN Habitat 2006a). If, therefore, it is impossible to prevent the emergence of new and increasingly serious risks in megacities, the progress of human development on a global scale is at risk.

3. The governance of megacities

Preventing, reducing, mitigating or preparing for and coping with risks is now widely acknowledged as a vital contribution to the achievement of sustainable development. The UN Millennium Declaration identifies “protecting the vulnerable” and “protecting the environment” as key objectives, combining them with the aim to “intensify cooperation to reduce the number and effects of natural and man-made disasters”. The Johannesburg Plan of Implementation proclaimed at the *World Summit on Sustainable Development* in 2002 calls for an integrated, multi-hazard inclusive approach in addressing vulnerability, with risk assessment and disaster management as essential elements of a safer world in the twenty-first century (UN Habitat/ DFID 2002, paragraph 37). The Hyogo Framework for action “Building Resilience of Nations and Communities to Disasters”, formulated at the *World Conference on Disaster Reduction* in 2005, declared the integration of disaster risk considerations in sustainable development policies, planning and programming at all levels as its strategic goal (UN ISDR 2005).

Integration of these considerations depends to a large extent on the quality of governance, i.e., how decisions on publicly relevant affairs are made in and between the spheres of the state, civil society and the private sector. Extreme air and water pollution, deterioration of infrastructures, the spread of violence and crime, transport gridlocks, and social and spatial polarization challenge the sustainability of megacities and large agglomerations, making well-designed governance strategies indispensable to resolving and overcoming these problems and their attendant risks (UN Habitat/ DFID 2002). On the other hand, there is evidence that poor governance performance can amplify or even produce risks to and negative impacts on human security (Hardoy et al. 2001). The failure of city systems to manage basic urban issues, such as regulation of pollution-generating industries, provision of safe transport systems, adequate water supplies and sanitation facilities, creates a hazardous situation for the city and its population.

Governance in megacities confronts new and particular challenges, which are quite distinct from those of smaller cities. Rapid expansion beyond the political-administrative boundaries of the city has rendered existing administrations and their organizational structures unable to cope with developmental dynamics. Jurisdictional fragmentation increases the demand to balance municipal and metropolitan planning and to outweigh competing agendas. This calls for the re-adjustment and redistribution of national and local responsibilities, as well as for strategies to pursue and implement policies across different fields and levels of administration. Democratization opens the arena for the involvement of an informed constituency, but must first reach out to all social strata. Privatization assigns a vital role to private actors, for example as providers of services for water or housing, but must be accompanied by public control. Finally, informal processes of decision-making, which take place beyond official administrative structures or markets, have considerable impact on urban development in numerous megacities, thus raising the question of how such processes can be understood and influenced.

4. Emerging research priorities

Discourses on urban sustainability and risk take place for the most part in the domain of operative urban management. With the “urbanization” of the Habitat Agenda and strategy adjustments of major development institutions on issues of urban sustainability (e.g., World Bank 2000a), several major programmes on these aspects have emerged, such as the

Sustainable Cities programme of UN Habitat, the *Cities Alliance*, or the *Healthy Cities* project of the World Health Organisation (WHO). Similarly, the *Global Natural Disaster Risk Hotspots* project of the ProVention Consortium and the *Reducing Disaster Risk* project of the United Nations Development Programme (UNDP) have contributed much to the conceptualization of frameworks and the implementation of disaster risk management at global level (Dilley et al. 2005; UNDP 2004).

Several activities also focused on megacities. The first of these was the *Mega-Cities project*, which has conducted studies and published a newsletter since 1987. Another arena for scholarly discourse on megacities was provided by *The Megacities Foundation*, which hosts frequent lectures on megacity issues. In the same way, the International Year of Planet Earth maintains the key theme of *Megacities – our global future*. The work of a study group from the International Geographic Union (IGU) on *Disaster Vulnerability of Megacities* led to several publications (Mitchell 1999a; 1999b; Uitto 1998; also Steedman 1995), followed by more recent contributions (Cross 2001; MunichRe 2004) that include the social dimension and the role of local organizations in confronting natural and human-made disasters (Wisner 1999; 2003). The literature on megacities also addresses the quantitative dimension of mega-urbanization (Bronger 1996) and the function of megacities for the global economy (Wehrhahn 2004). Other studies are largely disciplinary and concentrate on particular aspects of mega-urban development in selected cases. Examples are socio-spatial fragmentation and gated communities (Coy/ Pöhler 2002; Mertins 2003), marginality (Perlman 2004), atmospheric pollution (Molina/ Molina 2004), and informal economies (Daniels 2004). The *Comparative Urban Studies* project at the Woodrow Wilson Centre brings together studies that relate to governance in megacities (Ruble et al. 2000; Tulchin et al. 2002), addressing issues such as decentralization, participation and privatization. It is worth noting that some of the most influential theoretical concepts in urban research, the “Space of Flows” (Castells 1997), the “Global City” (Sassen 1991) and the “World City” (Beaverstock et al. 1999) make explicit reference to the phenomena of mega-urbanization.

However, while the scale, the velocity of change, the global connectedness and complexity of mega-urbanization pose fresh challenges for research, megacities are rarely explicitly, let alone systematically, taken up as a distinct category or focus of empirical research. These challenges require priorities that move research in three innovative directions:

- (1) Research should allow for the complexity of the subject megacity, and involves a comprehensive rather than a sectoral approach. This research approach adopts an integrative perspective on the megacity, attunes analysis to the mutual interdependence of processes, and provides a basis for modelling and scenario techniques.
- (2) Research must embrace a problem perspective, linking the generation of orientation knowledge with action-oriented knowledge and the implementation of solutions. This implicates context-specific investigation with the aim of moving governance in megacities “from response to action”.
- (3) This kind of research needs to be transferred into both academic and professional education, and to local stakeholders.

Risk Habitat Megacity faces these research challenges. With its innovative framework, the initiative adopts a comprehensive and interdisciplinary approach. By investigating the processes and associated risks of mega-urbanization and developing implementation solutions for sustainable urban development, it presents new knowledge for orientation and application. It furthermore widens the skills required to analyse the complex urban habitat and the knowledge to propose and monitor adequate policies.

II. The *Risk Habitat Megacity* research initiative

1. General objectives and key research questions

The overall objective of the research initiative is to deepen the understanding of those complex urban processes, interactions and feedback mechanisms that turn megacities and large agglomerations into a risk habitat. It intends to evaluate urban risks under sustainability criteria, to develop analytical tools and instruments for action-oriented knowledge to tackle the risks of mega-urbanization, and to derive paths for a more sustainable development. It seeks answers to several core questions: what risks, or indeed opportunities, are associated with the trend towards mega-urbanization? How can local stakeholders engage in the participation process of defining the type of city and urban culture/ values they want to preserve or promote? How can we predict and describe the transformation of the complex *Risk Habitat Megacity*? What specific strategies and policies can steer the urban system towards a more sustainable development? What institutional and organizational preconditions are required for their effective implementation?

The research focuses on the correlation between the urban habitat as a space of risk and a space of opportunity. Because megacity risks are frequently the result of interaction between natural conditions and human activity (settlement, economic activity, use of natural resources, etc.), leading to multiplication, propagation and reinforcement, research must capture risk interdependencies. The research methodology should make the network of interdependencies explicit, visible and open to analysis. This demands a holistic analysis approach to the complex system of interdependencies, avoiding partial improvement in some subsystems at the expense of worsening the situation in others. To make solutions convincing, analysis will be based on empirical evidence and appropriate simulation models. The research initiative intends to go beyond the generation of orientation knowledge; it aims to develop workable implementation solutions for risk management, which include new forms of urban governance.

The specific objectives of the initiative are:

- (1) To contribute to the specification and identification of sustainable development as the central guiding principle for the future development of megacities. Based on an existing sustainability concept developed in the Helmholtz Association that has already been applied to several projects and estimated as a suitable analytical basis by the Chilean partners, this will be primarily achieved by working out a system of appropriate and locally adopted indicators, and according targets. A top-down approach, i.e., proposals from the research team, will be combined with a bottom-up approach, i.e., the involvement of local political and administrative authorities, to serve this purpose
- (2) To assess characteristic risks and their driving factors and interdependencies in megacities. An appropriate combination of natural, applied and social scientific risk research approaches will be worked out and applied to the perspectives of hazardous events and the vulnerability of the "System Megacity". Analysis and the strategic conclusions will, in accordance with the stakeholders, reflect both exogenous risks (i.e., natural phenomena such as earthquakes) and endogenous risks, such as social inclusion-exclusion mechanisms, impairment processes between the city and its hinterland, or impacts of the socio-technical supply systems for energy, water, waste and sewage.

- (3) To design strategies and instruments for risk management (mitigation, adaptation) as key tools for a more sustainable urban development. Recently implemented or proposed governance elements, such as decentralization, privatization, participation or informality, and existing governance structures will be included with respect to their positive and negative (i.e., risk-producing) impacts
- (4) To develop implementation solutions that take institutional, political, economic and social backgrounds into consideration. The actors and their objectives, relationships and interactions (in terms of organization or cooperation), existing legal frameworks, rules and norms, economic framework conditions, or forms and results of decision-making processes will be considered and analysed. In addition, local political and administrative authorities will be involved in the process of working out targets for sustainable urban development and of proposing appropriate ways to meet them
- (5) To build a platform for continuous interdisciplinary, cross-cultural learning and application to integrate academic research and practice. On the hand, the research initiative will create a suitable environment for young researchers, where activities will comprise training and education by the Chilean and German research partners. On the other hand, it will transfer results and knowledge into academic and professional practice.

2. Research approach and programme architecture

The research plan adopts an *integrative research approach* that combines basic theoretical and conceptual considerations with empirical and application-oriented analysis. The underlying notion of integration is a broad one, taking different dimensions of integration into account and making them explicit (see Box 1).

Box 1: The initiative's interpretation of integration

Integration is a prominent and, at the same time, innovative aspect of the research initiative *Risk Habitat Megacity*. In the understanding of the project consortium, integration comprises:

Integration of sustainability dimensions: Sustainability points to important social, economic, ecological and institutional aspects of development. All four dimensions and their interrelations should be analysed in a common analytical framework that takes unintended side-effects into account;

Integration of scientific disciplines (interdisciplinarity): From the very beginning of its implementation, the multi- and cross-dimensional approach requires interdisciplinary research activities and the continuous cooperation of the social, natural, and engineering sciences and of all partners involved;

Temporal and spatial integration: Both analysis and recommendations for policy and should take into account the need to balance short-term (interests of certain actors, legislative periods, etc.) and long-term (resource and sink functions of ecosystems, development of societal values and rules, demographic change, educational issues, etc.) considerations. Analysis at city level must take into account relevant interrelations to the respective hinterland, the regional, national and even global level;

Stakeholder integration (transdisciplinarity): The importance of different societal groups for development processes requires a transdisciplinary research approach, i.e., the integration of non-scientific actor groups (in particular local policy-makers and authorities). They should not only be included in scientific processes but also in the dissemination and transfer of project results;

Integration of cultural traditions and conditions: As a transnational and even transcontinental initiative, *Risk Habitat Megacity* must ensure cultural integration in the project team, and among the stakeholders. Of particular importance is a common understanding of terms, goals, concepts, and methods among the research group members, and between scientists and the local authorities.

To implement the integrative and interdisciplinary research approach and to offer a common framework for orientation, the research initiative applies three well-established, theory-based analytical concepts:

- (1) The concept of *Sustainable Development* formulates the target dimension of the initiative. It provides orientation towards basic *goals* by defining specific sustainability criteria in close cooperation with the Chilean partners. The aim is to identify the desired future mega-urban development and to provide guidelines for both research and urban policy.
- (2) The *Risk* concept focuses on the extent of the *problems* and their severity. In addition, it helps to identify and analyse the conditions for and impact of the emergence of risks that pose a potential threat to future sustainability.
- (3) The *Governance* concept concentrates on the *actions* to be undertaken. This will be achieved by analysis of current efforts to enhance sustainability in megacities, and by the provision of knowledge and recommendations relevant to the appropriate solutions to specific problems and their potential for implementation.

The initiative applies these analytical concepts to several typical megacity issues, such as *Land use management, Socio-spatial differentiation, Energy, Transportation, Air quality and health, Water resources and services, and Waste management* (see Figure 1). Hence, the programme encompasses ten topics: three “cross-cutting concepts” – *Sustainable Development, Risk, and Governance* – and seven “fields of application”.

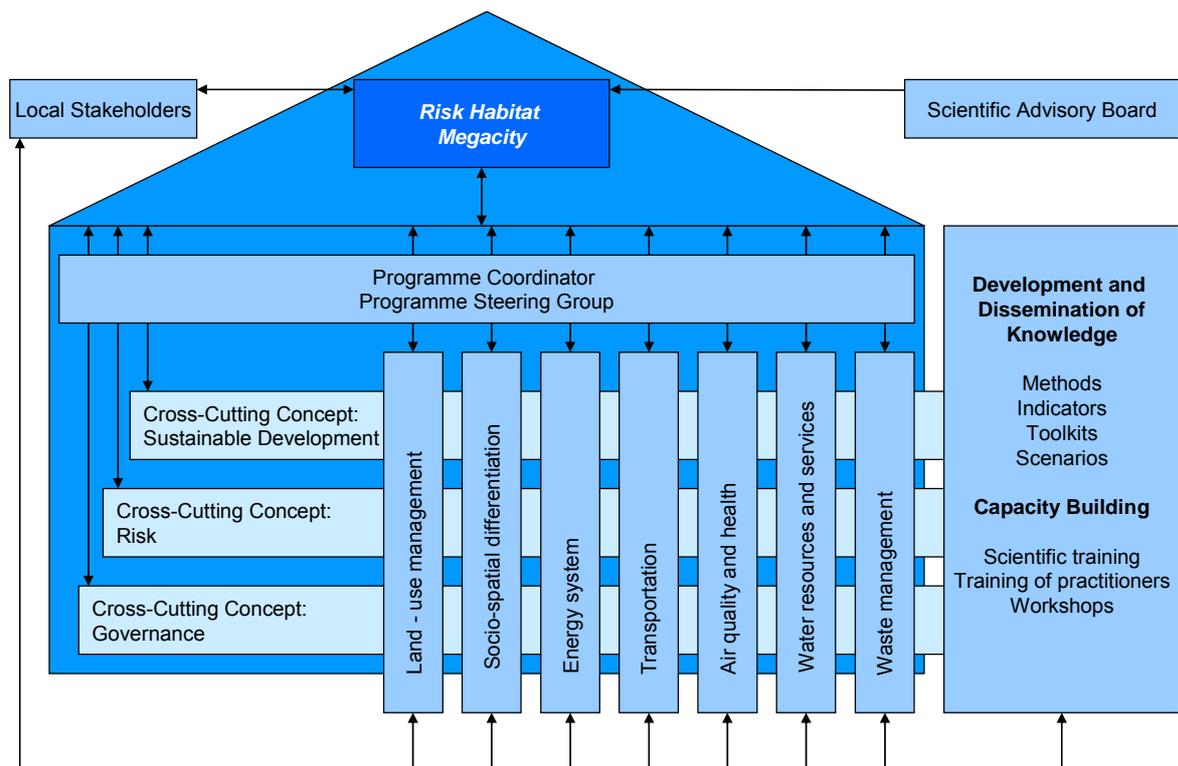


Figure 1: Programme architecture

This selection of cross-cutting concepts and fields of application represents an appropriate combination of theory-based and empirical research approaches. The three cross-cutting concepts are closely interlinked. Together they make the entire complexity of urban systems and the dynamics of development explicit and allow for their adequate analysis. They also

play a crucial role in the integration of research and its findings into the fields of application, and thus for the coherence of the overall initiative.

The fields of application were selected on the basis of three considerations:

- (1) The topics were selected for their relevance to megacity development. They illustrate the outstanding role of megacities as consumers of resources such as land, energy and water; they highlight the critical function of large agglomerations as major producers of waste, pollution and associated health effects; and they point to social aspects of mega-urban growth.
- (2) Partner institutions and local stakeholders have confirmed the relevance of the fields of application, the specific problem focus and the need to deal with them scientifically.
- (3) The specific research capacities and competences within the consortium provide an excellent basis for research on these particular topics.

It should be noted, however, that the resources available have put constraints on the scope of the initiative. Therefore, the initiative does not contain fields of application for other very relevant problems, e.g., food security and violence.

3. Tools for integration

As mentioned above, integration plays a vital role in *Risk Habitat Megacity*. The initiative makes use of several integration tools, which are employed at different levels and serve different functions.

Conceptual and cognitive integration

A key tool for integration is the linkage between the three cross-cutting concepts of *Sustainable Development*, *Risk* and *Governance* and the seven fields of application (see above). Each field of application is required to take into account the perspective of the individual cross-cutting concepts. The concepts can thus be seen as the lens through which the fields of application are analysed. This approach was chosen as a means of strengthening collaboration between the research partners and of assuring conceptual and cognitive integration.

The *Risk Habitat Megacity* research initiative built up “integrative capital” in its preparatory phase (from October 2005 to March 2007) with the development of a so-called “catalogue of issues“. The task of the catalogue was (1) to develop a common understanding of the key concepts and terms, and (2) to support application of the cross-cutting concepts to the fields of application. Worked out in agreement with the Chilean partners, it contains a detailed breakdown of all three cross-cutting concepts into the various fields of application. It sheds light on the concrete relevance and interrelationship of the individual cross-cutting concepts and fields of application, and indicates cooperation requirements. The catalogue served as a tool to identify the issues that were most relevant and to exclude those of less consequence. Hence, it provided a basis for the definition of work packages and the elaboration of a networking matrix. Developing the catalogue in the preparatory phase had a strong heuristic function, and noticeably reinforced cognitive integration between the research partners.

Methodological integration

Another method of ensuring the coherence of research and the integration of results is the application of jointly elaborated scenarios. The shared use of scenarios guarantees that the fields of application adopt the same assumptions on societal framework conditions and apply a common time horizon. Furthermore, analysis in the framework of scenarios will improve the action orientation of research by delivering important insights with respect to the most effective and acceptable strategic options and their implementation.

To ensure close cooperation within the consortium, a mutual understanding of various types of data is indispensable; it requires a common database, the homogenization of different data sets, and ongoing data administration. Data inquiry and data acquisition must be carefully arranged. Demands must be precisely formulated in cooperation with the partners, and access to available data established from and for both sides. Beyond data structuring, a meta-database in English and Spanish is being considered, and in the event will be made available to all partners.

Integration of scientific disciplines and societal actors

The multi- and cross-dimensional approach in addressing the complexity of the research content calls for the work of an interdisciplinary research team. The *Risk Habitat Megacity* research initiative has embraced a wide spectrum of disciplines from the very beginning. The researchers on both the German and the Chilean side are highly experienced in matters of interdisciplinary work.

Furthermore, research is to be conducted in a transdisciplinary manner, i.e., in cooperation with the relevant local stakeholders (in particular local authorities), and implemented in a variety of ways, such as in workshops on site, interviews, etc. The research approach and intended questions have already been discussed with representatives from other institutions in Latin America, in particular in Chile. One important task of the Latin American partners will be to facilitate and organize the process of local stakeholder participation in order to enable implementation of the proposed solutions in the countries analysed.

Integration of findings

The initiative gives particular prominence to integrating research activities concerning the cross-cutting concepts and fields of application, and the respective results. The application of the conceptual and cognitive tools described earlier plays a major role in putting the foundations in place, and involves joint work on the development of indicators in an initial work package and identification of the most pressing problems and risks in the fields of application. The initiative has identified research priorities (questions) that will lead to closer collaboration between the teams involved. Governance-related questions on decentralization is one of the many examples; this issue will be scrutinised in relation to public transport policy in the *Transportation* field of application.

In a concluding activity, we will synthesize the findings. First of all, we will generate orientation knowledge from the fields of application with respect to the overall research questions on the sustainable development, risks and governance of mega-urban growth. Secondly, we will develop recommendations for a “risk-governance concept for sustainable urban development” at the level of the metropolitan region.

Organizational integration

Measures to foster integration will also be implemented at the organizational level. A key procedure for the promotion of integration between cross-cutting issues and empirical research is the involvement of representatives from the cross-cutting topics in the research teams for each field of application. Another instrument to link ongoing work is the installation of a steering group to coordinate research activities, ensure that fields of application are integrated, and take responsibility for the overall realization of the programme (see Chapter II.7 below). Annual status conferences are planned in order to promote the exchange of information with partners. They will facilitate the integration of results and the involvement of the stakeholders. In addition, networking and short visits on a bilateral basis will be carried out.

4. Focus on Latin America

The geographic focus of the research initiative is on Latin America. Two salient features characterize the region: it is by far the most urbanized developing region in the world, and it has the distinction of being the most inequitable (ECLAC/CEPAL 2005). Of a total 527 million people in the year 2000, approx. 400 million lived in cities (UN Population Division 2002). The region's overall urbanization coefficient of 76 % compares with that of Europe (75.5 %), and substantially exceeds that of other world regions, such as South-East Asia (36 %) and Sub-Saharan Africa (35 %). In some Latin American countries, the urban population has reached 90 % and beyond (ECLAC/CEPAL 2000). At the same time, the region's population is concentrated in its principal cities rather than elsewhere, which explains the significant number of vast agglomerations and megacities. The latter are of crucial economic importance. At the same time, they are centres of unequal distribution of income as well as profound and increasing poverty (Gilbert 2005).

Box 2: Population of Latin American cities and agglomerations	
City, Country	Population
Ciudad de México, Mexico	18 700 000
Sao Paulo, Brazil	20 000 000
Buenos Aires, Argentina	13 000 000
Rio de Janeiro, Brazil	11 200 000
Lima, Peru	7 900 000
Bogotá, Colombia	8 150 000
Santiago de Chile, Chile	5 500 000
Belo Horizonte, Brazil	5 400 000
Guadalajara, Mexico	3 800 000
Caracas, Venezuela	3 200 000
Recife, Brazil	3 750 000

Source: UN Population Division (2004)

After decades of excessive growth in its primary centres, urbanization in Latin America has reached a turning point. The predominantly rural-urban migratory flows that characterized population movements throughout the region have given way to a more diversified pattern, which includes migratory flows from one urban area to another, intra-metropolitan migration, and international migration. Vast socio-demographic changes, such as a steep drop in fertility rates and an increase in life expectancy, heavily impact on the age structure. Migration and demographic change accompanied by new spatial patterns of urban growth and, despite declining population growth rates, conversion of rural land for urban expansion is taking place at an

unprecedented rate (UNEP 2004). Urban sprawl, which is characteristic for all megacities in Latin America, has accentuated a range of typical trends in the region, such as socio-spatial

fragmentation and segregation (Coy/ Pöhler 2002; Sabatini et al. 2001; De Mattos 2002). Unequal distribution of resources or political power coupled with weak institutional controls go hand in hand with extremely high rates of urban violence and insecurity (UN Habitat 2006a). Increasing transport problems and air pollution (ECLAC/CEPAL 2000; 2005a), inadequate housing conditions, substandard materials (Gilbert 1996; 2005), deficits in the supply of water and sanitation, inefficient transformation and use of energy, and deficient disposal and treatment of a rising amount of solid waste all impact on environmental health (ECLAC/CEPAL 2005a; Winchester 2005). The major cities in the region are likewise extremely vulnerable to natural disasters and the technological risks inherent in high-risk activities (ECLAC/CEPAL 2005a). Patterns of urban expansion, in particular the occupation of high-risk land, inequity, social exclusion and environmental degradation are major causes of vulnerability (Fernandez 1996; ECLAC/CEPAL 2005a).

At the same time, faced with the challenges of urbanization, the region has altered its political, administrative and fiscal structures. The larger countries in particular have seen a transfer of power, resources and responsibilities to subnational units of government. While bringing decision-making closer to the citizens and potentially increasing the relevance and efficiency of urban services, decentralization also puts substantial demands on local authorities with limited financial resources, and requires new integration mechanisms for territorial linkage (Ward 1996).

5. Santiago de Chile as “anchor city” and platform

Santiago de Chile will be the ‘anchor city’ for the initiative and host its coordination and the dissemination of results. The partners aim to establish a “research and training platform” for megacities, which will connect Risk Habitat Megacity with the relevant programmes of the partners already in existence (see Chapter II.8). The metropolitan region of Santiago de Chile will also be the pilot case for the first implementation phase. The choice rests on four arguments:

Argument 1: Santiago de Chile gives access to a wide range of representative problems associated with megacities, permitting the design of a conceptual framework and its transfer to other urban agglomerations in the region. The metropolitan region is typical in terms of spatial structure and growth patterns, and a commonly used representative or “ideal” model to illustrate the stages of urban growth in Latin American cities. At the same time, urban expansion and land use in Santiago de Chile show some very recent trends in mega-urbanization and new forms of sprawl (Borsdorf/ Hidalgo 2005). Land conversion for urban expansion is taking place at a higher rate than ever before. While the city expands outwards on an unprecedented scale, the dominance of the central area has, similar to other large cities in the region, declined sharply. Santiago de Chile is socially one of the most polarized cities in the region (De Mattos 2002). Inadequate public transport and the segregation of functions have contributed to the rise in vehicle emissions and had an immediate impact on extreme air pollution levels. The valley location of the city, between the Andes and the coastal mountains, has aggravated this condition to the extent that atmospheric contamination continues to be a major problem, despite extensive efforts to improve air quality (Reyes Paecke et al. 2003). Frequent seismic activity makes the city vulnerable to substantial risk of earthquake. Urban expansion has furthermore led to an interruption of the drainage system and the subsequent increase of flood incidences. Of great concern is the standard of housing and infrastructure provided either by the government or private initiatives for lower income groups.

Argument 2: The advanced stage of urbanization in Santiago de Chile make it the ideal city in which to detect emerging problems and opportunities, and to draw lessons from the strategies adopted in response to the challenges of sustainable urban development. Chile was among the first countries in Latin America to respond to globalization by shifting its macro-economic policy from import substitution to market liberalization, and by promoting foreign direct investment. In terms of urbanization, it is one of the most advanced countries in Latin America (along with Argentina, Uruguay and Venezuela). Approximately 85 % of the Chilean population lives in the urban centres; roughly one-third is concentrated in the capital of Santiago de Chile. Urbanization nevertheless continued to increase by 1.7 % for the period 1995 – 2000 (ECLAC/CEPAL 2000). The implications of Santiago's advanced state of urbanization and the attendant demographic transformation make it an excellent illustration of the pressures and consequences of urbanization, and the corresponding political responses. Firstly, the nature and structure of the problems involved are of growing relevance to the majority of agglomerations, where urbanization, although increasing, is less advanced, and problems are beginning to be addressed. Secondly, because Santiago's large-scale urbanization took place comparatively early, the city has gained a wealth of experience. From the point of view of problem response and lessons to be learned, Santiago de Chile is a case worth studying. Significant progress was made, for example, by introducing new technologies to measure air quality and to forestall critical conditions, but also by predicting drops in air quality for prompt emergency and preventive measures. This and the establishment of air quality standards yielded positive outcomes that led to a constant decline in air quality emergencies (ECLAC/CEPAL 2000). Likewise, the authorities introduced innovative economic instruments for regulation, such as tradeable particulate emission permits (ECLAC/CEPAL 2005a), and are currently in the process of completing their new public transport system.

Argument 3: As the centre of regional networking, Santiago de Chile holds a strategic position. It is home to key international institutions, in particular the Economic Commission for Latin America and the Caribbean (ECLAC/CEPAL). ECLAC/CEPAL is one of five regional Economic Commissions established by the United Nations. Its mandate is to conduct regional analysis, elaborate proposals and provide technical cooperation to the governments of Latin America and the Caribbean in the interests of promoting economic, social and sustainable development. Its members comprise the thirty-three states of Latin America and the Caribbean, and nine countries from other regions, including Germany, Japan and the USA. ECLAC/CEPAL follows up activities in Latin America and the Caribbean associated with the implementation of Agenda 21, the Habitat Agenda and the Johannesburg Plan. With their vast store of knowledge on the region, the divisions of this focal organization, such as the Centro Latinoamericano de Demografía (CELADE), are in a position to analyse development trends. ECLAC/CEPAL likewise coordinates research initiatives of regional relevance and cooperates with international organizations on the production of studies, such as the OECD Environmental Performance Reviews. Sustainable urban development is one of the key concerns and responsibilities of the División de Desarrollo Sostenible y Asentamientos Humanos (DDSAH). This division is the technical secretariat for several regional bodies, such as the Forum of Ministries of Housing and Urban Development (MINURVI) and the Latin America and the Caribbean Organization of Intermediate Governments (OLAGI). ECLAC/CEPAL will take part in the *Risk Habitat Megacity* research programme.

Argument 4: Santiago de Chile offers excellent research partners, infrastructure and data. The Helmholtz Association centres involved have established links with a range of research organizations in Chile, and cooperation with the partners at the Universidad de Chile and the

Pontificia Universidad Católica de Chile is particular strong. As the two major universities in the country, they have the competence and the resources, and are clearly committed to the initiative.

At the Universidad de Chile, the Facultad de Ciencias Físicas y Matemáticas conducts research (including modelling) on transport, air quality, land use, energy, water quality, environmental economics, and policy analysis and instrument choice. The Faculty initiated the *International Research Centre for the Sustainable Urban Development in Metropolitan Areas* (ISUD Centre) in cooperation with the Forschungszentrum Karlsruhe. At the Pontificia Universidad Católica de Chile, the *Instituto de Estudios Urbanos y Territoriales* of the Facultad de Arquitectura, Diseño y Estudios Urbanos has research experience in urban governance, urban sustainability, socio-spatial segregation, sub-urbanization, sprawl and land use planning. The Institute belongs to a regional network (*Red Latinoamericana y del Caribe de Instituciones de Vivienda, Gestión y Medio Ambiente Urbano*) of approx. forty organizations on urban development in Latin America. In cooperation with the *Revista Latinoamericana de Estudios Urbano-Regionales* (EURE), the Institute publishes the only indexed journal on urbanization research in the region.

Scientists from the two universities receive considerable financial support, e.g., from the National Commission for Scientific and Technological Research (CONICYT). The Chilean government maintains a visible political agenda to strengthen research and scientific teaching in the country, with the commitment to support research activities on sustainable urban development. Generating resources from international counterpart organizations, such as the World Bank or the United Nations Development Programme (UNDP) was also crowned with success. In both universities, scientists work directly at the research/policy interface, where scientific knowledge, models and tools are tested and transferred into practice. This has contributed to a significant advance in data availability and modelling efforts. Hence, Santiago de Chile differs from most other megacities in transition or developing countries, and will enable the initiative to produce transferable results on how to tackle complex issues.



Figure 2: Santiago de Chile

6. Common outcomes and dissemination

The initiative will lead to a variety of results in the different topics, i.e., empirical findings, methods, models, tools and measures associated with the fields of application and problems under review. The topic-related results represent the essential products to be integrated and synthesized at the overall level of the initiative. Here, the most important outcomes for the first implementation phase and its case study are:

- a set of operable sustainability indicators for all topics, representative for Latin American megacities
- a database for these indicators and other relevant issues
- a proposal for a consistent sustainable development strategy for Santiago de Chile
- a documentation of risks across the fields of application and recommendations for the appropriate consideration of the most pressing current and future risks in urban management
- a refined analytical concept for transfer to other Latin American megacities
- training of young scientists in interdisciplinary and problem-oriented research as an integral part of *Risk Habitat Megacity*

The dissemination of the major outcomes will take various forms and is geared to specific groups. We will share results with the scientific community through joint publications, use the intended annual conference as a forum for scientific exchange and discussion, and integrate the concept and its results into existing or specifically designed academic courses. Policy briefs addressing stakeholders, in particular policy-makers and local authorities, are planned and will be distributed in Santiago de Chile and at the regional level through ECLAC/CEPAL. In addition, annual conferences will provide a science policy window for continuous dialogue on the results of the initiative. Finally, societal groups will have the opportunity to participate in these conferences and contribute to the debate from their respective points of view.

7. Programme implementation

Implementation phases

Implementation of the conceptual and analytical research framework has a dual function. Firstly, its application to megacities throughout the region provides generalized orientation knowledge. Secondly, application to individual megacities generates case- and context-specific implementation solutions. Achieving these two objectives requires a combined comparative and in-depth approach and an implementation design that consists of two interlinking phases.

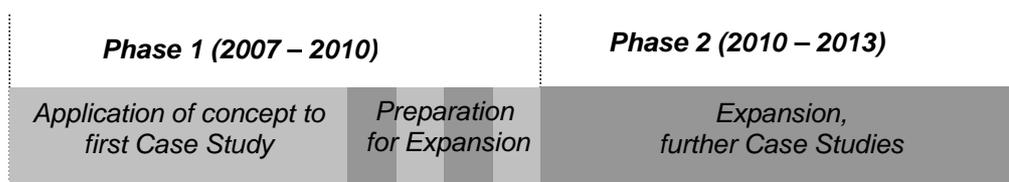


Figure 3: Implementation phases

In the course of an initial three-year phase (2007–2010), we will test the applicability of the integrative concept and develop implementation solutions for the pilot case Santiago de Chile. The programme of work will focus on the development and adjustment of indicators, status analysis, evaluation, and the development of measures in the different fields of

application. On this basis we will synthesize the results to a consistent sustainability strategy and recommendations for improved integration of risk mitigation and risk management in urban governance in Santiago de Chile.

In a second phase (2010-2013), we plan to transfer the *Risk Habitat Megacity* initiative to two other Latin American megacities. During the final year of the first phase (2007-2010), we will therefore examine the analytical framework of *Risk Habitat Megacity* with respect to its transferability to other Latin American megacities. This includes an assessment of the proposed strategies and measures with regard to their applicability outside Chile, i.e., in other contexts. It likewise includes the adjustment of the focus and research questions in the fields of application to the specific context of the case cities in the second phase.

Preliminary criteria¹ for the identification of case studies for a second phase have been discussed with the Chilean research partners and will be further refined. In some justified cases, the empirical investigation in phase 1 can advance to the case cities of phase 2. While we will apply the overall framework to these cases, the focus of empirical investigation and the selected fields of application may well differ from case to case. At the end of the second phase, results from the individual case studies will be aggregated and generalized to a regional perspective.

We will further pursue the integration of the research programme into the regular programme-oriented research structure of the Helmholtz Association.

Work plan

The work plan for implementation phase 1 provides a general framework and orientation for the structure and implementation of the research topics and their work packages, as outlined in Chapter III below. It is likewise a guide for overall programme management and progress monitoring.

Activity	Months					
	1-6	7-12	13-18	19-24	25-30	31-36
Concept and development of indicators						
Status analysis						
First evaluation, scenarios (models)						
Measures, policy recommendations						
Final evaluation, conclusions						
Overall integration of results						
Preparation for expansion						
Coordination						

Table 1: Work plan for phase 1

The implementation of the programme includes annual status conferences (see Table 2), which are seen as occasions to share and integrate results, and to involve stakeholders in

¹ Megacity; accessibility; willingness; interest of scientists and institutions; access to information and data; international research undertaken in subjects related to the project at a metropolitan level

Santiago de Chile. From an early stage of implementation, the consortium will furthermore encourage the participation of research communities (including PhD candidates) and policy-makers from other megacities in the region. Thus, these conferences play a significant role in enabling interested partners to join the process, to cooperate in developing the concept, and to identify the cases for investigation in phase 2.

Conference/Timing	Main agenda	Required inputs
Kick-off meeting Month 2-3	– Clarify concept and adopt mechanisms for coordinated implementation of phase 1	– Research plan
1 st annual conference Month 12 or 13	– Consolidate existing situation and trends in all topics (fields of application and cross-cutting concepts) and their linkages – Integrate set of sustainability indicators – Involve potential adopters from other megacities	– Status reports on existing situation and trends (each topic) – Indicator sets from all fields of application – Coordination with potential adopters
2 nd annual conference Month 24 or 25	– Discussion of first results of investigation in all topics (fields of application and cross-cutting concepts) – Agreement with adopters for phase 2	– Reports with first results (each topic) – Coordination with potential adopters
3 rd annual conference Month 35	– Integration across topics (at level of metropolitan region): elements for a consistent sustainability strategy; integrating risk mitigation into metropolitan governance – Adopt implementation plan for phase 2	– Consolidated reports with results and recommendations (each topic) – Draft implementation plan for phase 2

Table 2: Status conferences (phase 1)

Progress monitoring is based on two programme milestones:

- reports with a status analysis are available for each cross-cutting concept and field of application (after 12 months)
- reports with a first evaluation and measures are available for each cross-cutting concept and field of application (after 24 months)

Resources for implementation phase 1

A significant share of the human and material resources required to carry out the programme will come from the regular budget of the participating Helmholtz centres. This investment indicates both the commitment of the centres and the strategic relevance of the initiative. About twenty-five scientists from the five participating Helmholtz centres cooperate either as topic speakers or key scientists in the cross-cutting concepts and fields of application. Scientists and professionals from the four partner organizations in Chile commit their scientific time as counterpart topic speakers and key scientists. The partners in the consortium will jointly ensure the quality of research, supervision of the PhD candidates involved, and the delivery of results.

Moreover, the consortium will apply for additional resources from the Helmholtz president fund (see Appendix V for a detailed allocation). Apart from mobility and coordination, these funds will be dedicated to capacity building at postgraduate level. We plan to create 10-12 positions for PhD candidates at the Helmholtz centres involved. In addition, approx. 10 % of the resources will be allocated to co-funding an equal number of PhD positions in the partner

organizations in Chile. This measure is crucial to ensuring the success of the initiative and to fulfilling the Helmholtz mission. The additional number of young scientists in the partner organizations is a cost-effective measure that:

- substantially increases the international visibility of the initiative
- significantly raises the commitment of the partner organizations to contribute counterpart resources and, thus, expands the overall scale of the initiative
- ensures a strong presence of the initiative at the research location and enhances the quality and relevance of results and their local application
- builds interdisciplinary research capacities in the partner country in a highly relevant field of scientific-technical cooperation
- enhances the level of intercultural interaction between the partners in Chile and Germany and, hence, constitutes an important instrument for a long-term partnership

Besides positions for young scientists created directly by the programme, we expect the research initiative to open up additional funding opportunities for young scientists engaged in research activities closely related to it. The cooperation substantially increases the access, for example, to programmes of the National Commission for Scientific and Technological Research in Chile (CONICYT) or programmes of the German Academic Exchange Service (DAAD) in Germany. These two organizations recently agreed on a jointly funded programme for up to 200 full and sandwich scholarships for the period from 2007 to 2010. Senior researchers from the partner organizations in Germany and in Chile will actively support the acquisition of scholarships from available funding instruments.

Management

A programme steering group, consisting of the topic speakers from the Helmholtz centres, will lead the research initiative in Germany. The group is responsible for the overall realization of the programme in the Helmholtz Association and reports to the Helmholtz bodies concerned. It likewise takes care of integrating research on the cross-cutting concepts and fields of application. The steering group meets every four months. It will appoint Prof. Bernd Hansjürgens, Helmholtz Centre for Environmental Research – UFZ, as programme coordinator. He is responsible for the external representation of the programme, as well as its management and coordination. The steering group takes decisions by majority vote on issues that cannot be resolved on a consensual basis.

At the level of individual research topics, the topic speakers from the Helmholtz centres are responsible for producing results in line with the overall work plan (see Table 1). The speakers submit annual status reports to the coordinator, including milestones. They continuously coordinate with their counterpart speakers from the respective Chilean organizations (see Chapter III).

A scientific advisory board, consisting of seven internationally renowned experts in the field of megacity research and policy, will act in an advisory capacity to the programme (for information on the members, see Appendix VI). The board, which meets annually, advises on the scientific quality of research. It has likewise the experience and mandate to assist in matters of intercultural cooperation. The constitutive meeting took place on 29th November 2006, at which a first draft of this research plan was reviewed and discussed with the members of the research consortium.

The partners in Chile influence the initiative through a Chilean-German coordination committee, whose task is to share information on the various forms of cooperation and to

implement measures to promote their integration (see Appendix III). The committee, which meets annually on the occasion of the annual status conferences, is made up of six members: three from the Chilean and three from the German side. Furthermore, the organizations in Chile have an immediate impact on work in the research topics as counterpart topics speakers.

Progress monitoring and steering takes place on the basis of the work plan (see Table 1), the framework for the status conferences outlined in Table 2 above, and the respective milestones. In addition, the steering committee evaluates progress at regular meetings. The programme coordinator reports annually to the president of the Helmholtz Association on the progress of the programme and on the allocation of funds from the president fund. The coordinator prepares contractual agreements with the participating Helmholtz centres, regulating responsibilities and the allocation of funding for each topic. The topic speakers report annually on progress to the coordinator. The annual disbursement of funds depends on progress reporting.

An internal and external website (www.risk-habitat-megacity.org) has already been set up and will be regularly updated to facilitate communication, access to working documents and progress results within the consortium. Similarly, it will support the dissemination and storage of information on related resources and events.

8. Capacity building and transfer into professional practice

The interdisciplinary, international and intercultural nature of the research initiative creates unique opportunities and challenges for the capacity building of young researchers. The initiative shows a strong commitment to academic formation and will use the network of researchers and institutions involved for this purpose. *Risk Habitat Megacity* contains several instruments for the integration of PhD candidates at the overall programme level as well as the topic level at which young scientists will be working. This includes fellowships in the different partner institutions.

At the programme level, close to twenty young researchers working at the Helmholtz centres and with the partners in Chile will meet annually for a young researchers workshop. The main purpose of this event, which takes place in the context of the regular status conferences, is to present and discuss individual work. The workshop is connected to a school, for which senior researchers and PhD candidates identify the lectures and inputs relevant to the integrative cross-cutting concepts and fields of application.

At the topic level, the PhD candidates will work under the close supervision of a speaker or a key scientist, whose responsibility is to guide the work and link it to the interdisciplinary framework of the initiative. Supervisors likewise assist in the identification of individual scientific training and mentoring needs of the young researchers in the research network. Apart from individual supervision, several training instruments support their integration:

- participation in regular meetings of the topic teams
- participation in the regular doctoral colloquia at the Helmholtz centres and the PhD programmes of the university partners in Chile
- participation in courses and lectures relevant to the research focus
- attendance at graduate schools where key scientists are involved. Short visits to partner organizations in Chile to clarify the research focus, carry out empirical investigation and exchange ideas with counterparts

The transfer of knowledge into academic and professional practice will be facilitated by existing and envisaged programmes of the Chilean partners. The Facultad de Ciencias Físicas y Matemáticas at the Universidad de Chile is currently in the process of establishing postgraduate courses on sustainable urban development at the ISUD Centre (International Research Centre for the Sustainable Urban Development in Metropolitan Areas). The curriculum will derive from the concept of the initiative. The Instituto de Estudios Urbanos y Territoriales at the Pontificia Universidad Católica de Chile runs several master programmes (*Asentamientos Humanos y Medio Ambiente; Desarrollo Urbano*) and courses leading to a “certificado académico”. It likewise offers diploma courses for professionals and practitioners, such as seminars directly related to the research initiative topics. Helmholtz scientists have expressed interest in contributing to these activities in the form of lectures and short visits.

The División de Desarrollo Sostenible y Asentamientos Humanos of ECLAC/CEPAL is committed to training professionals and practitioners via its training network throughout Latin America. The division, in addition to its secretariat functions for regional bodies, maintains bilateral research and technical cooperation throughout the region. It runs a training programme on themes such as sustainable environmental urban management, indicators of sustainable development, environmental economy and development policy, and shelter and urban land.

9. Networks and strategic alliances

The *Risk Habitat Megacity* research initiative complements a number of recent international schemes that address the challenges of megacities and large agglomerations. Coordination and cooperation with these schemes figures high on the agenda of *Risk Habitat Megacity*. During the preparatory phase, the research initiative engaged in intense consultations with the *Megacity Task Force* of the International Geographic Union (IGU). Furthermore, initial contact has been established with the United Nations University Institute for Human Security, which conducts and supports research on vulnerability. The same holds true for the core programme on Urbanisation and Global Environmental Change of the International Human Dimension Programme (IHDP). Moreover, the research initiative will continue to develop its links to the international academic community in general. The *Environment, Health and Sustainable Development* conference of the International Association for People-Environment Studies (IAPS) in Alexandria, Egypt, in 2006, is one example of how the consortium presented the initiative to the international academic community.

During the preparatory phase the research partners in Santiago de Chile facilitated or arranged contact between the Helmholtz consortium and several relevant actors and stakeholders in Chile and elsewhere in Latin America. On these occasions, research was discussed with representatives of several organizations in Chile, such as the non-government organizations SUR (Corporación de Estudios Sociales y Educación) and CIUDAD Viva, the Comisión Nacional del Medio Ambiente (CONAMA), the Cámara Chilena de la Construcción (CCC), the Corporación para el Desarrollo de Santiago (CORDESAM), the Ministerio de Vivienda y Urbanismo (MINVU), the Board for Public Transport Infrastructure Investment (SECTRA), and the Chilean Development Agency (CORFO). The Chilean partners also maintain links with the *Red Latinoamericana y del Caribe de Instituciones de Vivienda, Gestión y Medio Ambiente Urbano*, with the Facultad Latinoamericana de Ciencias Sociales (FLACSO) and the Forum of Ministries of Housing and Urban Development (MINURVI). In addition, the Helmholtz centres concerned bring a variety of existing cooperations into the research initiative, e.g., with Universidad Nacional

Autónoma de México (UNAM), Universidad Autónoma del Estado de Morelos (UAEM) and Universidad de Guadalajara in Mexico; the International Earthquake Research Centre Montessus de Ballore (IERC-MB) and the Millenium Institute on Engineering Complex Systems at the Universidad de Chile; the Centro de Ciencias Ambientales (EULA) at Universidad Concepción, Chile; Universidad Simon Bolivar and Universidad Central de Venezuela in Venezuela; Universidad de Cuyo, Mendoza, and Universidad Nacional Mar del Plata in Argentina; and Universidad Sao Paulo in Brazil.

In Germany, *Risk Habitat Megacity* is one of four current and complementary initiatives:

- (1) The *Integrated Earth Observation System* (EOS) of the Helmholtz Association focuses on the impacts of natural hazards on megacities
- (2) The programme *Research on Sustainable Development in Megacities of Tomorrow* launched by the Federal Ministry of Education and Research (BMBF) concentrates on the management of urban growth. It currently supports sixteen consortia in the development of a research plan, three of which work in Latin American cities (Lima, Recife, Guadalajara). In a series of meetings, the Helmholtz consortium developed an agenda for common activities with these three initiatives (see Appendix III)
- (3) The core programme on informal dynamics in megacities (*Megastädte: Informelle Dynamik des Globalen Wandels*), funded by the German Research Foundation (DFG), highlights informal dynamics in Dhaka (Bangladesh) and the Pearl River Delta (China), and, as of November 2006, supports the implementation of nine projects

The concurrent development and implementation of research focusing on megacities offers an internationally unique setting with exceptional opportunities for all partners. Representatives from the initiatives have already agreed on arrangements for joint workshops and a supporting role of the Gesellschaft für Technische Zusammenarbeit (GTZ). The research initiative was jointly presented at the World Urban Forum in Vancouver in June 2006.

Finally, the Helmholtz consortium has established contacts in the business community. This led to contributions by the research initiative at events held by Siemens (*Forum Megatrend Urbanization* in November 2006), the BMW Foundation Herbert Quandt (November 2006) and the Herrhausen Society of the Deutsche Bank (*Urban Age* Conferences in May and November 2006).

III. Description of topics

Cross-cutting concepts

The cross-cutting concepts *Sustainable Development*, *Risk* and *Governance* provide the theoretical, conceptual and analytical framework for more detailed research in seven fields of application and are crucial to the overall integration of the research initiative. Research on the concepts is therefore organized in a way that guarantees the link-up of scientific analysis across the three cross-cutting concepts and seven fields of application. Accordingly, there are three types of work packages on the cross-cutting concepts.

The first type concentrates on topic-specific questions of exclusive relevance to a particular cross-cutting concept. These work packages are carried out independently by the research teams of the cross-cutting concept concerned. Examples are the contextualization of the integrative sustainability concept to Santiago de Chile (*Sustainable Development* team), the analysis on the emergence and handling of systemic risks (*Risk* team) and the exploration of the issue of informality (*Governance* team).

The second type focuses on specific issues of common interest to a particular cross-cutting concept and field of application, and requires joint research. An example of this is the collaboration of researchers from the topics *Governance* and *Water resources and services* on the role of the private sector concerning water supply and sewage. The collaboration of the research teams on *Risk* and *Energy system* in investigating systemic risks is another example.

The third type of work package is dedicated to the overall integration of cross-cutting concepts and fields of application in the entire initiative. Related activities will be carried out by all involved research teams in two work packages: (1) Concept development, integration of research and results; (2) Scenario analysis. The three cross-cutting teams take the lead responsibility for these collaborative tasks. Accordingly, the two work packages are only listed in the cross-cutting concepts and described in detail in the description of the cross-cutting concept *Sustainable Development* (see work packages 3 and 4).

The following is a more detailed explanation of the three cross-cutting concepts. The text provides background information on each concept and its key elements. It states objectives and research questions, describes work packages, and specifies methods and data requirements. In a final section, it lists the resources, and the key scientists and organizations involved.

1. Cross-cutting concept: Sustainable Development

*Speakers: Jürgen Kopfmüller, Forschungszentrum Karlsruhe;
Jonathan Barton, Pontificia Universidad Católica de Chile*

Background and proposed concept

Within the conceptual framework of the initiative, the *Sustainable Development* concept provides for orientation of the research on basic goals. In the last twenty years, “sustainable development” has emerged worldwide as the most frequently used guiding vision (“Leitbild”) for debates on humanity’s future development in general and for different societal sectors such as transportation, energy or housing in particular. According to the original and still highly important documents – Brundtland Report (WCED 1987), Rio Declaration, and Agenda 21 – certain elements are constitutive for sustainable development: intra- and intergenerational justice (i.e., responsibility for present and future generations), the global perspective (i.e., the well-being of people worldwide is at stake), and the anthropocentric view (i.e., the focus on human needs). In other words, it means ensuring the preconditions for a “good”, i.e., humane and liveable, life for all human beings now and in the future.

Megacities and metropolitan regions as key driving factors for regional, national and global economic, social and cultural development in an increasingly globalized world play a crucial role in the realization of sustainable development. On the one hand, they “produce” problems that endanger sustainable development both in their own territory and at the global level. On the other hand, they provide opportunities for the reduction or solution of such problems. Consequently, “sustainable urban development” was a pivotal issue at the Rio-Conference 1992, in the Rio documents and other international conference declarations, and was translated into the Local Agenda 21 (LA21) initiatives worldwide. In particular, the HABITAT II world conference (Istanbul 1996) was dedicated to the issues of “adequate shelter for all” and “sustainable human settlements in an urbanizing world”; the URBAN 21 world conference (Berlin 2000) demonstrated “best practice” examples of sustainable urban development with regard to different types of cities, while the *Johannesburg Summit 2002* also dealt with sustainable urban development as a cross-cutting issue (Keiner et al. 2004).

Despite the broad consensus on the Leitbild of sustainable development on a general level, two main deficiencies must be stated: firstly, considerable disagreement on its definition and basic conceptual orientation in concrete terms (see e.g., Hopwood et al. 2005; Osorio et al. 2005; Spangenberg 2005), and secondly, lack of operational policies to put sustainable development into practice.

At the conceptual level, controversies primarily centre on three questions:

- (1) The equity of distribution regarding ecological resources, income, access to information, burdens arising from political measures, etc., and the relevance of the “limits of growth”. These issues were controversially discussed in the 1970s and re-emerged in the sustainability debate (see e.g., Beckerman 2002; Islam et al. 2003; Dietrich 2001; Haslinger/ Stöner-Venkatarama 1998).
- (2) The kind of weighting between inter- and intragenerational justice (see e.g., Keiner 2006; Jörissen 2005). In general, the “northern” countries focus more strongly on ecological and intergenerational aspects, whereas the “south” tends to concentrate on economic, social and intragenerational aspects (Spangenberg 2005, 23).

- (3) The structure of the bequest package passed on to future generations. Two positions can be distinguished in relation to the degree of substitutability between natural capital (resources, carrying capacities, etc.) and man-made capital (plants, machinery, buildings, etc.): “weak” sustainability, i.e., substitution is possible, and “strong sustainability”, i.e., substitution is not permitted (Neumayer 2004; Ayres et al. 2001),

The second deficiency refers to the fact that despite the enormous relevance given to the Leitbild in governmental documents, programmes, declarations, etc., in 2004, national sustainable development strategies had been worked out in only 12 % of the 190 countries that exist worldwide; in a further 24 %, a comparable strategy was in the process of development, with the regional focus predominantly in OECD countries (with Mexico as the only Latin American member state as yet), Europe and some newly industrializing countries in the south (OECD 2006; UN-DESA 2004). Moreover, in many cases where sustainable development strategies exist, only poor progress can be reported, mainly because operational policies are insufficiently oriented at the sustainable development goals set (see e.g., Swanson et al. 2004; George/ Kirkpatrick 2006; Eberhardt 2006; for the German case, see Kopfmüller/ Luks 2003/04).

A similar picture of unequal international distribution should be drawn for the local level: here, Europe accounted for more than 80 % of the 6,400 LA21 initiatives working worldwide in approx. 110 countries in 2003, Latin America only for 2 % (with 36 in Brazil and 15 in Chile) (ICLEI 2003). The number of ongoing initiatives worldwide is low in most regions of the world and few success stories have surfaced as yet (Eberhardt 2006). Lack of financial resources and political support from national governments is seen as the key obstacle to greater success on the way to sustainable development (ICLEI 2002).

The integrative sustainable development concept

With the integrative Helmholtz sustainability concept (for a detailed description, see Kopfmüller et al. 2001) an analytical tool that is both theoretically and conceptually well-founded and consistent will be applied. The concept is based on the three constitutive elements of sustainable development mentioned earlier – the postulate of inter- and intragenerational justice, the global perspective, and the anthropocentric view – that are translated into three general goals: to secure human existence, maintain society’s productive potential, and preserve society’s options for development and action. These goals are further concretized by a set of sustainability rules, such as the satisfaction of basic needs with regard to accommodation, food, and health; equal access to education and information; the opportunity of autonomous subsistence bases on own income, the sustainable use of renewable and non-renewable resources, an adequate development of human and knowledge capital, maintenance of social resources, or the preservation of cultural heritage and cultural diversity. These rules constitute the core element of this concept. They describe guiding principles for action, defining a priori universally valid minimum requirements for a global sustainable development. Hence, they serve as basic orientation for future development and provide a comprehensive set of evaluation criteria (relating to countries, cities, societal sectors, strategies and innovations).

The integrative concept is clearly positioned within the above-mentioned controversies. Inter- and intragenerational justice are assumed as equitable postulates, since a just distribution of resources and opportunities to satisfy the basic needs of the living is an ethical imperative and a prerequisite for the fulfilment of the postulate of responsibility for future generations as well. With respect to the controversy on weak/strong sustainability, the concept adopts a

medium position of “critical sustainability”, i.e., capital substitution is possible only to the extent that basic functions of natural systems remain secure (see Seragelding/ Steer 1994). Concerning the growth debate, in the “philosophy” of the integrative concept, economic growth is not in itself a goal, but acceptable to an extent that does not endanger the fulfilment of the sustainability rules.

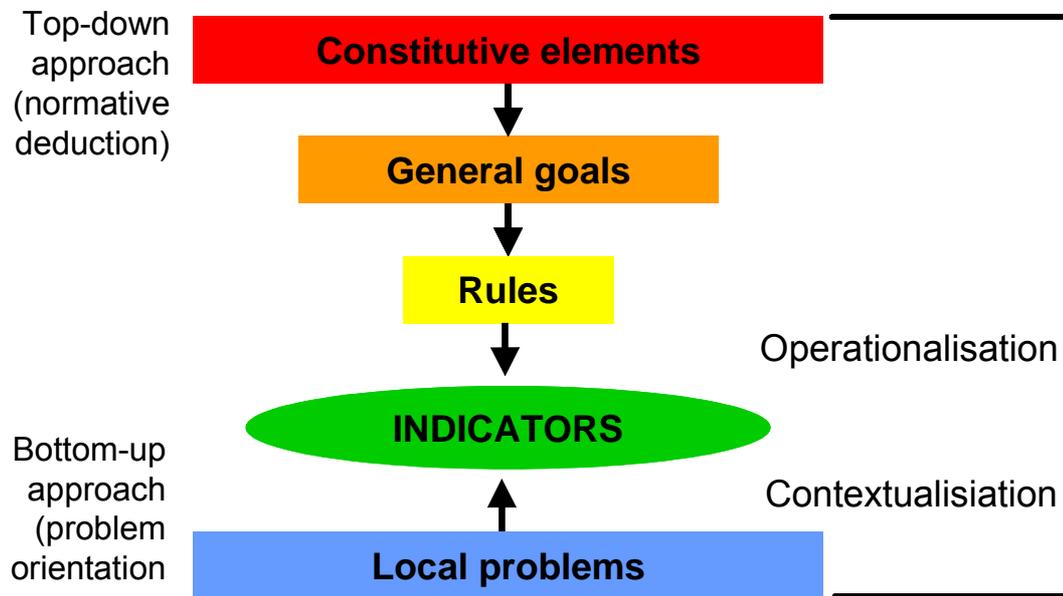


Figure 4: Architecture of the integrative concept

In recent years, several research groups have successfully applied the integrative concept to different topics in the German and European context (see Kopfmüller 2006). Given the integrative character of the research initiative, the concept provides a useful foundation for the concretization of the sustainable development Leitbild and for the intended analysis – a perception shared by the Chilean partners. Combining this concept appropriately with the concepts of Risk and Governance and applying the analytical framework to the seven fields of application are preconditions for the realization of integrative research as well as for the creation of appropriate orientation knowledge for decision-makers in the context of megacities.

The case of Latin America and Santiago de Chile

Although Latin America set a milestone at the first *Summit of the Americas* in 1996 in Santa Cruz, Bolivia, as the first region with a common presidential agreement on acting for sustainable development (OAS 2003), this goal has not yet been translated into political action. Despite several efforts, only first steps have been taken on the path to sustainable development. While many countries have undergone a process of economic reform directed towards liberalization of trade and national financial markets and the privatization of public services and social security systems, serious problems and challenges still exist. Poverty, income inequality, unemployment, insufficient housing, environmental degradation and health problems are the most urgent of these challenges (ECLAC/CEPAL/ UNEP 2002; ECLAC/CEPAL 2005; Reyes Paecke 2004). Structural economic change has led to a decline in the demand for low-skilled jobs, to increasing unemployment and informal employment, and to larger wage gaps between skilled and unskilled jobs (ECLAC/CEPAL 2004). Compared to other Latin American countries, Chile performs mostly in the upper third with

respect to these indicators (see ECLAC/CEPAL 2005b), but nevertheless faces substantial problems that call for political action.

As a result of this situation and unlike most industrialized countries, scientific and political debate on sustainable development in Latin America and the input of the region to the international debate has been characterized from the beginning by an emphasis on social and economic goals. Issues such as reduction of poverty, unemployment and particular inequalities, or education improvement are seen as both an ethical requirement and a key prerequisite for the reduction of environmental problems. This is reflected in the debate on sustainable urban development (ECLAC/CEPAL 2004). Taking these challenges seriously demands appropriate strategic and goal-oriented urban development planning.

In Chile, as in many other Latin American countries, the national government has not formulated a sustainable development strategy as yet, albeit the process is currently in progress. Neither is there an official sustainable development plan for Santiago de Chile. The situation there appears to be characterized by a specific combination of factors: on the one hand, far-reaching economic, structural and technological changes in the last decade, and on the other hand, ongoing serious problems – both typical scenarios for most Latin American cities – accompanied by the extremely ambitious goal of the regional administration to develop the region in the direction of top global ranking by 2010 (see Gobierno Regional 2005). Global competitiveness and improvement in quality of life are the two core prospects for future development. These goals are to be realized by exploiting the huge potential of the region and its inhabitants, its geographical advantages, and its position in the global network of cities, while at the same time reducing current weaknesses in terms of inequalities of income distribution, social segregation, perception of inadequate public security, low identification of people with the country, and insufficient access of the poor to education, public services and health care (Gobierno Regional 2005). Nonetheless, a genuinely integrated view of regional development, as recently highlighted by Chilean President Bachelet in her annual address, and truly strategic, goal-oriented sustainability planning is widely lacking. This is the case not least because of counterproductive competition between national institutions such as ministries, the regional government, and local administrations (Barton 2006).

Objectives and research questions

A core objective of the *Sustainable Development* research team will be to study and compare the several approaches to sustainable development found in Chile. Subsequently, it will be analysed how and to what extent these approaches fit into the integrative Helmholtz sustainability concept. Based on this, the research team will strive to develop and apply an analytical tool to assess the current sustainability performance of Santiago de Chile and other Latin American megacities, their future perspectives, and their options for political and societal action in the interests of greater sustainability.

Core questions are:

- (1) How can the integrative Helmholtz concept (i.e., the goals and indicators) be adjusted to local conditions, and thus become an appropriate tool for sustainability analysis in Santiago de Chile and other Latin American megacities?
- (2) How can the sustainability performance of the cities and their hinterland be evaluated? What are currently the most pressing sustainability problems and the main factors that cause them?

- (3) What will be the impact of alternative societal framework conditions on the future development of selected sustainability indicators? Are there indicators with current values in line with the requirements of sustainable development?
- (4) How should the common analytical framework of the research initiative be developed to cope in full with the scientific and political challenges associated with sustainable urban development in Latin American megacities?

In Chile, significant efforts are currently being made at both the national and regional level to elaborate sustainable development strategies. The initiative will strive to take part in these ongoing political and administrative processes and consultations. This involves interaction in two directions: the initiative will use documents and other products evolving from these processes for analytical purposes and, at the same time, provide as much input as possible to these processes, based on initiative results.

Activities and expected results

According to the basic structure of the initiative, work will be divided into four work packages, taking into account the particular requirements of close interlinkages to the other research teams in the initiative.

Work Package 1: Development of a tool for sustainability analysis

In a first step, a synopsis of existing approaches and strategies for sustainable development in Chile will be worked out, and differences to and compliances with the integrative Helmholtz concept identified. In a next step, the concept will be adapted to conditions in Santiago de Chile in cooperation with Chilean scientists and local political and administrative authorities. Based on the integrative concept, a comprehensive system of sustainability rules that will guide the future development of the city and serve as a set of assessment criteria will be elaborated. The core element of this process of adaptation is the development of an operable set of indicators, concretizing the rules for Santiago de Chile, both at the level of each field of application, in cooperation with the respective research teams, as well as beyond the scope of their work. This set of indicators will also be applicable to other Latin American megacities, and could include single indicators or certain aggregated indices such as “ecological footprint” or “genuine progress index”. Finally, quantitative targets will be determined for the indicators as far as possible (based on existing political decisions or current debates). These targets and corresponding timetables are essential for both the identification of “problem phenomena” and sufficient planning reliability for societal actors.

Work Package 2: Analysis

Based on the results of Work Package 1, using the common data pool mentioned in Chapter II., and in cooperation with the local stakeholders, the currently most pressing sustainability problems related to Santiago de Chile will be identified and analysed, making use above all of distance-to-target considerations. This will be carried out at the two levels mentioned above, in cooperation with the respective research teams. Analysis will focus on the main causes of problems, on the interrelations of certain problems, and, based on this, on megacity-typical problems (predominantly caused by the particular amount of urban agglomeration of capital, resources, societal activities, etc.), taking into account the perspectives of the relevant stakeholders. As far as possible, analysis of interrelations between the megacity area and the regional, national, continental or global level concerning sustainability goals and the causation of problems will be carried out.

Work Package 3: Concept development, integration of research and results

This work package involves 1) the development and specification of an operable conceptual framework based on the three cross-cutting concepts, 2) permanent conceptual and methodological support of the work in the fields of application in applying this framework, and 3) integration of the research results of the individual fields of application, e.g., integration of proposals for political measures into a consistent sustainable development strategy and a synthesis of risks and recommendations for their appropriate urban management (see Chapter II.6). During the preparatory phase of the initiative (October 2005 to March 2007), the consortium undertook a first step in the direction of an integrated conceptual framework with the formulation of core categories and aspects (“catalogue of issues”) to be studied in the fields of application. The research teams will refine this ‘proto-framework’ and develop it into an applicable conceptual tool to orient research in the fields of application. They will base the integration of the framework on the analytical linkages between the cross-cutting concepts. Examples are the specification of governance-related sustainability indicators (link between *Sustainable Development* and *Governance*) or the identification and analysis of the most pressing risks related to sustainable development.

Work Package 4: Scenario analysis

In the light of the increasing complexity of urban processes and the unpredictability of their future development, jointly elaborated and analysed scenarios are vital to project integration and strengthen the action orientation of research. This work package involves (1) the elaboration of framework scenarios characterized by alternative developments of basic societal framework conditions, and (2) the conceptual and methodological support of the research teams in the fields of application in applying these scenarios.

Taking the current state and visible trends as a starting point, the major driving forces likely to shape future development will be identified (e.g., globalization of economy, changing values and lifestyles, political participation etc.). This will be followed by the elaboration of alternative scenarios marked by different assumptions on the future direction and extent of these driving forces. Static and dynamic models for the metropolitan region of Santiago de Chile will be developed on this basis and allow for evaluation of the economic, social and environmental impacts of different paths of urban development. Direct and indirect effects on economic variables such as regional product and sectoral production, social variables such as poverty and income distribution, and environmental variables such as local and global air pollutants or discharges to water and soil will be assessed.

Methods, data requirements

The research work will be based on the review and evaluation of the relevant scientific literature and political documents as well as the application of quantitative and qualitative methods. The latter include distance-to-target evaluations, cross-impact analysis, scenario techniques, simulation models; expert and stakeholder interviews.

Involved Organizations and Key Scientists

- Forschungszentrum Karlsruhe, FZK ITAS:
Juliane Jörissen, Jürgen Kopfmüller, Volker Stelzer
- Universidad de Chile, UCH:
Raul O’Ryan
- Pontificia Universidad Católica de Chile, PUC:
Jonathan Barton, Sonja Reyes
- Economic Commission for Latin America and the Caribbean, ECLAC/CEPAL:
Jeanette Plaut

Preliminary Time Frame

Months						
	1-6	7-12	13-18	19-24	25-30	31-36
WP 1						
WP 2						
WP 3						
WP 4						

Resources (in person years, implementation phase 1)

Person Years (scientific staff) 2007-2010	Key scientists --- permanent staff---				Additional Resorces --- to be funded ---	
	FZK ITAS	PUC	UCH	ECLAC/ CEPAL	At Helmholtz	In Chile
	4.7					3

Additional resources will be allocated for travel, fieldwork, workshops and consumables.

2. Cross-cutting concept: Risk

Speakers: Christian Büscher, Forschungszentrum Karlsruhe; Raul O’Ryan, Universidad de Chile

Background

Risk is a recurring notion associated with urbanization in general and megacities in particular. The steady growth of cities is observed as a problematic process that generates threats to human life and health, and to protected goods.

Risk research is a heterogeneous field and, depending on the scientific discipline, consists of a wide array of definitions, theories and methods. Geography and hazard research, for example, have approached the question of what is at risk and who or what is generating risks with the focus on the relation of exposure and natural processes (Pelling 2003; Mitchell 1999a; Kraas 2003; Mansilla 2000). The insurance industry also showed an interest in assessing the risks of urbanization processes (Greiving 2002; Munich Re Group 2004). Common to these and other approaches is the use of the terms “risk”, “hazard” and (physical or social) “vulnerability”.

Cardona (2003) provides a comprehensive review of different concepts of hazard, vulnerability and risk concerning development in Latin America. He observed a shifting emphasis on risk research in recent years under two aspects. Firstly, risk assessment is now focusing on social and not merely physical vulnerability. Secondly, it pays added attention to *endogenous* risk factors, which relate the emergence of risk to societal development, organization and decision-making. In Cardona’s view, the problems of mega-urbanization not only relate to the exposure of property and human life to natural hazards or to the physical susceptibility of exposed elements. Rather, they connect to what he calls “social frailties”, i.e., economic and political factors, and “lack of development”. Cardona argues for an approach that seeks to integrate research of the natural and social sciences: “It should be founded on a theoretic basis of complexity that takes into account not only geological and structural variables, but also those of an economic, social, political and cultural nature. An approach of this type could assess ... the non-linear relations of the contextual parameters and the complexity and dynamics of social systems” (Cardona 2003, 15).

Box 3: Definitions of hazard, vulnerability and risk

- (1) Hazard: the probability of the occurrence of an event with certain intensity at a specific site and during a determined period of time (reference to the quality of the event as exogenous risk factor).
- (2) Vulnerability: physical, economic, political or social susceptibility or predisposition of a community, and potential damage in the case of a destabilizing phenomenon of natural or anthropogenic origin (reference to the quality of the exposed element as endogenous risk factor).
- (3) Risk: potential loss to the exposed subject or system, which is determined by the convolution of hazard and vulnerability.

Source: derived from Rowe 1977; Grünthal 1984; Cardona 2003

The sociology of risk describes risk as a genuine phenomenon of modern society. Beck (1986) sees the cause for the emergence of risks in processes of economic growth in the industrialized world and in the quality of hazard-prone technologies. A different analytical approach connects risks and dangers to the development of polycentric and functionally differentiated societies (Luhmann 1993, 36). Today’s observation of accelerating

organizational, scientific and technical development is both a driving force and a result of functional differentiation in society, because of the exclusive orientation of single systems (politics, economics, law, science, mass media etc.) to specific problems and the lack of consideration of other problems that are vital. The exclusive orientation of (global) economic operations to differences in market prices and their complete indifference to moral, environmental and sustainability issues is merely one example of this exclusive focus.

Processes of functional differentiation are not only found in the “centres of modernity”. Aldo Mascareño (2001) gives a detailed description of the shift from a concentric to a functionally differentiated order in Latin America, and provides insights into the differentiation of autonomous social systems and the problems of political steering then generally emerging. This has a tremendous impact on the level of urbanization. As simultaneously cause and effect of this development, megacities seem to be the “burning glass” of modernization. Despite an often precarious situation, they generate the expectation of boundless opportunities for all. This attraction intensifies rural-urban and intra-urban migration. In consequence, the pressure for adequate and functioning infrastructure, shelter, services, employment and nutrition intensifies (Mansilla 2000).

Under these conditions the social organization of cities becomes key. The reference is to the organization of the co-existence of people who do not know each other (Weber 1964) but still work together (in business, administration, science, art, law etc.), travel together (in a public transport system) and live together (in need of housing, nutrition, water supply, waste disposal etc.). Accordingly, every city must develop social arrangements in the pursuit of three basic objectives (Nassehi 2002):

- (1) The integration of different functional parts² of the city. This includes the integration of various organizational and technological systems as a condition for economic, political, administrative, legal or educational action and, at the same time, for the provision of resources (energy, nutrition and matter).
- (2) The synchronization of different functional parts in the city. This includes the synchronization of transport systems with work shifts and office hours, the daily supply of goods from all over the world, and the rhythm of work and leisure time.
- (3) The inclusion of city inhabitants in different functional parts. This includes the opportunity of all inhabitants to have legal rights (as citizens), to do business, to work, to enjoy security of tenure, to vote and to participate in education.

Those challenges and their solutions vary across the cities of the world. Megacities sometimes face specific difficulties in coping with functional needs. Furthermore, their regular mode of operation simultaneously produces risks that endanger their own survival: “A megacity is a prime example of such a critical stage of development: an organism with more than ten million living cells gradually risks being suffocated by the problems it has itself created – like traffic, environmental damage and crime” (Munich Re Group 2004, 1).

Research concept

The cross-cutting concept *Risk* aims to provide the “basis of complexity” (Cardona) for a broad assessment of risks and dangers in megacities. It likewise intends to analyse the causes of risks.

² By functional parts we understand all social arrangements that address or relate to basic urban issues, such as housing, nutrition, traffic, energy supply, education etc.

We will achieve this with four measures:

- a combination of risk research approaches from the natural, applied and social sciences
- a shift in perspective from hazardous events to the vulnerability of the exposed system megacity
- adjustment of the perspective on risks and dangers resulting from the interaction of social and socio-technical systems in the city
- the linking of mega-urban development to overall societal development in Latin America

With this approach we can supply orientation knowledge on urban development for the other two cross-cutting concepts and the seven fields of application. The approach of the natural and applied sciences will be used in the *Land use management* field of application.³ The goal here is to identify natural processes that occur in areas with human settlements and protected goods. By identifying the probability and magnitude of the occurrence of natural events and the vulnerability of the exposed inhabitants and goods, the research topic will attempt to gain further knowledge on how to manage land use and spatial expansion in hazard-prone areas. This addresses *exogenous* hazards and the societal management of those hazards.

Work on the cross-cutting concept *Risk* complements this approach by expanding the focus to the *endogenous* risk production of megacities. We align with the recent risk research in sociology and research on societal development in Latin America in general. Our aim is to gain a comprehensive understanding of the emergence of risks and dangers by focusing on systemic aspects of organization, networks, synchronization and the phenomenon of uneven inclusion (exclusion). Hence, it is our interest to complement the probabilistic risk assessment of natural hazards with the evaluation of systemic risks.⁴

Systemic risks are distinguished from individual risks through their relation to organizational decision-making and not to individual action. This does not exclude the fact that individuals take risks in pursuit of opportunities or that they are exposed, for example, to the dangers of natural hazards. We attempt to identify the risks that emerge from an aggregation of actions and decision-making in social or socio-technical systems. Systemic risks frequently emerge when systems of distinguishable kinds interact, closely coupled in a non-linear way (Perrow 1984). The latter can be identified as social systems (functional systems, organizations) and socio-technical systems (traffic, for example, as a set of rules and technical artefacts in a limited space).

It is our hypothesis that mega-urbanization intensifies the critical interaction of such systems and leads to a significant endangerment of the function of single systems and the entity megacity itself. It includes the well-known phenomenon that social systems produce risks for other parts of society by operating in "regular mode", i.e., in their pursuit of system-related goals and rationalities (and not society-wide, collective rationalities). The emergence of risks in megacities is thus not an anomaly or deviation of an otherwise well-known ideal mode that has merely been ignored. The regular mode of social systems is related to the pursuit of "limitless" economic, political, scientific and cultural opportunities in megacities, and implies the immense exposure of human beings and goods to systemic risks.

Based on this understanding, we focus on distinctive mechanisms of risk production in megacities, including the mutual enhancement of development and endangerment. We adopt four distinctive mechanisms brought forward in the risk literature:

³ With reference to probabilistic risk research on seismic hazards (Grünthal 1984, 171): Risk (the summarized expected loss) as a function of hazard (H) and vulnerability (V).

⁴ See also OECD 2003, 30ff.

(i) Attraction/ exposure: The need to provide goods and services in a city to make it “liveable” for inhabitants is related to economic growth, and, at the same time, also to political, administrative, legal etc. differentiation. Depending on the “success” of providing the essentials for a liveable city, the city will attract more and more people from the rural areas, which leads potentially to more migration. This in turn leads to urban growth, resulting in a vast accumulation of human beings, economic values, basic infrastructure and governmental institutions within a limited space. Under these conditions natural hazards present a huge threat to key elements that are crucial to the sustainment of megacities. Because the probability of natural events occurring is “predictable” but not controllable, risk management must find ways to reduce exposure. Work on the *Land use management* field of application addresses this aspect.

(ii) Coordination/ synchronization: The development of numerous socio-technical systems in a limited space and the various forms of interaction (analysed along the variables loose/ tight coupling and linear/ non-linear interaction) lead in general to growing uncertainties about their dependability, controllability and the possibility of severe accidents. The *Transportation, Waste management, Energy system, Air quality and health* and *Water resources and services* fields of application generate a better understanding of the function of each of these essential infrastructural systems, particularly the aspect of risk emergence due to their susceptibility to failure and the error propagation of closely coupled socio-technical systems.

(iii) Urban/ rural: The increased use of natural resources, especially those from the surrounding rural areas, is indispensable to the existence of megacities. By overusing these resources, megacities destroy their own “grass roots”. Likewise, the consequence of growth and the exploitation of natural resources is a greater need for the disposal of outputs. As a result of excessive emission of waste, a product of the megacity’s metabolism, this need leads to rapid deterioration of the natural surroundings. Rural/ urban relationships will be addressed in particular in the *Waste management, Energy system, Air quality* and *Water resources and services* fields of application.

(iv) Inclusion/ exclusion: The inclusion of the majority of the population in economics, politics, law, education, art and mass media is a prerequisite for the existence of every city. The goal of a complete inclusion is addressed to the welfare state, which generates social transfer programmes. The limits of such programmes are visible all over the world and demonstrate that inclusion produces its counter effects: the exclusion of certain parts of the population from participating in outputs from the functional differentiated systems of society. Due to the absence of any kind of security (legal, social, technical), those who are excluded become more and more “vulnerable” to natural hazards and technical or organizational failures, and are therefore less and less able to develop “resilience” to these threats. These phenomena are particularly pronounced in mature Latin American megacities and will be addressed in the *Socio-spatial differentiation* field of application.

Objectives and research questions

The priority of our research on megacities is to identify and describe the main mechanisms of risk production in megacities, both exogenous and endogenous. Research on exogenous hazards will be carried out in the *Land use management* field of application and later integrated in the cross-cutting concept *Risk*.

Systemic risk research concentrates on identifying the conditions (generated by the cities themselves) for the possibility (it may or may not happen) of a self-endangering of megacities (manifested in the form of significant hazards or crisis situations). A systemic risk assessment must therefore describe the factors that enable or favour urban development (attraction, coordination and synchronization, natural resources from rural surroundings, inclusion) and the counter effects this development produces (exposure to natural hazards, close and linear interaction leading to accidents, overuse and natural degradation, exclusion), which could lead to the malfunction of cities and to crisis situations and heavy loss. Through the analysis of these mechanisms in general in the cross-cutting concept *Risk* and in the various fields of application in particular, we expect to gain a greater understanding of the relation between societal (differentiation) and urban development (integration and densification), and will attempt to describe megacities as a form of social order that is inherently precarious.

Risk Habitat Megacity provides the opportunity of testing the research findings on Santiago de Chile with the expertise of local scientists and stakeholders, and the detailed knowledge generated by in-depth studies conducted by the research teams in the fields of application. In addition, the cross-cutting concept *Risk* supplies orientation knowledge for governance and sustainability measures.

Activities and expected results

Work Package 1: Concept development, integration of research and results

see *Sustainable Development*, Work Package 3

Work Package 2: Scenario analysis

see *Sustainable Development*, Work Package 4

Work Package 3: Theoretical and conceptional work

The first step consists of theoretical work on the notion of city, its functional needs, and functional differentiation in Latin America. The second step is to formulate the above-stated mechanisms in detail (labelled with the distinctions attraction/ exposure, coordination/ synchronization, urban/ rural and inclusion/ exclusion) and to derive questions that qualify the development of cities in relation to the attributes mega and risk.

Work Package 4: Developing a heuristic framework for qualitative risk assessment

Based on the knowledge gained in Work Package 3, a heuristic as a set of qualitative statements will be developed to assess the mode in which megacities can be described with regard to risk. Santiago de Chile is the opportunity to test such a heuristic.

Work Package 5: Conceptual and analytical guidance/support for fields of application

Based on the findings of Work Package 3, the cross-cutting concept will offer conceptual and analytical guidance for the fields of application dealing with risk issues. This includes the moderation of discussions on risk issues, as well as terminological clarifications and support in relation to the re-interpretation of collected data from the system risk perspective. We intend to introduce a mediawiki (most prominent example: wikipedia) as an information and discussion platform to guarantee permanent access and availability for all research partners. This will be achieved with the research initiative's domain www.risk-habitat-megacity.org.

Work Package 6: Systemic risk assessment for Santiago de Chile

Once the general work has been carried out, we will take a thorough look at the research object. In mutual exchange with the fields of application we will attempt to reconcile the findings of the previous work packages with our research object Santiago de Chile. In order to gain a qualified assessment of the key processes of risk generation in Santiago de Chile, a structured compendium for expert interviews will be developed using the results of the Work Package 3.

Methods, data requirements

In the cross-cutting concept *Risk*, we follow a deductive approach based on theoretical work in formulating our theses, and validate them with text analysis, expert interviews and the integration of research results from the fields of application.

Involved organizations and key scientists

- Forschungszentrum Karlsruhe, FZK ITAS:
Gotthard Bechmann, Christian Büscher, Armin Grunwald, Helmut Lehn
- Universidad de Chile, UCH:
Raul O’Ryan
- Pontificia Universidad Católica de Chile, PUC:
Sonja Reyes, Claudia Rodríguez Seeger

Other collaborating partners:

- Universidad Alberto Hurtado, Santiago de Chile:
Aldo Mascareño

Preliminary Time Frame

	Months					
	1-6	7-12	13-18	19-24	25-30	31-36
WP 1						
WP 2						
WP 3						
WP 4						
WP 5						
WP 6						

Resources (in person years, implementation phase 1)

Person Years (scientific staff) 2007-2010	Key scientists --- permanent staff ---			Additional resources --- to be funded ---	
	FZK ITAS	PUC	UCH	At Helmholtz	In Chile
	3	0.4	0.2	3	3

Additional resources will be allocated for travel, fieldwork, workshops and consumables.

3. Cross-cutting concept: Governance

*Speakers: Henning Nuissl, Helmholtz Centre for Environmental Research – UFZ;
Claudia Rodriguez Seeger, Pontificia Universidad Católica de Chile*

Background

In order to tackle and resolve sustainability deficits and related risks in urban areas, we need to take into account by whom, how, and along which institutional lines political decisions are made and public affairs managed. If these governance issues are not considered, the strategies for sustainable urban development and mitigation of risks are likely to fail for two reasons. Firstly, it would be impossible to gear these strategies to the respective context of implementation; secondly, they would ignore an important source of problems, since governance structures can aggravate or even trigger the several risks present in megacities.

Almost all Latin American countries have embarked on a process of profound democratization in the last twenty years. Re-organization and transformation of public decision-making procedures, including the reformulation of the relationship between the state, civil society and the private sector, have been at the heart of this process. However, governance structures still seem inadequate to meet the significant challenges the continent's large agglomerations are facing (De Mattos et al. 2005). This also holds true for Santiago de Chile (Rodriguez 1999), although the Chilean capital comes nearest of all Latin American metropolises to matching the principles of "good metropolitan governance" (Ward 1996). There are at least four major issues and challenges of urban governance in Latin America that deserve – and receive in the literature – particular attention: (i) decentralization, (ii) privatization, (iii) participation and (iv) informality.

(i) Within the last twenty years, Latin American countries have been striving to overcome their extreme degree of centralization (Finot 2002) and have made *decentralization*, the transfer of power away from the central state level, a major policy goal. Decentralization can take quite different forms, depending on to whom authority is being conveyed and to what extent. It can either consist in the mere assignment of responsibility to lower levels of administration (deconcentration) or semi-private entities (delegation) or a fully-fledged transfer of powers to politically independent regional or local authorities (devolution) (Litvack et al. 1998).⁵ Moreover, the process of metropolization also calls for new political and administrative structures (Rodriguez/ Winchester 1999), with the establishment of metropolitan authority as one of the major issues throughout the continent's big cities (e.g., Sharpe 1995).

In Chile, decentralization policies meet considerable opposition for several reasons (Rodriguez Seeger, Ducci in press). Another impediment to the implementation of such policies is the political and administrative fragmentation of the Santiago de Chile Metropolitan Region. The Chilean capital consists of thirty-four independent communes, with a plethora of political authorities in charge of local government and the delivery of public services. Furthermore, entities and representatives of national ministries and institutions also intercede in the process of urban and regional development. In general, there is a considerable lack of coordination and frequently of trust between these diverse governmental actors. Valenzuela (1999, 17) gives a succinct description of this situation, referring to Santiago de Chile as the "victim" of a still over-centralized state.

⁵ It is important to note here that the Spanish translation of terms related to the issue of decentralization can deviate from their meaning in the English language (Rodriguez Seeger 1995, 2ff.).

(ii) *Privatization* is a leading paradigm of governmental policies in Latin America and strongly affects the governance of megacities in at least two respects. Firstly, whilst the provision of infrastructure and services by private companies has often led to the expected increase in efficiency and (occasionally) quality, it also bears risks with regard to the security of supplies, failure of technical systems, and accessibility of basic services for the poorer sections of the population. Secondly, far-reaching decisions with regard to urban development are left for the most part to the private sector; it is the independent choice of private investors as to where, when and how much to invest in development projects that largely determine the spatial, functional, economic and social patterns of the Latin American city. Therefore, the problem of “state-centredness” is often of minor importance to the governance of Latin American megacities, whereas the question of how the required amount of public control of common affairs can be achieved appears crucial.

The private sector plays a decisive role in Chile and maintained this role during the recent process of political transformation. On the remote fringes of Santiago de Chile, for instance, massive areas under development are fuelling urban sprawl and social disintegration, and the excessive power of private investors in the entire process of “city building” are beginning to cause concern (e.g., Borsdorf/ Hidalgo 2004; Cáceres/ Sabatini 2004). While developments of this kind are certainly detrimental to the chances for public participation, it is also arguable whether they could be reconciled with other goals of sustainable urban development.

(iii) *Civic participation* is not only a vital element of democratization. Participation also enhances the quality of urban policies, since non-governmental organizations and citizens have knowledge, competences and capacities that could contribute to the political process. In addition, the involvement of these actors helps to gear public decisions to local requirements and peculiarities. Both aspects are crucial to the (pre-emptive) reduction of human exposure to different kinds of risks (Sabatini et al. 2000). However, opinions are mixed on the success of recent efforts in Latin America to support public participation. Moreover, strategies that aim at strengthening civic participation must also at the same time address the socio-economic conditions of those who are to participate, as people can only engage in participatory processes if their basic needs have been met (Sabatini/ Wormald 2004).

In Chile, after the re-establishment of democracy in 1990, the once significant influence of civil society has begun to gather fresh momentum, albeit incrementally. Likewise, linkages between civil society and the private sector are still weak. On the other hand, asymmetric political power structures and the lack of political instruments in favour of civic participation provide for the “over-representation” of certain interests compared to others (e.g., Reyes 2004a). In terms of participation, these deficits are deemed the cause for the relatively low satisfaction of the inhabitants of Santiago de Chile with living conditions and urban policy in their city (De Mattos et al. 2004).

(iv) In Latin America publicly relevant affairs are often dealt with beyond the “official” sphere of administration and decision-making – with considerable regional differences, of course. For instance, the provision of housing and energy to the poor relies for the most part on forms of “self-organization”. In the more affluent countries such as Chile, however, the issue of *informality* is predominantly related to privatization, since activities in the private sector are rarely subject to public regulation. These types of informality do not necessarily mean that the activities are illegal. Nevertheless, they do raise considerable concern regarding property rights, security of tenure and legitimacy of urban development processes in general.

It is primarily the second type of informality, i.e., lack of public control of the private sector, that challenges urban governance in Santiago de Chile. However, we also find residua of an informal mode of regulation of public affairs in Santiago de Chile. The traditional system of public transport is an interesting case in point.

The proposed concept and research approach

The international political science discourse discussed the problem of managing publicly relevant affairs under the heading of governance for quite some time (e.g. Kooiman 1993). The term governance, i.e., “gobernanza”, has also been adopted by the Hispanic academic community, with both terms covering the same (wide) array of meanings and connotations, to be distinguished along two dimensions:

- (1) Different notions of governance vary with respect to how they are distinguished from the concept of government. On the one hand, the general mode of decision-making on publicly relevant affairs prevailing in a particular context can be labelled governance (e.g., McCarney et al. 1998). On the other hand, a more specific notion of governance implies that both civil society and the private sector have an influence on public affairs that is stronger than in the case of “ordinary” government (cf. Rodriguez, Winchester 1998; De Mattos 2005).
- (2) Governance can either denote an analytical or a normative concept (cf. Rodriguez, Winchester 1998; Balbis 2001). The UN has defined standards of “good governance” (World Bank 1992; United Nations High Commissioner for Human Rights 2000), which have also been translated to the local level, as criteria for the appropriate management of public affairs in cities and regions (Centre for Democracy and Governance 1998; TUGI 1999; UN Habitat 2004b)

With regard to these criteria, we adopt a notion of governance that, firstly, covers all spheres of decision-making on publicly relevant affairs (thus authorizing the subsuming of “execution of government” under the concept of governance) and, secondly, that is strictly analytical. This broad notion of governance allows for the variety of actual governance constellations and issues in Latin American megacities and is thus deemed appropriate for the scientific purposes of *Risk Habitat Megacity*. On the basis of a review of (empirical) literature on urban governance during the preparatory phase of *Risk Habitat Megacity*, and leaning in particular on the work of Patsy Healey (1996; 1997) and others (Healey et al. 1996; 2002), we have sketched out a heuristic categorial framework for empirical investigation of governance issues (Nuissl/Heinrichs 2006).

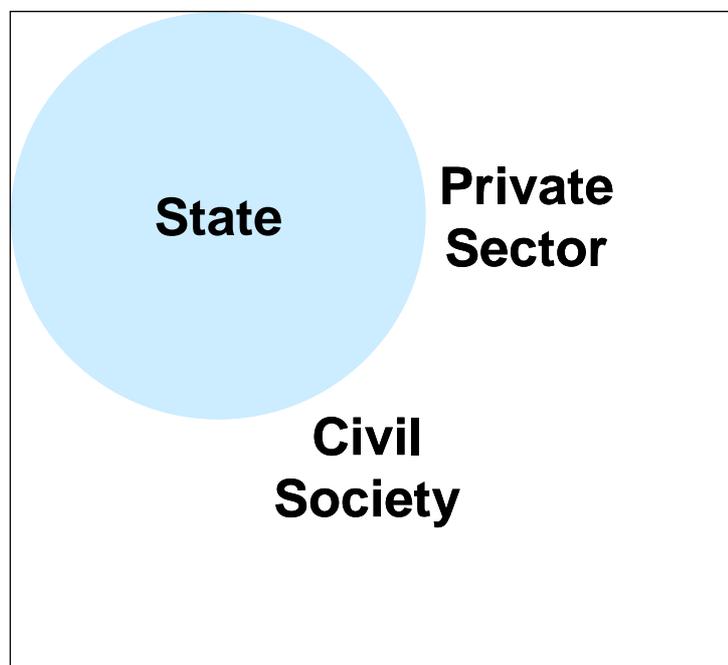


Figure 5: The three actors of governance

Objectives and research questions

The research will investigate the salient problems of urban governance in the case study region and aims at two overarching goals:

- to facilitate the implementation of strategies for sustainable urban development by clarifying the framework conditions set by existing governance structures
- to figure out in how far existing governance structures enhance certain risks and impede the attainment of sustainability goals, and to use the findings of Risk Habitat Megacity in order to support the improvement of governance performance

In more detail, the focus of research will be set along the lines of the four key issues of governance introduced above: decentralization, participation, privatization and informality. By relating research to these crucial aspects, it is our intention to supply the empirical research streams with background knowledge that supports their orientation towards application, thereby providing for the action orientation of the entire research initiative. Furthermore, we will also strive for general recommendations on the modification and amendment of governance structures.

Activities and expected results

Research on governance will be organized in six work packages. Work Packages 1 and 2 primarily focus on cooperation between the topics and will thus provide for overall integration of the research initiative. Work Packages 3 to 6 are dedicated to the exploration of the issues of decentralization, participation, privatization, and informality respectively. These work packages will be designed to produce general results that can be transferred to other policy fields and other megacities.

Work Package 1: Concept development, integration of research and results

see *Sustainable Development*, Work Package 3

Work Package 2: Scenario analysis

see *Sustainable Development*, Work Package 4

Work Package 3: Megacity governance in the light of decentralization

The lasting influence of the Chilean national government on local affairs and Santiago's fragmented administrative structure both constitute a major challenge for the definition and implementation of the urban policies at different levels ("multi-level governance") that allow for the complex needs of and interdependent processes in megacities. This challenge is currently not being adequately met, as evidenced, for instance, in the lack of coordination in the development of land use. The work package will explore the potential of compensating these governance deficits with decentralization strategies, such as the installation of consultative bodies or the delegation of public duties to semi-private bodies with metropolitan-wide responsibility. Provision has been made for analysis in the field of transport policy and planning, in close collaboration with the *Transportation* research team. The exploratory analysis of governance problems in the field of public transport ("Transantiago") carried out in the research initiative's preparatory phase (Schulz 2006) revealed that these problems could probably be overcome by some form of decentralization.

Work Package 4: Public-private interplay and “city-building” on the urban fringe

In Latin America, the paramount influence of the private sector on urban development becomes tangible on the urban fringes, where huge gated communities and private estates are under development. In addition, the state’s recent retreat from housing policy has given leeway to private activities. Against this background, the question emerges as to how a certain level of participation in urban governance by both civil society and the state can be guaranteed. If urban development is to be geared towards sustainability, participation is crucial. The work package explores the opportunities and strategies to get a grip on urban development processes that are largely driven by the private sector. The research will be carried out in close connection to Work Packages 1 and 3 on socio-spatial differentiation. While the focus in those work packages will be on studying and understanding the mechanisms and effects of “private city-building”, here particular concern will be awarded to potential strategies to enhance the participation of non-economic actors in, and their influence on urban development.

Work Package 5: Privatization – quality and governability of infrastructural services

The quality of infrastructures and services is fairly good in Chile compared to other countries in Latin America. However, there are instances of inadequate provision and/ or maintenance of privately organized infrastructures and services in Santiago de Chile. The field of water supply and disposal is a prominent case in point here. It serves as an empirical example of what this work package will investigate, i.e., whether, and under what conditions, private companies can, and will, provide infrastructures and services of the standard required from a sustainability and risk avoidance point of view. This question leads directly to the consideration of both the economic instruments to be employed and the state regulatory measures to be undertaken in order to steer activities of market-oriented actors in the desired direction. The research will be coordinated with Work Package 1 of the *Water resources and services* research team.

Work Package 6: Government and informality in Latin American megacity governance

Whereas urban development in Santiago de Chile is mainly organized by formal land and housing markets and regulated by the planning system, this is far less true of other Latin American megacities. Most of these cities are characterized by extensive processes of informal urbanization, thus raising doubts with regard to the applicability and implementation of governance strategies and instruments. In order to ascertain the transferability of research and to prepare implementation phase 2, an understanding of the relationship between formal systems of governance and informal modes of urbanization is therefore crucial. This work package is directed at elaborating the conditions and impacts of informal urbanization and on discussing the transferability of policy recommendations.

Methods, data requirements

The pursuit of research on governance is dependent on the progress of research on the fields of application, which provides the empirical material for the study of governance issues. Most of the work on governance will be conceptual and theoretical, and involves intense communication with the other research teams involved in *Risk Habitat Megacity*. In particular, the in-depth-studies carried out in Work Packages 3 to 5 will include empirical fieldwork to be carried out in close cooperation with the research teams in the respective fields of application. The fieldwork, however, will not be carried out deductively along the

lines of an elaborated theory but rather in an explorative way, so as to remain receptive to the actual problems encountered in the examined policy fields.

Involved organizations and key scientists

- Helmholtz Centre for Environmental Research – UFZ:
Matthias Bernt, Dirk Heinrichs, Henning Nuißl, Heidi Wittmer
- Pontificia Universidad Católica de Chile, PUC:
Jonathan Barton, Carlos de Mattos, María Elena Ducci, Oscar Figueroa, Arturo Orellana, Sonya Reyes, Claudia Rodriguez Seeger, Francisco Sabatini, Carmen Schlotfeldt
- Economic Commission for Latin America and the Caribbean (ECLAC/CEPAL):
Ricardo Jordán, Jeanette Plaut, Joseluis Samaniego

Other collaborating partners:

- Gobierno Regional Metropolitana:
Ana María Silva
- SUR – Corporación de Estudios Sociales y Educación:
Alfredo Rodriguez

The involved scientists are engaged in several international networks for research and/ or improvement of urban governance.

Preliminary Time Frame

Months						
	1-6	7-12	13-18	19-24	25-30	31-36
WP 1						
WP 2						
WP 3						
WP 4						
WP 5						
WP 6						

Resources (in person years, implementation phase 1)

Work Packages 1 and 2 will be delivered for the most part by the key scientists. The accomplishment of Work Packages 3 to 6 requires the employment of additional staff, who will also contribute to Work Packages 1 and 2, so as to ensure the integration of different aspects of governance.

Person Years (scientific staff) 2007-2010	Key scientists ---permanent staff ---			Additional Resources --- to be funded ---	
	UFZ	PUC	ECLAC/ CEPAL	At Helmholtz	In Chile
	3	0.8	0.2	3	3

Additional resources will be allocated for travel, fieldwork, workshops and consumables.

Fields of application

Land use management, Socio-spatial differentiation, Energy system, Transportation, Air quality and health, Water resources and services and Waste management are highly relevant topics in the context of megacity development. In the *Risk Habitat Megacity* research initiative, they are the specific fields of application.

Within the common conceptual framework provided by the cross-cutting concepts, the research in each field of application primarily pursues topic-specific questions and work packages. To deepen integration, research teams from the different fields of application work together on several common problems and/ or base their analysis on the findings in other fields of application. These joint activities in the fields of application and the corresponding focus of work are shown in Appendix IV.

Towards the end of the first, three-year phase, the research teams in all of the fields of application will work jointly with the cross-cutting concept research teams on two tasks: the adjustment and integration of findings and the preparation for transfer of the analytical framework and results of the *Risk Habitat Megacity* research initiative to other Latin American megacities. The previous text on the cross-cutting concepts has described the corresponding work.

The following description of the seven fields of application outlines the work programme. The text provides background information on the state of development in Latin American megacities concerning the relevant issues. It states objectives and research questions, describes work packages, and specifies methods and data requirements. In a final section, it lists the resources, and the key scientists and organizations involved.

4. Land use management

Speakers: Ulrike Weiland, Helmholtz Centre for Environmental Research – UFZ; Jochen Zschau, GeoForschungsZentrum Potsdam; Sonia Reyes Paecke, Pontificia Universidad Católica de Chile

Background

Similar to other metropolitan areas, Santiago is undergoing a rapid process of urbanization with changes in land use and urban morphology. Planned and informal expansion reduces valuable open space and soils, and increases impervious surfaces. Large cities will always face natural hazards, which only become risks or disasters when lives and livelihood are endangered. So risks are often the result of inadequate social or human practices associated with the complex natural setting and cause accumulated social and physical vulnerability (Brauch 2005; Winchester 2005). Due to the tectonic situation, large earthquakes are a frequent phenomenon. The amplification of ground motion over the sedimentary basin can increase their damage potential. The urban environment is also vulnerable to flooding and landslide risks. Their scale and complexity has a damage potential for humans, buildings and infrastructure with far-reaching socio-economic consequences. In addition, these risks modify the natural environment which leads to a loss of biodiversity. Building activities on the peri-urban piedmont and the clearing of avalanche forests in mountain regions has begun to affect a growing number of people.

Risk analysis and risk prevention of these natural hazards are major challenges, as the areas prone to risks vary and overlay with respect to spatial extent, time, and social groups (Borsdorf et al. 2002). Dynamic risk management knowledge of vulnerable groups is a prerequisite for the elaboration of adequate risk management procedures. Because “disasters are socio-environmental by nature and their occurrence is the result of socially created risk” (...) “society must embark on a decision-making process to reduce the risk of disaster” (Cardona 2005, 1). In the metropolitan region of Santiago de Chile, land use management is organized by a multitude of administrative units at different levels. Instruments such as the Plan Regulador Metropolitano or the Plan Nacional de Protección Civil (ONEMI 2002) and the results of the research project on risks in the metropolitan region (OTAS 2002; Rossetti 2000) will allow for an integrated and/ or sustainable urban development. The collaboration of various administrative bodies with numerous community-based organizations and local NGOs engaged in urban development is crucial to the dissemination of information on risks and the reduction of these risks in a move towards sustainable urban development.

Objectives and research questions

The overall objective of the *Land use management* field of application is to formulate and implement intervention strategies that will lead to the reduction of physical and social vulnerabilities with respect to the above-mentioned risks. These strategies are based on a system approach that takes into account the linkages between the environmental, economic and social dimensions of development and the identification of diverse risk scenarios facing urban morphology (Banzhaf/ Martini 2006). Close cooperation with the *Social-spatial differentiation* and *Transportation* fields of application is essential.

One main objective is to analyse dynamic land use patterns on different scales. The enhanced land cover/ land use analysis will contribute to hazard zoning and disaster damage mapping (e.g., earthquakes, flooding, landslides), as well as to disaster reaction activities.

Another objective is research on risk analysis, which should be undertaken individually for each risk associated with the megacity. Exposed areas where several risks co-occur will be detected. The interaction between an existing natural risk and a specific land use type that amplifies the risk will be investigated.

Furthermore, it is assumed that sustainable urban development implies comprehensive risk prevention, including strategies to minimize vulnerability and increase resilience (Gudiño/Reyes 2005; UNDP 2004). Existing risk management approaches and the available land use management instruments and procedures will be analysed and amended. Hence, recommendations for risk prevention will be elaborated on the basis of adequate land use management in the interests of sustainable urban development. Sustainability indicators, embedded in a management cycle, will be developed, and will serve as monitoring and steering instruments for sustainable urban development (Weiland 2001; 2006). The investigations will be carried out on different scales encompassing site characteristics, local districts, the entire city, and the metropolitan region.

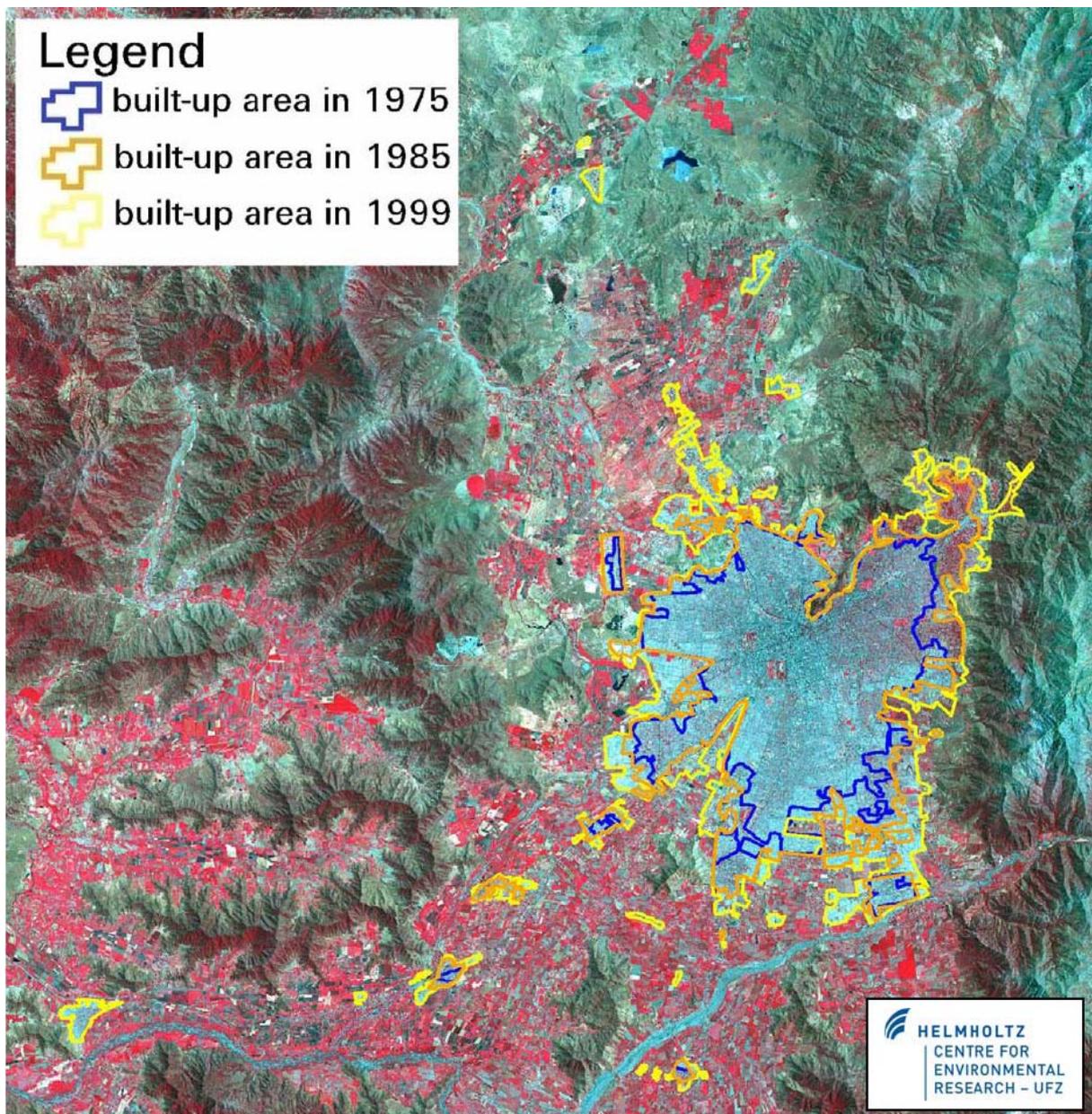


Figure 6: Expansion of built-up area in Santiago de Chile

The following questions will be explored for megacities in phase 1:

- (1) Where and how do types of land use and land use change modify metropolitan areas, and to what extent does this comply with recent models of Latin American cities?
- (2) Which urban structure types can be distinguished, and what is the relation between their characteristics and the respective level of vulnerability or resilience to natural risks?
- (3) Which risk-prone areas can be identified in the context of the predominant risks in Santiago de Chile (earthquakes, flooding and landslides)?
- (4) Which indicators are useful for urban and peri-urban land use management in relation to sustainability?
- (5) Which risk assessment and monitoring methods are useful for single and multiple risks?
- (6) How adequate are the existing land use planning and risk management approaches to the relevant governance structures; to what extent do they contribute to sustainable urban development?

To prepare the expansion of the research area to other Latin American megacities, methods and indicators that render the solutions developed for Santiago de Chile transferable will be analysed at the end of phase 1.

Beyond phase 1, several research tasks will be followed-up in phase 2:

- generation of a scenario simulation tool based on land use and risk monitoring for sustainable urban development. The relevance and applicability of the MUSSA (Modelo de Uso de Suelo de Santiago) land use model will be tested with respect to the risks under investigation
- application and adjustment of the phase 1 methodology to other Latin American megacities with regard to risks occurring in Santiago de Chile. Further risks will be taken into consideration.
- drawing up of transferable strategies for the integration of land use management in megacities

Activities and expected results

The research structure and research subjects of this topic, and the three cross-cutting concepts *Sustainable Development*, *Risk* and *Governance* are intertwined. Research activities will be organized in five work Packages, indicating the stepwise research agenda.

Work Package 1: Development of indicators

In general terms, indicators are parameters that describe situations or circumstances not immediately ascertainable either quantitatively or qualitatively. Sustainability indicators help to support communication in the field of sustainable urban development, or allow for comparisons. A challenging new use of sustainability indicators is steering towards a sustainability that includes higher resilience and less vulnerability. For this purpose the indicators need to be integrated in a management cycle and to refer to the objectives of sustainable urban development. In the *Land use management* field of application, indicators will be elaborated to assess the extent to which land use and risk management tools and procedures contribute to sustainable urban development.

The listed indicators will cover the following issues, for which quantitative indicators of the urban physis will be derived from remote sensing data and Geographic Information System (GIS) analysis:

- land use and land change over space and time (settlement density, detection of derelict urban land, imperviousness of soils, inventory of urban green spaces, and urban growth and its speed, dynamics and direction)
- urban morphology (urban structure types, especially building structures, height and density, and open spaces)
- natural resources and green spaces (pervious and impervious surfaces, i.e., seeping water rate/ soil capacity of pervious soils, surface run-off of impervious areas, location of derelict land and its spatial distribution as a potential for redevelopment or open space, and the network of green spaces relevant to urban biodiversity).
- social resources in the form of green spaces (parks, sports grounds with greenery, community gardens, cemeteries, and floodplains, as well as protected areas and their access and proximity to residential areas).
- risk indicators (with the focus on land use change in areas prone to natural risks).

Work Package 2: Analysis of land cover/ land use change

The inventory of actual land cover/ land use and the corresponding changes in Santiago de Chile will be analysed on the basis of the set of indicators developed in Work Package 1. Information gained from inventory and monitoring helps to analyse the different risks and to overlay land use data and the spatial expansion of risk-prone areas. These results are key for the other work packages and fields of application:

- the *Social-spatial differentiation* field of application will be vital for *Land use management* in terms of information on demographic and social development, and their dynamics and patterns. From the *Land use management* field of application, this topic needs data on land use and its change, especially urban structure and its pattern, concentration and direction of development
- the *Transportation* field of application will be significant for *Land use management* in terms of arterial roads and other infrastructural information, including high-traffic roads in the context of risks. *Transportation* requires information on the urban fabric from *Land use management*. The special interest is on urban structure and density with respect to distribution and concentration of commercial/ industrial sites, major shopping centres, residential areas, and the adjacency to open spaces and parks
- the *Water resources and services* field of application requires differentiated information on land use from *Land use management*, while the former will deliver data on ground water recharge and surface water routes to *Land use management*

Work Package 3: Status-quo analysis of land use management systems

In this work package, existing land use management and risk management systems will be analysed with regard to steering efficacy and efficiency towards sustainable urban development.

Based on information gained during the *International Decade for Natural Disaster Reduction* (see Elo et al. 1995), the UN Habitat *Disaster Management Programme* (UN Habitat 2006b), and knowledge elaborated by the United Nations University (e.g., Birkmann 2006), an analysis will be undertaken of existing models at the interface of society and nature (e.g., Borsdorf/ Hidalgo 2005; Wisner et al. 2004), risk governance approaches (e.g., International Risk Governance Council 2005) and risk assessment methods useful for urban planning (e.g., Mardones/ Vidal 2005) with respect to their applicability to megacities. The results will indicate whether, and if so where, risk management is feasible in land use management.

The results of the *Initiative on Hazard Reduction and Response in Metropolitan Regions* will be analysed in relation to their transferability to Santiago de Chile (Comfort 2003); the research will also focus on the differentiated vulnerability of cities, their relation to disasters, and their resilience (e.g., Pelling 2003; Godschalk 2003).

Work Package 4: Risk analysis

In Work Package 4, selected risks amplified by human activity and its consequences are investigated in and exemplified by Santiago de Chile. As a prerequisite, information from Work Packages 1 and 2 will be integrated. Resource constraints lead to focusing the investigation on two natural risks only.

(i) Earthquakes

Many of the megacities located in tectonically active regions are threatened by large earthquakes. Moreover, urban areas often expand over sedimentary basins, where strong amplification of ground motion can heighten the damage potential of earthquakes (Ansal 2004). Both issues apply to Santiago de Chile (Gardi et al. 2006). Our pursued research objective in the frame of the research initiative is to evaluate the performance of different tools for reliable ground motion scenarios, especially with regard to the high development dynamics of the megacity. This includes the study of local effects as a result of variations in ground motion over short distances, and the survey of specific sites relevant to managing an urban area (e.g., lifelines, critical facilities, hospitals, schools, expansion areas etc.). The most appropriate tool for risk calculation of dynamically expanding megacities will be selected and applied.

Several steps are necessary in carrying out the study:

- (1) A regional earthquake study will be conducted to identify the seismogenic structures likely to generate the most hazardous seismic scenarios. Instrumental and historical seismicity catalogues provided by the Chilean partners will be analysed for this purpose (Wiemer/ Wyss 2002)
- (2) A collection and revision of relevant data (geophysical, geotechnical, geological) for the sites under investigation will be performed.
- (3) An input model for the ground motion scenario will be created, using data from (2.).
- (4) Additional measurements will be carried out at selected sites (Chilean-French-GFZ collaboration).
- (5) Several simulation techniques will be tested, and the influence of the different model input parameters on the final results assessed. This allows for evaluating the sensitivity of the scenarios, and will guide the choice of best practice to be pursued. Recently proposed techniques to estimate site amplification effects from topography will also be tested (Wald et al. 2004).

(ii) Flooding

The mediterranean climate of the metropolitan region of Santiago de Chile and its geographical position in the central basin between the coastal Cordillera and the major Andean mountain range are the cause of heavy rainfalls and subsequent landslides during the winter months (Araya 1966). Sudden rainfall leads to extreme flooding and landslides in the mountain areas, not least because the city is expanding and land cover change from natural to impervious surfaces produces a decline in the seeping water rate of the soil and to a decrease in soil resilience due to lack of vegetation (ONEMI 1983). The growing rate of impervious surfaces and the inappropriate technical solutions in water engineering (canalization and covering of river courses, inadequate or ineffective drainage etc.) increase

the risk of flooding, and cause ecological and economic damage. Housing on the river banks and generally in areas affected by flooding magnifies the risk for lives and livelihood. Furthermore, housing areas have been mushrooming in the Andean piedmont and other mountainous areas, thereby adding to the quantity and velocity of surface run-off into the city and the urbanized hills, and in turn leading to new areas of potential landslide risk. All these processes derive from the complex interaction of climate, earthquakes, and urbanization.

The following steps will be taken:

- (1) The urban water balance will be calculated for extreme flooding incidences, depending on the urban structure types, ancillary information on soil, precipitation, and other climatic conditions, since different structure types possess different impervious rates and are thus significant for the dynamics of evapotranspiration, surface run-off, and the seeping rate of water (Weichel et al. 2005).
- (2) Applicable solutions to manage surface run-off and groundwater in extreme flooding incidences will be formulated and assessed.
- (3) A flood vulnerability analysis will be carried out, based on the indicators of “element-at-risk” (persons, buildings, infrastructure, ecological species, etc.) and *exposure* (location, elevation, proximity to rivers or inundation areas, return periods of different types of floods, etc.) (Tapsell et al. 2002; Messner/ Meyer 2006).
- (4) Frameworks for flood risk assessment and risk management will be tested and adapted to the requirements of megacities (ISDR 2002).

As landslides are a grave natural risk for the entire metropolitan area and are closely associated with flooding, it should be checked in phase I how landslides could be investigated in phase II. Hence scientific intention can sometimes outwit resource limitations.

Work Package 5: Recommendations for integrated land use and risk management

Based on these activities, the recommendations on combined land use and risk management will focus on:

- formulating the different aspects of the resultant vulnerability as a prerequisite for recommendations
- discussing how to enhance resilience in general, and in exposed sites or local districts in particular
- illuminating the point at which steering efficacy and efficiency needs to be improved for sustainable urban development (Weiland 2002)

Outputs of Work Packages 2 to 5:

A key result will be digital maps of structure types on various scales and dynamic maps representing processes of urban development (e.g., of land use change, change detection, population changes, etc.). These maps of local and regional vulnerability and resilience will be derived from physical and social indicators. Earthquake and flood risk analysis, vulnerability analysis and risk assessments will lead to the creation of several scenarios, all of which will serve as the basis for recommendations on how to decrease vulnerability and enhance urban resilience to the selected natural risks. The latter involves improving existing land use and risk management systems for sustainable urban development. Risk area maps will be generated and provided for other research topics and cooperating stakeholders. Sustainability indicators, integrated in a management system, will be elaborated.

All of the partners in the research consortium will contribute to the elaboration of a simulation and modelling tool, to be realized in the second implementation phase. Creating the framework for this tool will be one of the outputs of the first phase.

Methods, data requirements

Remote sensing methods (image processing and classification procedures), GIS, and cartographic modelling will be used in analysing data from other work packages and fields of application, and visualizing the results. Site measurements will be undertaken and simulation tools tested. Revision of documents and interviews with authorities and technicians will be carried out. The applied methodology encompasses quantitative and qualitative analysis of remote sensing and GIS data, statistical information on socio-demographic and economic parameters, risk analysis and assessment, and the elaboration of scenarios.

Data requirements are: remote sensing data from different sensors (in different spatial, spectral, radiometric and temporal resolutions), census and other statistical data (for different years), information on administrative divisions, and topographical information. A digital elevation model, ground truth data, and information on specific test sites are essential. Geophysical data (geology, soil, climatology), data on flora and fauna, exceptional land uses, such as mining activities or artificial water bodies, will be required for all risk analysis.

Involved organizations and key scientists

- Helmholtz Centre for Environmental Research – UFZ:
Ellen Banzhaf, Dirk Heinrichs, Annegret Kindler, Ulrike Weiland
- GeoForschungsZentrum Potsdam, GFZ:
Jochen Zschau, Stefano Parolai, Monika Sobiesiak
- Forschungszentrum Karlsruhe, FZK ITAS:
Juliane Jörissen
- Universidad de Chile, UCH:
Jaime Campos
- Pontificia Universidad Católica de Chile, PUC:
Sonja Reyes Paecke

Preliminary Time Frame

	Months					
	1-6	7-12	13-18	19-24	25-30	31-36
WP 1						
WP 2						
WP 3						
WP 4						
WP 5						

Resources (in person years, implementation phase 1)

Person Years (scientific staff) 2007-2010	Key scientists ---permanent staff---					Additional resources --- to be funded ---	
	UFZ	GFZ	FZK ITAS	PUC	UCH	At Helmholtz	In Chile
	4.2	1.2	0.3	0.75	0.75	6	6

Additional resources will be allocated for travel, fieldwork, workshops and consumables.

5. Socio-spatial differentiation

Speakers: Sigrun Kabisch, Helmholtz Centre for Environmental Research – UFZ; Francisco Sabatini, Pontificia Universidad Católica de Chile

Background

Intensive socio-spatial differences are a characteristic trait of Latin American societies and have a powerful impact on land use patterns. While large-scale residential segregation has long dominated cities all over Latin America (Sabatini 2003), it is now approaching a new dimension (Borsdorf 2006). Current patterns of social problems heavily correspond to spatial fragmentation. The simultaneous expansion of informal or popular settlements, often in high-risk locations, and upper-class residential neighbourhoods intensifies urban sprawl at the cost of the inner city. Besides its strong impact on urban ecosystems and the probability of environmental hazards, the rapid growth of land consumption could lead to an aggravation and spatial concentration of social vulnerability, crime and violence. Santiago de Chile can be seen as paradigmatic for these trends. It is one of the fastest growing large cities in terms of per-capita increase in urban land use in Latin America.

In the last decade Santiago de Chile has witnessed an emergence of vast real estate projects in previously disadvantaged areas. As a result, upper and lower income groups now live closer to one another than was the case in the past. Hence the spatial dimension of social differentiation has decreased. Social separation, on the other hand, has increased and is now far more pronounced than ever (Sabatini et al. 2001).

Social housing programmes for poor households likewise have a considerable impact on socio-spatial differentiation. They are mainly located in poor, risk-prone areas (flooding or earthquakes) on the urban periphery, with the corresponding services. As a rule, public transport services in these areas do not meet transport demand, and many residents remain excluded from access to the labour market in the city centre. The use of private cars, however, increases traffic congestion. The outcome of constructing up to 45,000 social housing units per year on the urban fringes is therefore ambivalent. Satisfying the basic need of disadvantaged social groups for shelter becomes in its consequence a key driver of land consumption, produces poor standards, reinforces socio-spatial segregation and contributes significantly to transportation stumbling blocks.

Objectives and research questions

Our research focuses on core patterns, drivers and consequences of socio-spatial differentiation in Latin American megacities. It intends to uncover and explain constitutive relations between these aspects of socio-spatial differentiation as a basis for political intervention. Building on the outstanding expertise of the Chilean partners, we will conduct three thematic studies, each concentrating on one main aspect of socio-spatial differentiation. While this ensures a degree of autonomy in implementing individual studies at the beginning of the research, it also allows for their integration and for a more comprehensive focus on socio-spatial differentiation in Santiago de Chile later on. We expect that this procedure will ease the formulation of results, which will be context-specific and therefore of greater significance in supporting local interventions, and will at the same time permit generalization and the dissemination of results to other megacities.

The research follows three major questions:

(1) What is the role of land markets in patterns of socio-spatial differentiation?

Land markets are both the main stimulant of expansive suburban growth in the metropolitan region of Santiago de Chile and a driver of changing segregation patterns (Sabatini et al 2001). They are the product of and make explicit the interaction between residential demands, the supply provided largely by private investors and real estate agents, and the particular regulatory environment provided and enforced by government. The investigation will specifically address two issues:

- What is the relation between quantitative changes in land prices for residential land use, the construction of housing units and the spatial concentration of certain social groups in Santiago de Chile for the period 1992-2002 (last two censuses)?
- What is the role of the private sector in the expansion of the city? And how does the market function?

These questions connect to the research topics of other research teams in the initiative, such as the prospects for private-public interplay and city building on the urban fringe (*Governance*, Work Package 4). The clarification of land markets as a driver of urban expansion further connects to scenarios of urban development and the respective recommendations (*Land use management*, Work Package 4) and associated risks (*Risk*, Work Packages 1 and 4).

(2) Does spatial proximity promote social integration?

If land markets create new patterns of segregation, the question arises as to whether or not closer spatial proximity of upper and lower income groups provides more opportunities for social inclusion and integration. The relation between spatial proximity and social inclusion depends on the concrete (inter)actions of people, their expectations and resources, and the quantity and quality of the contacts various social groups uphold in a particular neighbourhood. Thus, spatial proximity is not equivalent to social integration. In fact, spatial *inclusion* can even be accompanied by social exclusion (Cáceres/ Sabatini 2004). The following questions will be at the centre of the investigation:

- What are the main determinants of the relation between spatial inclusion and social integration?
- To what extent do new patterns of segregation generate opportunities for social cohesion or the risk of social tension?
- What practical policy measures promote social inclusion?

Answering the question "Who segregates whom?" (Roitman 2005) means knowing whether residents in different quarters are aware of the social differences outside their own "world". Insecurity and perceived high crime rates (Dammert/ Oviedo 2005) are frequently driving forces for separation, as is the desire to achieve an ideal lifestyle (Janoschka/ Borsdorf 2006). However, lack of contact to and knowledge about life in front of or behind the gates respectively leads to a widening of social distances and re-inforces residential segregation.

We will explore the relation of social development, housing and living conditions, and transportation with regard to their linkage to social, physical and environmental problems. In close cooperation with the other research teams (*Governance* Work Package 4, *Transportation* Work Packages 3 and 5, *Land use management* Work Package 5), we will examine the options for strengthening social cohesion within the urban structure.

(3) Do housing policies prevent or stimulate socio-spatial differentiation?

While housing markets are a key driver of residential segregation, they are also subject to a wide array of political regulations, such as the provision of "social housing" by the state, planning and zoning laws, and direct and indirect subsidies.

Housing policies consequently affect the prospects for urban sustainability, and promote or restrict land consumption, traffic and settlements in high-risk locations. To ease the policy- and action-orientation of the research, we will include housing policies in the research programme. The focus is on a comparison of Chilean and German housing politics, and their relation to problems of social exclusion. We deem this comparative approach to be most suited. Because its scope is wider, contexts can be integrated more successfully, thus contributing to a greater understanding of causal mechanisms and drivers.

Special focus will be on:

- relations between local and central government bodies with respect to housing politics, and their effect on policy-programmes
- Public/ private sector relations and the potentials/ problems of private sector involvement in supporting public sector policies related to sustainability (equity, efficient allocation of land etc.)

We see close links to the cross-cutting concept *Governance* and will organize conceptual clarifications and dissemination of results in close collaboration with the respective research team.



Figure 7: Contrasting perspectives, Santiago de Chile

Activities and expected results

Work Package 1: Development of indicators

This work package includes assessment of the appropriateness and applicability of sustainable development indicators focusing on social trends and patterns. The aim is to clarify the relation of the research results to the cross-cutting issues. While, on the one hand, a research design based on common indicators has the advantage of improving integration into the programme framework (sustainable development) and supporting communication with local stakeholders, we clearly see, on the other hand, both practical and theoretical limits to creating thresholds for social processes. We will therefore concentrate on comparison and the description of typical social trends and patterns. Commonly used indicators will most likely emphasise aspects such as access to resources (land, housing and related infrastructure, including transportation), employment, social cohesion, poverty and crime.

Work Package 2: Spatial patterns of segregation and the role of land markets

This work package conceptualizes the interaction between the market and residential segregation patterns. The first step is a quantitative assessment of urban land markets and urban land development on a city-wide scale, consisting of:

- refinement and clarification of methodological considerations
- data assembly, including land prices, residential land uses, building permits, development projects by type (social housing, megaprojects etc.), segregation patterns
- data processing and thematic mapping, correlation and interpretation

The quantitative assessment will be complemented by a case study, which will include a closer investigation of the real estate market and its institutional and social capacities (Wallace/ Williamson 2006). We will apply the analytical *Governance* concept of the research initiative to assess the role of the private sector in city building. While this step helps to uncover the strategies of investors, real estate developers, intermediaries, and landowners, it likewise permits assessment of the role of land speculation. Moreover, it sheds light on the resources and opportunities of both authorities and civil society to influence market-driven urban development patterns.

The results of the analysis at the two levels provide inputs for the conclusion, recommendations and scenarios in Work Package 5.

Beyond its immediate results, the research leads to the modification of theoretical concepts and models of residential differentiation and socio-spatial growth in Latin American megacities. A second outcome is the inclusion of segregation patterns in scenarios on spatial and social trends, as well as their implications for the potential risks (flooding, earthquakes) associated with large-scale urban expansion.

Work Package 3: Does spatial proximity promote social integration?

Work Package 3 focuses on the linkages between spatial fragmentation and social differentiation. Based on a detailed theoretical concept of residential segregation (Rodriguez Vignoli 2001; Sabatini 2003), we will conduct empirical case studies that include in-depth analysis of interactions between various social groups. Major issues will be the strength of social networks in different types of residential neighbourhoods and the quantity and quality of the social contacts among the residents of different social status. We expect to achieve a better understanding of the social factors affecting resilience to social vulnerability. In addition to these social issues, we will consider spatial dimensions and the public service supply as important context conditions. This will be accomplished in cooperation with the *Land use management* and *Transportation* research teams.

We will employ a methodologically mixed research design consisting of both quantitative and qualitative empirical approaches. Detailed steps include:

- generation of hypotheses
- selection of case study areas, survey among residents, and additional in-depth interviews with key-persons and experts
- data interpretation, verification or falsification of hypotheses, and interpretation

The case studies provide a detailed description of social structures (in particular social networks) for community development. Furthermore, we will provide an assessment of the opportunities and risks of new patterns of segregation. We will formulate concrete policy recommendations and practical measures on this basis.

Work Package 4: Housing policies and socio-spatial differentiation

Work Package 4 aims to provide high-quality explanations of the opportunities and risks of housing policies with regard to social exclusion and the problems involved. These will be derived for the most part from secondary interpretation of available data and expert interviews.

The main steps in this work package are:

- an outline of concepts on the role of housing politics in the “welfare-mix”
- a case study on the changes in Chilean housing politics (compared with Germany) in the last two or three decades – roots, struggles and consequences
- synthesis and interpretation in relation to scales of governance, and public/ private mix

The case study will be based on a combination of secondary analysis of existing research, document analysis, and interviews with experts. The synthesis will be based on a compact discussion of the results produced in the cross-cutting concept *Governance*.

The result of Work Package 4 will lead to a fuller understanding of the range, impact and applicability of instruments directed towards influencing socio-spatial differentiation. This will allow for an assessment of existing policies and intervention proposals.

Work Package 5: Comprehensive conclusion

Work Package 5 integrates the results of the three studies along the identified patterns of social segregation, the findings on the causes and drivers of these patterns, and the insights into the advantages and problems of political intervention. It explores scenarios and delivers proposals for action. The discussion of research results with stakeholders and professionals plays a vital role in supporting data interpretation and stimulating the formulation of final conclusions. The main steps are:

- a workshop and a discussion on the results of Work Packages 1 to 4, scenarios, and a “Charette” i.e., an in-depth participatory workshop with stakeholders
- a symposium and comprehensive review of theoretical approaches, empirical findings and policy implications with academics from different Chilean and German universities and institutes to clarify and define contrasting interpretations
- the formulation of practical recommendations

The MUSSA model (www.mussa.cl), operated by the partners at the Universidad de Chile, facilitates analysis of the economic equilibrium of market-oriented policies such as taxes, subsidies and specific regulation programmes related to land use and housing (Martinez 1996). We will explore the opportunities and capacities to include this tool, and undertake complementary efforts to use the model in relation to issues such as residential location choice.

Methods, data requirements

The implementation of our research programme demands an extensive range of local data, maps, statistics, documents and other relevant material. While some of this data is available at the partner institutions in Santiago de Chile (Pontificia Universidad Católica de Chile, ECLAC/CEPAL), we have also identified other significant sources in Santiago, including the Instituto Nacional de Estadística (National Statistics Office), the Gobierno Regional Metropolitano de Santiago (Metropolitan Government), scientific institutions, local authorities and other relevant organizations.

Empirical case studies in specific areas of Santiago de Chile, including surveys and qualitative approaches, will be carried out. This mix of quantitative and qualitative methods gives us insights into social patterns and trends, as well as into the behaviour and interaction

of different social groups. Thematic mapping, spatial correlation and interpretation will involve GIS.

Involved organizations and key scientists

- Helmholtz Centre for Environmental Research – UFZ:
Matthias Bernt, Dirk Heinrichs, Sigrun Kabisch
- Universidad de Chile, UCH:
Francisco Martinez
- Pontificia Universidad Católica de Chile, PUC:
Maria Elena Ducci, Rodrigo Hidalgo, Francisco Sabatini
- Economic Commission for Latin America and the Caribbean, ECLAC/CEPAL:
Ricardo Jordan, Jeannette Plaut, Jorge Rodriguez

Preliminary Time Frame

	Months					
	1-6	7-12	13-18	19-24	25-30	31-36
WP 1						
WP 2						
WP 3						
WP 4						
WP 5						

Resources (in person years, implementation phase 1)

Person Years (scientific staff) 2007-2010	Key scientists ---permanent staff ---				Additional Resources --- to be funded ---	
	UFZ	PUC	UCH	ECLAC/ CEPAL	At Helmholtz	In Chile
	2.1	0.1	0.1	0.1	0.1	3

Additional resources will be allocated for travel, fieldwork, workshops and consumables.

6. Energy system

Speakers: Sonja Simon, German Aerospace Centre; Luis Vargas, Universidad de Chile

Background

As the result of a 20 % population growth between 1991 and 2005 (Ducci 2002), a highly dynamic period of economic development, and of ongoing deficits in the efficient use of energy resources, energy consumption in Santiago de Chile is rising fast. In the electricity sector, for example, the annual average growth rate is between 7 % and 8 %. Apart from the problem of resource exploitation, this energy use also leads to the production of pollutants that contribute to a worsening of the air quality in the city (Arenas et al. 2000). In addition, more and more industries in the hinterland of the city consume energy resources such as oil and natural gas. A core strategic question is how the rapidly growing energy demand can be managed and how air pollution can at the same time be controlled. Severe disruptions are known to have occurred in the delivery of natural gas from Argentina to Chile in recent years. This forced industries and residential consumers to switch to other fuels, which in turn led to higher costs and frequently to a further deterioration of the air quality in Santiago de Chile (EIA 2006). The issue of how to tackle gas shortages and the concomitant negative consequences, and enhance the security of energy supplies is a pressing problem that requires several long-term decisions.

Specifically, the main energy-related problems in Santiago de Chile are (most of them are common to all Latin American megacities):

- shortage of gas imports in recent years, causing serious energy supply deficits for industry, services and households
- increasing inequality of energy access and consumption in relation to high and low income households
- air quality is affected by energy production and consumption
- indoor pollution from energy use has been observed as a problem in the residential areas where poorer people live
- a strategy for the use of renewable energies has not been developed systematically
- energy resources are used inefficiently and despite the existence of a state energy efficiency programme, concrete political measures have as yet not been implemented systematically
- Santiago de Chile is situated in one of the regions most affected by earthquakes in the whole world. This means high risks for energy supply system operations, especially for gas and electricity grids
- some districts in the city suffer from high landslide risks, which can endanger the energy system or parts of it

Objectives and research questions

The overall objective of the *Energy system* field of application will be to define what a (more) sustainable energy system looks like and, based on this, to provide a comprehensive and feasible implementation strategy to realize the defined goals. The focus of the first implementation phase (2007-2010) is to work out such a strategy for Santiago de Chile, in close cooperation with local experts and societal groups. At the end of this three-year phase, the methodology and specific implementation strategy developed should be sharpened and prepared for application to other Latin American megacities.

The specific conditions in Latin American megacities make a twofold demand on research. On the one hand, there is an obvious need to propose viable solutions for the most pressing, sustainability-related problems of the energy system, as mentioned earlier. On the other hand, these solutions should be part of an overarching strategy for the cities analysed, in order to ensure that they contribute appropriately to the achievement of several societal sustainability targets that have already been set or will be in the near future.

Against this background, the three key objectives for research in the interests of a sustainable energy system are:

- (1) What are the chief structures and characteristics of the system with respect to the city and their relation to the environment, and how is the current situation to be evaluated?

Answers to these research questions will include a description of the energy supply infrastructure, such as power and heat supply technologies, fuel supply, transmission and distribution grids, etc., the analysis of energy-related needs and demands (regarding energy resources and services) in the city, the analysis of energy production and provision costs, as well as the resulting environmental, economic, social or cultural impacts. This characterization of the energy system allows for an evaluation of its sustainability performance, based on the integrative sustainability concept, as part of a detailed overall sustainability analysis of the city and its environment, taking into account certain linkages to other fields of application, such as *Waste management*, *Water* or *Transportation*. Due to high income inequalities in the city, it will not be enough to analyse existing data merely at city level. Furthermore, the analysis should, as far as possible, take differences between city districts with regard to energy into account.

Based on this analysis, the next step is to identify the most pressing sustainability problems of today and the direction they are taking, to analyse their spatial differentiation, and to identify the extent to which they are a risk for the city and its interrelations or could be in the future.

- (2) What are the most suitable and most effective political and societal strategies to mitigate or avoid current or future problems and risks?

For this purpose, the variety of measures and instruments relating to the specific local and regional conditions should be analysed. Proposals for the most suitable combination of policy instruments and their implementation will be submitted. Due to the manifold interactions and interdependencies of countless supply areas, infrastructures and societal activities in the area of investigation, analysis will be partly carried out in cooperation with the other fields of application. In this context, the focus will necessarily be on how and to what extent current energy production and consumption patterns oppose a sustainable energy use, and what future patterns could support it? How can supportive behaviour and activities be increased, or what is the best combination of instruments to induce the indispensable evolution of the energy supply structure, e.g., towards greater security of the energy supply, a reduction of pollutants or saving of energy resources

- (3) How can strategies for a highly stable and sustainable energy system be guaranteed?

The core element of this stability will be a risk management strategy that considers specific risk situations in a mega-urban environment. Hence the *Energy system* field of application will identify and analyse the principal hazards for the governance process towards a more sustainable energy system. In addition, possible risk management measures to support the sustainability process in terms of risk prevention, adoption and compensation will be analysed. In cooperation with the other research teams, these measures will be integrated into a comprehensive implementation strategy aimed at a kind of “sustainability road map”,

which will consider a viable, supportive implementation process adapted to the specific risk situation in Santiago de Chile.



Figure 8: Annual energy demand from CDEC-SIC from 1985 to 2006 (CIDE-SIC 2007a)

Activities and expected results

Work Package 1: Energy system inventory and sustainability indicators

The first step is to provide an inventory of the current energy system, including the energy matrix on the supply and demand side, infrastructures, relevant societal sectors (industry, households, transportation), the institutional, political and administrative framework at the level of Santiago de Chile and the different city districts. To describe and assess this system, a suitable and operable set of energy-related sustainability indicators conceptually based on the integrative sustainability concept and taking existing studies into account (e.g., Vargas 2006) will be carried out.

Work Package 2: Sustainability analysis

Here, in a first step, target values will be determined for the selected indicators, considering existing political decisions and current debates, and closely cooperating with the local political and administrative authorities. A first overview will subsequently be given of today's most pressing energy-related sustainability problems, comparing current states with the targets set for the indicators, above all in terms of distance-to-target considerations.

Work Package 3: Analysis of current sustainability problems and risks

In a next step, the problems identified will be analysed and evaluated with respect to their causes and the extent to which they constitute a substantial risk for the operability of the energy system of the city and its hinterland, and the corresponding interrelations. For this purpose, the criteria temporal and spatial scope and the (ir)reversibility of impacts that affect sustainability will be applied. The analysis of the particular risk perceptions of the different actor groups (science, administration, industry, politicians, societal groups, etc.) will be part of this assessment. Considering the current problems in Chile and Santiago and the present debate on Latin American megacities, analysis will be conducted on the potential for renewable energy sources. This will centre on the use of hydropower as a key source of the electricity supply in Santiago de Chile, with a substantial increase predicted for the next

fifteen years (INE 2004, 104). Energetically usable fractions of municipal waste will be an additional focus. The prime sources of airborne emissions from stationary energy use have been identified as the basis for exploring the link between energy use and air quality.

Work Package 4: Scenario analysis

To cope with the various uncertainties attached to future development, the scenarios will be characterized by alternative assumptions for core societal framework conditions and driving factors for future development with respect to the energy system, based on scenarios developed for the cross-cutting level of the fields of application. The core indicators will be analysed in the context of these scenarios, concentrating on sustainability deficits, renewable energy potentials, energy efficiency measures, and on the possibilities of preventing harmful developments with regard to promoting sustainability with specific measure and instrument combinations. An energy system simulation model adapted to the specific conditions of Santiago de Chile will be used to support scenario analysis.

Work Package 5: Analysis on action strategies, endangering risks and risk management

Suitable combinations of problem or risk reduction measures in relation to existing problems and their potential development will be analysed on the basis of the scenario analysis results, concerning environmental, economic and social impacts. These measures include market-based, regulatory and informational measures to influence societal behaviour and lifestyles, on the one hand, and technology-focused options and the corresponding political and institutional framework conditions, on the other. In a subsequent step, existing or potential hazards or risks endangering the pathway to a more sustainable energy system and their impacts will be analysed. In this context, we will identify and analyse the critical system elements (and their probability) that potentially amplify threats and increase the susceptibility of the energy system, as well as those that could mitigate negative impacts and thus improve the resistance of the system. These elements can be described as *system-internal* (e.g., suitable or counterproductive political framework conditions, etc.) or *system-external* (e.g., in the case of natural disasters).

Risk management analysis will be carried out on this basis with the aim of identifying feasible measures to tackle risks endangering the sustainability process with regard to alternative scenario frameworks. Finally, these measures will be integrated as far as possible into a feasible and consistent overall sustainability strategy provided by the research initiative.

Methods, data requirements

Both quantitative and qualitative methods will be applied in Work Package 1 to 4. As a tool for evaluating certain political measures and their integration into feasible energy system development pathways, energy system modelling in quantitative terms seems indispensable. In this sense, scenario analysis is a vital component of appropriate strategy development. Data for quantitative modelling and scenario building is available and already in use for Santiago de Chile to an adequate extent. Analysis on the spatial differentiation of the energy system and particular indicators will be carried out as far as possible in Work Packages 1 to 4.

More qualitative methods will be applied with regard to governance issues and include the analysis of actors, their targets and behavioural patterns, and the definition of appropriate (economic) policy instruments. The extent to which agent-based modelling in this context will be beneficial to the development of these instruments on the basis of modelled actors'

behaviour or in the form of “activity models” (Palma et al. 2003) cannot be fully concluded as yet. This will be decided upon in the course of the research process.

Involved organizations and key scientists

- German Aerospace Centre, DLR-STB:
Wolfgang Krewitt, Sonja Simon
- Forschungszentrum Karlsruhe, FZK ITAS:
Jürgen Kopfmüller, Volker Stelzer
- Universidad de Chile, UCH:
Luis Vargas

Preliminary Time Frame

	Months					
	1-6	7-12	13-18	19-24	25-30	31-36
WP 1						
WP 2						
WP 3						
WP 4						
WP 5						

Resources (in person years, implementation phase 1)

The total work effort for the described work packages in the first, three-year phase is listed in the following table. Implementation requires close interaction and cooperation between the three main research partners in all work packages. Due to the integrative and international character of the overall research initiative, substantial resources for the integration of the research topics and the coordination between the partners are required.

Person Years (scientific staff) 2007-2010	Key scientists ---permanent staff---			Additional resources --- to be funded ---	
	DLR STB	FZK ITAS	UCH	At Helmholtz	In Chile
	0.75	2	1.4	1.4	3

Additional resources will be allocated for travel, fieldwork, workshops and consumables.

7. Transportation

Speakers: Barbara Lenz, German Aerospace Centre; Francisco Martínez, Universidad de Chile; Cristián Cortés, Universidad de Chile

Background

The unceasing spatial expansion of Latin American megacities such as Santiago de Chile is closely linked to a growing demand for transport, which in turn generates a permanent need for new infrastructure, i.e., an extension of road networks and public transport systems. While rising transport demands, served in particular by private motorization, became evident for European cities in recent decades, similar processes in



Figure 9: Rush hour (Santiago de Chile)

Santiago de Chile are taking place at a far more rapid rate. Although the city's population increased by only 10 %, the proportion of trips undertaken by private motorized transport rose by almost 20 % between 1991 and 2001 (Fernández/ Osses 2004; SECTRA/ PUC 2001; INE 2006). Due to this highly dynamic development, the city authorities are constantly confronted with new challenges. Apart from the typical problems of traffic congestion, specific challenges to ensure accessibility standards and public transport services for all groups of the population have emerged. If these challenges are not met, inequalities among the different social groups will increase. Air and noise pollution, and road fatalities are other problems that contribute to the creation of a risk habitat in megacities.

As the extreme dynamics in the transportation sector jeopardize the sustainability of megacities and create specific risks, the need for qualified planning and management measures that gear transportation and travel behaviour towards sustainability goals seems urgent. Consequently, transportation planning in megacities requires tools that allow for the evaluation of policy measures with respect to their potential to achieve ecological, economical and social sustainability goals. If knowledge on the driving forces behind rising transport demand and the respective planning tools are brought together, medium and long-term strategies for sustainable urban transportation planning are within reach. With regard to the application of planning tools, transport models in particular are widely accepted in urban planning sections.

The overall focus of the *Transportation* research team is the further refinement and application of these supportive planning tools in Santiago de Chile. Given that the most pressing problems in today's megacities are still caused by the rising demand for private transport, issues of passenger transportation will be a key research object. Data gathering and ensuring data quality for transport research, planning and modelling will be the prime elements of the research work.

Objectives and research questions

The achievement of sustainability goals in the transportation sector is linked to the introduction and enforcement of the management measures that influence transport demand. Hence, a chief objective of the research is the evaluation of measures to potentially move the transportation system towards sustainability. The ability of these measures to reduce air pollution and the corresponding health risks are important criteria for the selection of measures.

The evaluation of measures will be supported by the application of transport modelling tools. As a rule, transport models generate traffic flows and volumes based on the relation between people's homes, their workplaces, and the location of other activities, such as shopping or leisure. Models not only record the traffic itself but take into account the purposes of travel. As transport policies frequently focus on influencing people's travel demands, the models enable quantitative evaluation of possible impacts. Modelling, however, requires data. The better the data, the more useful the modelling. Since inadequate data can be expected in most Latin American megacities, a major research task will be to explore alternatives to conventional data gathering.

Given that the overall impact of car traffic is highly dependent on the vehicle fleet (old cars are more detrimental in terms of air pollution and health risks than new cars) detailed data on vehicle fleets is required. Data of this kind can upgrade the quality of modelling substantially. It is therefore a joint objective of the *Transportation* and *Air quality and health* research teams to specify the current vehicle fleet structure and improve the database for micro-scale traffic and air emission models.

The following research questions are stressed:

- (1) What are the most effective transport demand management measures in Santiago de Chile with regard to a more sustainable transportation system now and in the future? How do these measures work and to what extent do they influence transport demand or support modal shifts from private to public transport?
- (2) What kind of data is required and available in Santiago de Chile or other Latin American megacities for the work with modelling instruments and how is this data collected? To what extent can specific transport data in megacities be substituted by other transport-related data (e.g., airborne views on traffic situations)?
- (3) How can expertise in micro- and macroscopic modelling be brought together to enable the evaluation of transport demand management measures such as congestion charging, speed limits or changes in service of the public transport sector?
- (4) To what extent does the transportation sector contribute to air pollution throughout the city and how can the analysis of the vehicle fleet structure improve the forecast of emission distribution models?

To address these research questions, Chilean and German expertise on transport modelling will be merged. The German group from DLR-IVF are highly skilled in microscopic demand modelling to simulate effects of transport policy measures in German cities (e.g., Berlin, Cologne), while the Chilean partners at the Universidad de Chile have vast experience in macroscopic modelling at the level of the entire city of Santiago de Chile.

Activities and expected results

The research activities are organized in five work packages. Subsequent to the definition of sustainability indicators, a state-of-the-art analysis will be carried out in relation to transport demand management measures and the data situation in Santiago de Chile. Results are used as input information for the transport modelling activities pursued in Work Package 4. Finally, the research group aims at the formulation of policy recommendations in Work Package 5.

Work Package 1: Definition of sustainability indicators

This work package deals with the definition of sustainability indicators for the transportation sector in Santiago de Chile and subsequently with the description and quantification of the gap between the current situation and conditions envisaged in the sustainability goals. The identification and testing of strategies and measures addressed in the following work packages requires the establishment of performance indicators that point to change and make it measurable. Sustainability indicators will be formulated in cooperation with the *Sustainable Development* research team, and address, for instance, accessibility standards, the level of public transport services and road safety or the extent of air pollution reduction.

Work Package 2: Status analysis of transport demand management (TDM)⁶ measures

Transport demand management measures can be effective instruments for policy-makers in handling existent and emerging traffic problems. Such instruments include regulatory, legal, fiscal and economic measures.⁷ In order to identify the most effective measures in relation to the particularities of megacities, an analysis of measures already in effect and of those planned will be undertaken, and the result of their impact on transport demand ascertained. This allows for categorization of transport demand management measures in terms of overall sustainability performance and includes cooperation with the public authorities and institutions involved in the identification and application of these measures, e.g., ministries or public planning sections. Moreover, specific measures will be selected and tested by the transport modelling tool developed in Work Package 4.

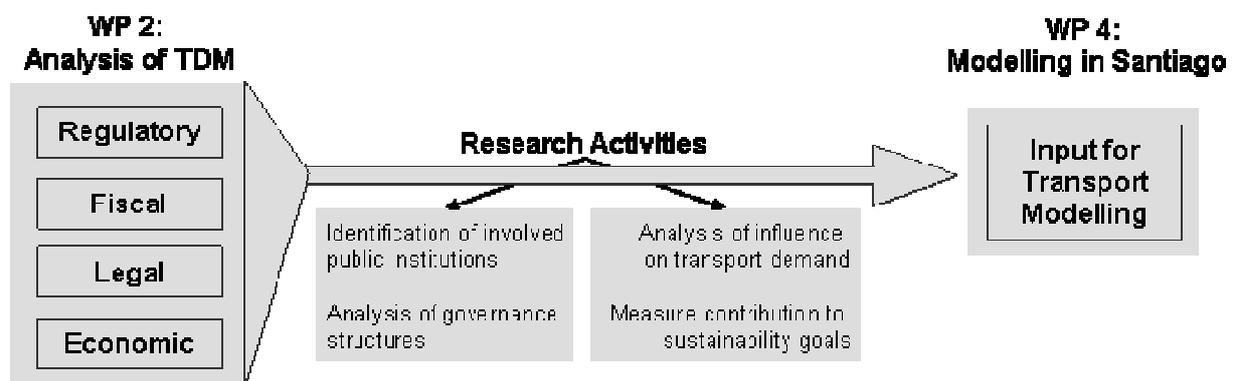


Figure 10: Connection between Work Packages 2 and 4

⁶ In the European context of transport research, the term mobility management is often used as a synonym for transport demand management.

⁷ The measures focus, for example, on the introduction of toll roads or speed limits (regulatory), the adjustment of tariffs in public transport (economic), taxation, or prescription of limits for emissions (legal, fiscal).

Measures with impacts on the transportation system need user acceptance and appropriate governance structures to ensure their implementation. Accordingly, the investigation of existing governance structures in Santiago de Chile aimed at the “level of translation” between technical planning sections and policy-makers, will be a priority. Hence, this work package is linked to Work Package 3 on the cross-cutting concept *Governance*, whereby researchers from the *Transportation* and *Governance* research teams will mutually contribute to their respective work packages. This joint analysis of transport policies will specifically focus on the potential for implementation at the political stakeholder level.

Figure 10 summarizes the research activities of Work Package 2 and highlights its connection to Work Package 4.

Work Package 3: Data situation in Santiago de Chile and other Latin American megacities

This work package is first of all dedicated to the definition of data needs and standards. For instance, data sets on spatial structures (demographics and land use patterns), the socio-economic situation (e.g., number and structure of households, income and mobility budgets, car ownership), and (mega-urban) citizens’ travel behaviour are of interest. Work will begin with the collection and harmonization of existing data sets, and the identification of data gaps. The second step focuses on data availability in other Latin American megacities as a prerequisite for further transport research activities and modelling. Since we cannot expect to find data availability similar to Santiago de Chile, methodologies will be defined to overcome possible data deficits.

Work Package 3 also intends to define minimum data requirements and analyse survey methods and instruments. Concretely, aspects of variable definitions, survey methods and the influence of different ages of data sets will be questioned. The work package is closely linked to Work Package 4 in that the quality of transport modelling strongly depends on data input. However, the creation of data inventories does not yet allow for modelling itself, but paves the way for future application. Work Packages 3 and 4 are part of the expansion strategy to other megacities, with Santiago de Chile as the point of reference.

Work Package 4: Transport modelling in Santiago de Chile

The design of this work package is the result of collaboration between the researchers from DLR-IVF and *Universidad de Chile* during the preparatory phase. It was found that the combination of modelling approaches aimed at the development of a coupled modelling tool would improve the evaluation of transport demand management measures significantly.

It is important, first of all, to compare notes on transport modelling. The model-relevant databases of the Chilean and German partners will be compared, and particularities in data collection and processing discussed. Thus, the Chilean EOD (Survey Origins-Destinations of Trips) household survey will be analysed for its usefulness in applying the TAPAS (Travel and Activity Patterns Simulation) microscopic modelling approach developed by the German research group (e.g., Hertkorn 2004, 2005). The main task here is for the Chilean macroscopic modelling structure MUSSA-ESTRAUS⁸ to adopt the German activity-based demand generation step. As a result of Work Package 4, the coupled modelling tool will be used to ascertain the citywide modal split values and vehicle miles travelled per mode. The tool will be applied consecutively for the assessment of transport policy measures defined in Work Package 2.

⁸ MUSSA (Land Use Model of Santiago) and ESTRAUS (Supply-Demand Equilibrium Model for Multimodal Urban Transportation Networks with Multiple User Classes) are official governmental models for transport and land use in Santiago.

This work package also involves joint activities with Work Package 1 (Emission calculation) of the *Air quality and health* research team. A local analysis of selected locations with high-traffic loads, e.g., a main junction or arterial route, will be conducted in order to gain detailed information on the current vehicle fleet structure in Santiago de Chile. Knowledge of the fleet structure in combination with the emission performance of vehicles enhances emission modelling at local levels, serves as validation data for the *Transportation* field of application and opens the path to a microscopic simulation of traffic situations. The interpretation of additional static counting locations in Santiago de Chile could deliver further insights if the information from different locations is summarized and conclusions drawn for the entire city of Santiago de Chile. Hence, the development and application of a traffic microsimulation prototype tested for selected urban areas is expected.

Work Package 4 also delivers valuable results for the research activities of the *Energy system*, *Land use management* and *Socio-spatial differentiation* research teams. Information on the city's vehicle fleet structure combined with the average traffic flows on the network provides vital data for energy consumption calculations. Additionally, information on highly frequented roads and connectivity of residential areas is significant for the activities of the *Land use management* and *Socio-spatial differentiation* fields of application. Delivery of the respective information has been agreed upon.

Work Package 5: Interpretation of results and definition of policy recommendations

This work package will summarize the results of Work Package 2 in a catalogue, which in turn provides the basis for selecting measures tested by the coupled modelling tool. The catalogue embraces proposed solutions specific to Santiago de Chile, but will also serve as a basis for future research activities in other Latin American megacities.

Moreover, the definition of data collection standards and survey methods in Work Package 3 will be summarized and made accessible to public and private entities. Work Package 5 picks up the results on the evaluation of measures by the modelling tool in Work Package 4, and aims at defining policy recommendations for authorities in the transportation sector. Accordingly, measures tested by the modelling tool will be individually assessed and translated into these recommendations. At this point, the collaboration with the researchers dealing with *Governance* will be of particular advantage in terms of identifying the relevant stakeholders. Ideally, a catalogue of tested recommendations will be formulated, passed on to and discussed with the respective authorities.

Methods, data requirements

The inventory of travel demand management measures will be based on a review of the literature and a survey of experiences with measures already in effect in Latin American and other megacities. To examine the effectiveness of these measures, an analysis of the respective situation before and after implementation will be conducted. Important contributions are expected from the practical experience of the Chilean partners as experts in the field of transportation in Santiago de Chile. With regard to data, the relevant databases of the associated university partners will first of all be investigated. Data collection will then be expanded to public entities such as ministries, planning sections or statistical offices. The support of the Chilean partners will also help to identify key private partners (e.g., engineers, consultancies) in the transportation sector.

The comprehensive analysis of the Chilean travel behaviour data sets with respect to exigencies of the activity-based modelling approach is a precondition for the coupling of modelling approaches in Work Package 4. If supplementary information on the travel

behaviour of Santiago's inhabitants is needed, self-contained fieldwork will be carried out.⁹ Work Package 4 includes the testing of independent transport policies via the modelling tool. Hence, selected measure combinations could create a basis for scenario calculations of possible future developments. However, iterative calculation and evaluation of such combinations cannot be addressed in the first phase of the initiative. The relevance of drawing scenarios and the evaluation of their impacts has been recognized by the *Transportation* research team and will be part of its work in the second phase.

Involved organizations and key scientists

- German Aerospace Centre, DLR IVF:
Andreas Justen, Barbara Lenz, Markus Mehlin
- Universidad de Chile, UCH:
Cristián Cortés, Francisco Martínez

Preliminary Time Frame

Months						
	1-6	7-12	13-18	19-24	25-30	31-36
WP 1						
WP 2						
WP 3						
WP 4						
WP 5						

Resources (in person years, implementation phase 1)

Person Years (scientific staff) 2007-2010	Key scientists ---permanent staff---		Additional resources --- to be funded ---	
	DLR IVF	UCH	At Helmholtz	In Chile
	2.1	3	2.4	6

Additional resources will be allocated for travel, fieldwork, workshops and consumables.

⁹ As the approach of the German research team is based on time-use data, fieldwork could embrace additional data on daily activity patterns in a sample of the city's inhabitants.

8. Air quality and health

Speakers: Peter Suppan, Forschungszentrum Karlsruhe; Rainer Schmitz, Universidad de Chile

Background

Air pollution in megacities and densely populated areas has become a serious problem and is most pronounced in topographically structured areas (Molina/ Molina 2004; Gurjar/ Lelieveld 2005). Major contributors to air pollution are traffic emissions, domestic heating and industrial sources. In the face of the expected growth of urban populations, rise in standards of living, expansion of the economy and urban sprawl in megacities, air pollution will reach intolerable levels in the future, with serious socio-economic and ecological implications.

Health problems specific to megacities can be caused by chemical and physical environmental exposure, contagious germs (intensified by extremely high population densities) and socio-economic conditions. Primary and photochemically produced pollutants create fundamental human health risks (Peters et al. 1997; Phalen 1998; Pope et al. 2006; WHO 2002, 2006).

In transition and developing countries, air quality is a predominant factor in the genesis of environment associated diseases. Emissions from different anthropogenic processes and topographical and meteorological conditions determine outdoor air quality. A detailed knowledge of the air quality situation is a basic requirement for the development of feasible strategies to improve air quality and the concomitant health status.

The definition and implementation of measures for mitigation and adaptation requires a sound understanding of the current pollution situation. This is not available and must be established through the coordinated and integrated efforts of the scientists, stakeholders, and local authorities.

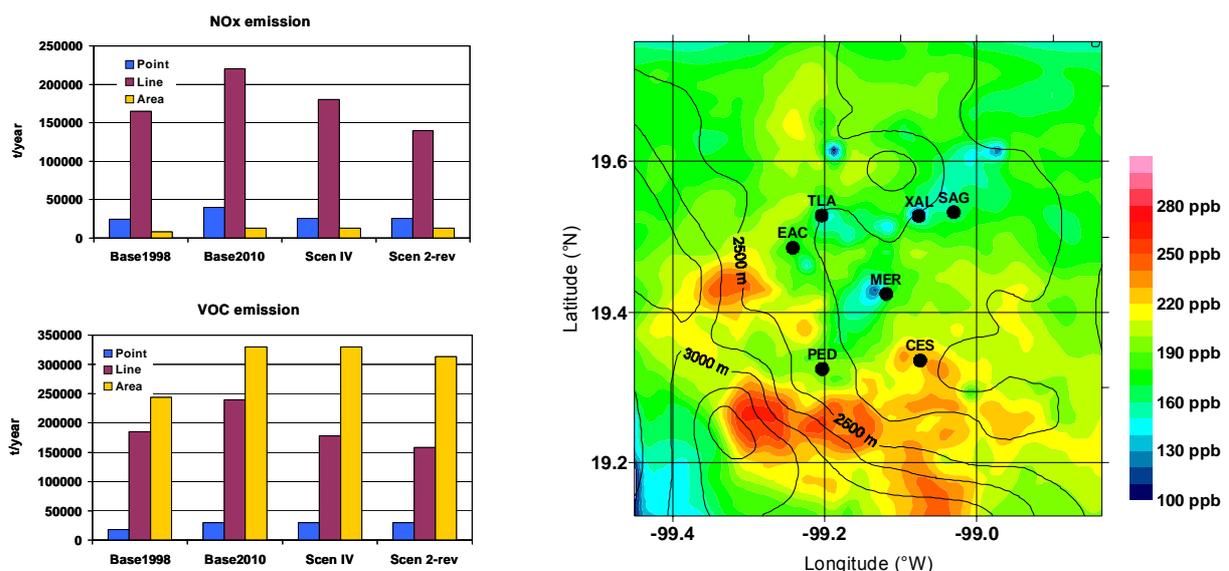


Figure 11: Emission scenarios for VOC and NOX for Mexico City reflecting different sources (left) and predicted mean ozone concentrations on a typical summer afternoon in 2010.

Whereas in both Germany and Chile measuring techniques and numerical models exist for the assessment and forecast of air pollution in megacities (Steinbrecher 2002; Rappenglück et al. 2005; Schmitz 2005), reliable data for model inputs is rare. The lack of knowledge about emissions poses the greatest obstacle in this respect.

The dynamic development and distribution of emissions in megacities pose particularly significant challenges for research. In order to assess air quality and its impact on human health in a given area, it is vital to be informed about the dynamics and distribution of emissions from traffic, industrial sources, domestic heating and biogenic sources. Among these sources, traffic emissions are crucial to air quality impact assessment studies in conurbations like Santiago de Chile. Due to their immense contribution to air pollution and their fast-changing characteristics, traffic emissions are highly significant for the formation processes of air pollutants. In transition and developing countries, both the composition of the vehicle fleet and the fuel characteristics differ greatly to those of industrialized countries. Road conditions and infrastructure is usually less developed and leads to different driving patterns and higher particulate matter emissions. In the light of these uncertainties, the development of a methodology for the accurate assessment of these transport emissions is a pressing need.

A complete and consistent emission inventory is the basis for reliable air quality simulations that could serve as decision-making tools and as an input for future scenarios, as well as abatement strategies for the improvement of living conditions and human health. Despite substantial knowledge gaps on air pollution in Latin American cities, progress has been registered in recent years. For Santiago de Chile, Schmitz (2005) described dispersion patterns of the Santiago de Chile basin, using a numerical air quality model. Rappenglück et al. (2005) carried out a photochemical campaign to identify the basic characteristics of ozone chemistry dynamics in Santiago de Chile. Universidad de Chile (<http://metano.dgf.uchile.cl/calidaddelaire.cl>) currently operates a numerical air quality forecast model using WRF/Chem model (Grell et al. 2005) developed in a joint effort by institutions from the USA, Chile and the Institute of Meteorology and Climate Research – Atmospheric Environmental Research Division (IMK-IFU) in the Forschungszentrum Karlsruhe (FZK) in Germany. Moreover, in cooperation with national and local environmental authorities, universities and the World Bank, IMK-IFU has evaluated current air pollution and mitigation strategies for specific emission scenarios for Mexico City (Forkel et al. 2004). Several measuring campaigns focusing on biogenic and anthropogenic emissions and air quality have been carried out in recent years.

Objectives and research questions

Numerous processes in the urban system, including traffic (emissions) and air pollution, are frequently described on a rough scale, with distances at best measured in kilometres. Processes that occur on a smaller (finer grid) scale are thus not explicitly treated. In mathematical models they are either ignored or parameterized. The broad scale approach to the investigation of air quality may be feasible for studies on regional air pollution but is ineffective when it comes to understanding the dispersion and impact of traffic emissions. Information on pollution levels on the micro-scale is essential for the study and assessment of ecological and human health impacts. Therefore an integrated approach that takes into account the micro- and macroscopic processes of traffic (e.g., traffic counts, flow) and its impact on air quality is indispensable. Air quality risk maps for particles and other toxic pollutants (e.g., PM₁₀, NO₂) will be provided for health impact assessment studies.

The research will address the following questions:

- (1) Given the scarcity of data in Latin American megacities, how can a suitable emission inventory for the production of reliable air quality assessment studies be developed?
- (2) To what extent are traffic emissions and air quality in megacities and their surrounding regions dependent on vehicle fleet composition and traffic flows?
- (3) How can separate information platforms (satellite data, in situ measurements and modelling tools) be linked as a preliminary to the development of an integrated approach to air quality assessment in Santiago de Chile and other Latin American megacities?
- (4) How should the relation between the levels of outdoor air pollution by various airborne substances (gaseous and particles) and the incidence of selected environment-related diseases be determined, taking local topographical and meteorological conditions into account?
- (5) How can the following be assessed:
 - (i) the contribution of traffic emissions to health conditions using traffic-related data to correlate air quality and health?
 - (ii) health risks associated with housing area/ housing type using the evaluation of different housing areas/ types?

Research in the *Air quality and health* and *Transportation* fields of application is strongly interlinked. The results from the *Transportation* field of application are a prerequisite for the calculation of traffic emission rates in selected neighbourhoods of Santiago de Chile. Furthermore, data on fuel consumption by area industrial sources, large point sources (e.g., power plants) and domestic heating, as well as on the transportation sector in general will be provided by the *Energy system* field of application. This will make it possible to link the bottom-up approach (car by car emission estimate) with the top-down approach (estimate of emissions from total fuel consumption) for the assessment of the traffic emission inventory. In addition, detailed information on land use patterns on different scales (local, regional, continental) as a basis for the calculation of biogenic emissions from forests and soils, and emissions from domestic heating will be delivered by the *Land use management* field of application. The former are highly relevant as a result of their vast contribution to the VOCs (volatile organic components) and their vital role in photochemical build-up processes (e.g., ozone, peroxyacethylnitrate (PAN)).

The findings on air quality will be used for health impact assessment studies. Furthermore, in combination with specific planning policies (using regulatory tools and economic incentives) they will also contribute to the definition of mitigation and adaptation strategies aimed at reducing environmental risks (e.g., air pollution, congestion, noise), social risks (e.g., spatial segregation, health problems), and costs (e.g., for transportation or production). This step towards the implementation of results will be undertaken in cooperation with the research teams working on the cross-cutting concepts.

Activities, methods and expected results

Work Package 1: Definition of indicators

In the *Air quality and health* field of application, indicators are generally linked to threshold values for certain pollutants (primary pollutants such as SO₂, CO, NO_x and PM, secondary pollutants such as O₃, PAN and NO₂) for a defined (exposure) time period (hourly, daily and annually). In many countries worldwide (including in Latin America) legal thresholds or limit

values are defined for the most harmful pollutants in the interests of protecting human life, animals and plants. This also holds true for Santiago de Chile, where in 1978 the Normas primarias de calidad de aire were introduced. Single indicators such as ICAP and IMECA represent air quality in terms of particles and other pollutants, respectively. In Mexico City, for example, the IMECA algorithm was introduced to describe the level of air quality on a normalized scale for all pollutants, and serves to inform the general public.

A combination of various pollutants, main tracers or other parameters could be relevant as specific indicators in health impact studies. The data will be determined with statistical tools in Work Packages 5 to 7. The aim is to find a certain number of indicators to be used in decision-making processes.

Work Package 2: Emission calculation and distribution of pollutants

Annual emissions by traffic can be approximated reasonably well with a top-down approach by statistics of fuel consumption within a specific country or city. However, air quality assessment studies require data with higher temporal and spatial resolution, which can only be derived with a bottom-up approach. Traffic emissions are controlled by factors such as vehicle fleet (e.g., type and age of cars), driving habits (e.g., acceleration, speed), pavement conditions etc. Micro-scale traffic models describe these factors. Hence they represent a powerful tool for the generation of meaningful information on emissions as input for air quality models. These models and their respective input data exist in many industrialized countries, allowing for the translation of data obtained by micro-scale traffic simulations into emission figures. However, the tools, i.e., the input data on which they are based, cannot be applied automatically to other countries, since the characteristics of the vehicle fleet, fuel quality, driving habits, road quality etc. may differ significantly. There is an obvious need for research if these tools are to be adapted to other conditions. Since only certain areas in the city can be subjected to simulation with micro-scale tools, information on traffic emissions for the rest of the city will be determined by applying the top-down approach, which takes the energy consumption of the entire traffic sector as the basis for calculations. This work package will be pursued in close collaboration with Work Package 2 in the *Transportation* field of application and Work Package 1 in the *Energy system* field of application.

A key issue in this work package is the validation of the emission data. For this purpose, specific methodologies, measurement strategies and inverse modelling tools to determine and validate emissions must be taken into account. Due to time constraints in the first, three-year phase of the initiative, this vital undertaking could be in the hands of the Chilean partners.

The overall output of this work package will be an updated, validated traffic emission inventory for Santiago de Chile, as well as detailed information on the distribution of traffic-related air pollutants in specific parts of the city.

Work Package 3: Combining models and measurements of different scales in order to assess current and future air quality for health impact assessment studies

Air quality in many Latin American cities is frequently described by data from monitoring stations located close to major streets in order to be representative for a large area. However, European experience in this context proves that data collected via monitoring stations in close proximity to major roads systematically and significantly exceeds average air pollution levels in a given urban area. In terms of air pollution these hot spots are typically associated with high concentrations of people. Hence, their impact on public health is crucial. Because common air quality models operate on broader scales, they are unable to consider these hot spots appropriately. To quantify air quality on the different scales, micro- and

meso-scale models must be combined and integrated. If they are to produce reliable results these models must have information concerning emissions on the corresponding scales provided by a traffic/ emission model, and macro-scale information for boundary conditions, e.g., by satellite. Combining the models will allow for an assessment of current air quality in and around Santiago de Chile. Air pollution risk maps (e.g., on NO₂, PM_{2.5}, PM₁₀ and O₃) for health impact studies will be a major output of this work package.

Work Package 4: Space-based remote sensing for regional air quality assessment

Air quality assessment from space has made significant progress in recent years (ACCENT 2005). Remote sensing can give area-wide regional information compared to spatially limited ground-based observations. However, the transfer of operational methods from Europe to Latin America is highly challenging with respect to the available data, local needs and conditions observed. In a first step, current operational methods for the retrieval of tropospheric trace gases NO₂ (Thomas et al. 2003) and SO₂ (Thomas et al. 2005) will be adopted for the Santiago de Chile area, using data from ENVISAT and MetOp atmospheric instruments. For example, regional air-mass factors will be provided to derive total column densities. Results will then be applied to improve background conditions for regional air quality models used in Work Package 2 (results will also contribute to improving emission inventories used in Work Package 1). Depending on cloudiness and scanning characteristics, cycles of polar orbiting instruments can vary between several days and several weeks and result in reduced coverage. Thus in order to evaluate the potential and limitations of space-based observation, the quality of augmented air-quality forecasts will be assessed with respect to instrument resolution and data coverage. These working steps will lead to area-wide coarse grid information on air pollutants for the metropolitan region of Santiago de Chile

After successful implementation of the gas phase component, the provision of space-based aerosol data will become part of the second implementation phase. The SYNAER method (Holzer-Popp et al. 2000), which is currently adopted for regional European air-quality modelling can then be applied to the Santiago de Chile area for the purpose of deriving aerosol optical properties.

Work Package 5: Time series analysis

In this work package the increase in health risks by air pollutants (see Work packages 2 and 3) will be quantified. To achieve this, the temporal variations of air quality will be correlated to health data.

Time series analysis allows for assessment of environment-associated risks without using comparison groups. A time series analysis will also be used to compare different groups. The aim is to identify risk groups and quantify the air pollution associated risks for societal groups generally assumed to be risk groups (children, the elderly and the chronically ill). For this purpose, the time series analysis will be carried out separately for different groups. With regard to environment-associated diseases, the research will focus on respiratory and cardiovascular diseases. Health data with daily resolution and in time scales from days to years can be included in the investigations.

Furthermore, risks triggered by various air pollutants will be ranked with respect to selected clinical endpoints. Risk rankings of air pollutants and disease symptoms of varying severity and incidence will be used in decision-making processes.

The results of time- (and space-) resolved air pollution modelling will be integrated. Meteorological data will be included as important confounders.

Work Package 6: Transversal studies and space-resolved analysis

The risk of air pollution associated diseases will be compared between various groups of the population of Santiago de Chile. Age cohorts and groups suffering from the relevant chronic diseases will form the core of these investigations, which do not require time-resolved data. Socio-economic data will be included.

As several areas in Santiago de Chile are particularly affected by car traffic and exposed to air pollutants to varying degrees, this work package intends to rank living areas with respect to their associated health risks. This will be achieved by correlating area-specific data on the occurrence of environment-associated disease to the results of (time- and) space-resolved modelling of air pollution (yielded by Work Packages 2 and 3).

Urban areas also differ with respect to their housing stocks. Therefore, it will be a major task of this work package to consider housing issues as confounders. Meteorological parameters will also be included as confounders.

Work Package 7: Extended confounder analysis

Other factors apart from air quality will be investigated for their impact on clinical endpoints associated typically with air quality (especially selected cardiovascular and respiratory diseases). This concerns above all the comparative assessment of risks related to housing areas with different population strata. Other parameters of interest are site density, traffic density, housing types, green space and other parameters related to socio-economic conditions. Additionally, at a later date, results of the *Socio-spatial differentiation* field of application will be checked for their relevance to this work package.

Work Package 8: Measures

On the basis of Work Packages 2 to 7, mitigation and abatement strategies aimed at reducing the concentration of specific pollutants and their impact on human health, i.e., risks to various clinical endpoints, will be developed. Collaboration with the Chilean partners will facilitate cooperation with local stakeholders, which is vital to achieving the practical relevance at which this work package is aimed. The key scientists from Universidad de Chile have long-standing, strong links to local and regional authorities.

Proposed focus of research on health within the second phase (2010-2013)

Since people spend the majority of their time indoors, the problem of indoor air exposure will be addressed in the second phase of the research initiative. The concentration of certain types of air pollutant (VOCs) is often higher indoors than outdoors. Hence health impact is always related to indoor and outdoor air quality. The main aims of this work package are to determine typical indoor/ outdoor concentration ratios for distinct pollutants and the influence of outdoor on indoor air quality, and to assess the dependency of this ratio on housing types and housing areas, and on behaviour (Franck et al. 2003; Schlink et al. 2004).

Data requirements

Air Quality: Detailed assessment and analysis of the air quality situation in Santiago de Chile demands a comprehensive emission inventory. All information on emission sources will be made available and/ or estimated via research work in other fields of application, in particular *Transportation* and *Energy system*. Additional information on air quality in and around Santiago de Chile will be provided by data from permanent measuring stations. Furthermore, background data on air pollution in the metropolitan region will be provided by the remote sensing methods employed in Work Package 4.

Health: Data from various sources is a prerequisite for analysis. Air pollution data yielded by Work Packages 2 to 4 forms the basis of the health impact studies. Furthermore, data on traffic flows and housing provided by the research teams in the respective fields of application (*Transportation, Land use management*) will be used. Data on public health will be delivered by the Chilean national health organization (FONASA), with which cooperation was established in the preparatory phase.

Generally, the acquisition and collection of data will greatly benefit from the close links of the Chilean key scientists to local authorities and regional ministries. Cooperation in these areas is a precondition for the successful pursuit of the work packages planned in this field of application.

Involved organizations and key scientists

- German Aerospace Centre, DLR DFD:
Frank Baier
- Forschungszentrum Karlsruhe, FZK IMK-IFU:
Renate Forkel, Klaus Schäfer, Peter Suppan
- Helmholtz Centre for Environmental Research – UFZ:
Ulrich Franck, Olf Herbarth
- Universidad de Chile, UCH:
Ricardo Muñoz, Rainer Schmitz

Other collaborating partners:

- Fondo Nacional de Salud, FONASA:
Michael Hagen

Preliminary Time Frame

	Months					
	1-6	7-12	13-18	19-24	25-30	31-36
WP 1						
WP 2						
WP 3						
WP 4						
WP 5						
WP 6						
WP 7						
WP 8						

Resources (in person years, implementation phase 1)

Person Years (scientific staff) 2007-2010	Key scientists ---permanent staff ---				Additional resources --- to be funded ---	
	FZK IMK-IFU	DLR DFD	UFZ	UCH	At Helmholtz	In Chile
Air Quality	2.5	1		0.4	1.25	1
Health			1	0.1		0.5

Additional resources will be allocated for travel, fieldwork, workshops and consumables.

9. Water resources and services

Speakers: Helmut Lehn, Forschungszentrum Karlsruhe; Ana Maria Sancha, Universidad de Chile; Andrei Jouravlev, Economic Commission for Latin America and the Caribbean (ECLAC/CEPAL), enquired

Background

Drinking water supplies and discharge of waste water are indispensable prerequisites for human life and well-being, and the prevention of infectious and chronic diseases. Furthermore, lack of access to basic services can lead to grave economic consequences, as the example of Peru's cholera epidemic in 1991 shows: the losses in fish product exports alone exceeded US\$ 700 million (Jouravlev 2004).

Compared to other Latin American megacities, such as São Paulo, Buenos Aires or Mexico City, the water supply in Santiago de Chile is of a high standard (Dourojeanni/ Jouravlev 1999; Morande/ Doña 1997; Jouravlev 2004). According to Aguas Andinas, the main water supplier in Chile (primarily owned by Aguas Barcelona), 100 % of the population in Santiago de Chile have access to public water supplies and 98.3 % are connected to an appropriate sewage system (SISS 2006). Several different sources of raw water are used. Surface water sources amount to 85 %, and consist predominantly of Río Maipo (river), Laguna Negra (lagoon), Embalse El yeso (dam) and Estero San Ramon (matting). Groundwater as the second source amounts to 15 %, and is provided by 150 deep wells and drains that extract water from three aquifers (Aguas Andinas 2006). The population estimates the water quality as relatively good (SISS 2006).

At the beginning of the twenty-first century only 13.7 % of waste water from the homes of Latin America's approx. 240 million inhabitants connected to sewerage networks receives some degree of treatment. The figure for Chile is approx. 20 %, with 10 % for Argentina and 15 % for Mexico. The return of the cholera in 1991 with about 400,000 cases and 4000 dead in the entire region was one of the factors for the initiation of an ambitious investment programme for waste water treatment in Chile, with an estimated volume of approx. US\$ 2 billion. Whereas in 1989, only 8 % of waste water was treated, the rate soared to 71 % in 2003 (Jouravlev 2004). Currently 73 % of urban waste water is treated. The country plans to treat all urban discharges in the near future (approx. 2010).

City	Population (mio.)	Juridical nature of enterprise	Water supply coverage (1998)	Sewerage coverage (1998)	Sewage treatment coverage (Date of Publication)
Bogotá	6.5 (2001)	public	91 %	81 %	20 % (2004)
Buenos Aires	12.1 (2001)	public***	78 %	63 % (2006***)	14 % (2003)
Caracas	2.1 (n.d.)	public	90 %	93 %	n.d.
Lima	7.5 (2000)	public	82 %	72 %	14 % (2005)
Mexico City	17.6 (2000)	public***	> 95 %	90 %	14 % (2003)
Santiago	5.4 (2002)	private	100 % (2005*)	98 % (2006**)	n.d.
Sao Paulo	17.1 (2000)	mixed	> 95 %	90 %	n.d.

*Table 3: Water Services in seven major Latin American cities (Trejos Gómez 2006; *Aguas Andinas 2006; **SISS 2006; ***Jouravlev 2006)*

In order to accelerate this process, the Chilean government opted to have these investments financed with private capital. Between 1998 and 2004, all of the companies in the water sector were privatized. It is worth noting that Chile has found its own mode in the field of drinking-water supply and sanitation, taking advantage of economies of scale and organizing water services on the basis of regional companies (Solanes/ Jouravlev 2006). The Chilean experience arouses interest because of the high efficiency levels already evident in the public companies of the past e.g., the Empresa Metropolitana de Obras Sanitarias (EMOS) in the metropolitan region of Santiago de Chile (Sjödín 2007), and reinforced through private capital after 1998. Two major elements seem to have accounted for the high performance of the public companies in the past:

- strict standards of financial reporting similar to those of private companies
- the establishment of rigorous independent regulatory authorities

Other elements seem to be a highly qualified staff, competitive salaries, company autonomy, and accountability to directors, owners (CORFO) and consumers (ECLAC/CEPAL 1998).

The Chilean Superintendencia de Servicios Sanitarios (SISS) regulates water and sanitary services (SISS 2006). This is a functionally decentralized entity with an independent budget, subject to control by the president of the republic through the Ministry of Public Works. The main responsibilities of SISS are:

- to propose tariffs for urban sanitary services to the Ministry of Economy and Energy (in relation to the production and distribution of potable water, and the collection and disposal of waste water)
- to control the fulfilment of norms that regulate the sanitary companies operating in urban areas
- to control compliance with environmental norms related to the decontamination of residual waters

The duty of private companies is the abstraction and distribution of potable water, and the collection and disposal of waste water. SISS supervises all water company operations and develops norms and standards for water, waste water and liquid releases. Environmental auditing is arranged by the private companies themselves, although SISS does carry out random controlling (for water supply only). Unlike other examples (Buenos Aires, Argentina; Cochabamba, Bolivia) the privatization of water services does not appear to interfere with social responsibility in Chile. A system of direct subsidies for low income homes (Law N°18.778) is in place. Thus, for megacities in other Latin American countries, Santiago de Chile seems an interesting example in the context of standard-setting for access to drinking water, efficiency and quality of water supply, and waste water treatment.

Nevertheless, the benefits arising from expertise and the equipment of globally active water companies could be foiled by other factors, e.g., weak regulatory frameworks or aggressive economic behaviour, as discussed and criticized worldwide (Bravo 2006). Hence an in-depth exploration of the socio-economic interrelations between government and the water industry is crucial.

As far as water resources are concerned, the Dirección General de Aguas (DGA), which was established in 1967, must plan the development of natural water resources, based on rational use, and the investigation and measuring of water resources. The natural body of water must be monitored, water rights allocated, and the activities of user organizations carefully watched, with the aim of orienting its usage to the interests of the nation (DGA 2006). Despite the fact that Chile is endowed with opulent water resources (> 70,000 m³/c y compared, for example, to Germany with 2,400 m³/c y), it seems that the demand for water in

the metropolitan region has already reached availability levels (Nauditt et al. 2002). It is currently not clear to what extent Santiago de Chile uses the surface and subsurface water resources of its catchments, whether there is a relevant competition between urban water usage and other human purposes outside Santiago de Chile (e.g., irrigation), or what share of the stock should be reserved to secure the water-based ecological function of the region.

The question of whether and to what extent water management should be regulated by tradeable water rights remains unanswered. Large agricultural farms or mining companies, for example, buy water rights from poorer areas and settlements. Selling water rights can be a source of conflict when it comes to limited water resources in regions of interest, as seen in the case of a high water demand for intensified irrigation vs. available water resources investigated for the Limari basin (Alvarez et al. 2006). In more general terms, “the critical problem is that property rights to water are defined as strictly private commodities in such broad and unconditional terms that there is no effective way to assert or defend public rights and interests – whether these public interests are economic, social or environmental. ... Legislation should be drafted to clarify the rules governing the exercise of non-consumptive versus other water rights in managing river basins, dams, and reservoirs” (Bauer 2004).

In summary, Santiago de Chile is known for its high level of coverage, efficiency and quality in water service provision, distinguishing it favourably from most other cities in Latin America. Investigations of the specific determinants and implications of this performance (regulatory framework, upstream and downstream linkages, ecological, economic and social conditions) could provide a framework for comparison or application to other metropolitan areas in the region. To engross this topic a comparison with German framework conditions and German water associations, such as BGW (Bundesverband der deutschen Gas- und Wasserwirtschaft) or DVGW (Deutsche Vereinigung des Gas- und Wasserfachs) will be useful.

Objectives and research questions

The objective of the *Water resources and services* field of application is to provide a general implementation strategy for water supply services and waste water treatment in Latin American megacities that can be considered sustainable in terms of the relationship between the cities and their hinterland, as well as the access, soundness, quality and robustness of the services within the city. Chile can be seen as the most successful country in the region in the field of drinking water supply and sanitation. Santiago de Chile could serve as an example to demonstrate that water supply and sanitation services can, under certain conditions, be effectively provided by public and private companies in the appropriate framework.

The research questions in this field of application can be divided into four blocks:

- (1) Research topics associated with water and sewerage services are analysis of the legal frame, economic principles and tools, and the role of the state and stakeholders in governing water-related matters. The second important question is the economic impact of water use in the megacity on upstream (shortage) or downstream (chemical and microbiological pollution) economic projects, for example in the agricultural, mining or touristy sector. This issue is closely linked to the assessment of water resources management in the entire catchment area, including surface and subsurface resources (see block 2).

- (2) As far as the relations between city and hinterland are concerned, research on water resources will focus on the assessment of quantitative and qualitative aspects, and on the question of appropriate technologies. Ecological flows are important reference marks for the volume of water the city can be supplied with. They are also relevant benchmarks for the quantity and quality of waste water to be discharged in the rivers. Appropriate technologies for water saving or waste water treatment can scale down the stress the city puts on its environment.
- (3) The following are the key questions: What are the risks for sustainable development of the hinterland (upstream and downstream) arising from water usage in the city? What are the potential risks for the water supply of the city that result from potential changes in the water use upstream Santiago de Chile (85 % superficial resources)? What effects of global climate change could be anticipated for water-related sustainable development in the city and its hinterland?
- (4) The research questions in the fourth block deal with risks resulting from the water infrastructure itself. Badly designed pipe systems hold risks for human health and the ecosystem. The climatic conditions of many megacities in Latin America imply heavy downpours. This involves risks of flooding as a result of dysfunctional drainage systems and hygienic risks as a result of overflowing combined sewers. Groundwater under cities is at risk of pollution from leaky sewerage systems. The risk of damage to water or sewage pipes in the case of a natural disaster (earthquake) will also be a major research issue.

Activities and expected results

Work Package 1: Development of indicators

Water-related sustainability indicators and target values will be developed in close cooperation with the *Sustainable Development* research team and the scientific partners and stakeholders in Chile (e.g., Dirección General de Aguas, Superintendencia de Servicios Sanitarios, Aguas Andinas). Indicators for ecological interaction of the megacity with its catchment area could be: distributable water quantum, number and location of groundwater protection areas and quality standards for discharged sewage. To assess sustainability of services in the city, indicators could include, e.g., access to and per capita use of drinking water, prices, and chemical and microbiological quality standards.

Work Package 2: Status analysis (including data collection and harmonization).

According to the indicators of Work Package 1, a consistent database on water resources and water services will be built up in close cooperation with the above-mentioned stakeholders in Chile (Work Package 1) and the other research teams in the initiative, e.g., with *Governance* on the privatization of water services, with *Land use management* on groundwater protection areas, with *Waste management* in terms of usage of sewage sludge and groundwater pollution at waste disposal sites or with *Energy system* on hydropower.

The role and interaction of the individual stakeholders (the state, private companies, water users) in various fields of action (legislation, norm setting, dispatch control, payment practice) and the economic impact of water usage and pollution by various players upstream and downstream the city will be analysed. This includes the impact of urban water use on the economic sectors in downstream areas, e.g., agriculture (irrigation) or tourism, and the economic impact of upstream water usage (e.g., irrigation, mining) on the city itself. The distribution system for water and sewerage networks will be analysed in terms of hygienic, ecological and technical soundness.

Work Package 3: First evaluation (sustainability analysis)

Sustainability deficits will be identified and ranked by comparing the data describing reality with the indicators and their target values. The causes of the most urgent of these will be analysed in an effort to work out recommendations to further sustainability.

Work Package 4: Measures

Based on the findings of Work Package 3 and in interdisciplinary and transdisciplinary collaboration, the Chilean and German partners will compile recommendations to improve water supply and waste water treatment in terms of sustainability.

Work Package 5: Final evaluation, conclusion and recommendations

Anticipation of potential threats to water resources in the catchment area and water services in the city resulting from normal operation (systemic risks) or from hazardous incidents (e.g., earthquake, flooding) will be carried out in close cooperation with the *Risk* and the *Land use management* research teams in a scenario analysis. Recommendations must take into consideration the consequences of global climate change on the water supply (temporal and spatial availability, growing conditions for microbes) and sewerage systems (diluting capacities of rivers, decomposition of dissolved matter and survival conditions of pathogens), as well as on new concepts in treating sewage (membrane bioreactors, more decentralized systems, separate treatment of different waste water qualities).

Methods, data requirements

It is assumed that basic data to answer the research questions is available in the literature and the different public or private institutions. Collection and evaluation of this data will be supplemented by both expert and stakeholder inquiries, should this be necessary and possible. In the case of data gaps or contradictions with regard to the exchange of water from different water compartments or water quality, water samples from these areas will be taken and analysed hydrochemically and microbially. The microbial community structure will be assessed with fingerprinting methods and individual sites compared. Where possible, the functional diversity of the microbial communities will be evaluated. This will give a key insight into the resilience and natural attenuation of the different sites.

Involved organizations and key scientists

- Forschungszentrum Karlsruhe, FZK ITC-WGT:
Wolfgang Höll, Ursula Obst
- Forschungszentrum Karlsruhe, FZK ITAS:
Helmut Lehn
- Helmholtz Centre for Environmental Research – UFZ:
Gerhard Strauch
- Helmholtz Centre for Infection Research, HZI:
Wolf-Rainer Abraham
- Universidad de Chile, UCH:
Ana María Sancha
- Economic Commission for Latin America and the Caribbean, ECLAC/CEPAL:
Andrei Jouravlev

Preliminary Time Frame

Months						
	1-6	7-12	13-18	19-24	25-30	31-36
WP 1						
WP 2						
WP 3						
WP 4						
WP 5						

Resources (in person years, implementation phase 1)

Data collection and analysis is to be carried out by graduate students from Latin American universities working in Santiago de Chile and reported in six-monthly cycles to the key scientists. Key scientists and graduate students will conduct evaluations and work out recommendations. The linkages between the work packages in this field of application, between this and other fields of application, and between this application field and the cross-cutting concepts will be established by the key scientists. ECLAC/CEPAL, the key partner in Latin America for this field of application has shown substantial interest in participating. Some of the graduate students will be placed in ECLAC/CEPAL.

Person Years (scientific staff) 2007-2010	Key scientists ---permanent staff ---				Additional resources --- to be funded ---	
	FZK ITAS	FZK ITC-WGT	HZI	UFZ	At Helmholtz	In Chile
	1.9	1.2	1.5	1	3	3

Additional resources will be allocated for travel, fieldwork, workshops and consumables.

10. Waste management

*Speakers: Helmut Seifert, Forschungszentrum Karlsruhe;
Marcel Szanto, Pontificia Universidad Católica de Valparaíso*

Background

Although health and environmental problems arising from inadequate solid waste management are well known, many parts of Latin America have not given this issue the necessary weight. Nor has the development of services related to waste management received sufficient attention up to now. An average of 60 % to 80 % municipal solid waste is collected in the urban centres, with only 23 % disposed of in a sanitary and environmentally sound manner (UNEP 2003). Of the seven Latin American megacities (Mexico City, Bogota, Caracas, Lima, Sao Paulo, Buenos Aires, and Santiago de Chile), those with the lowest waste collection rate are the metropolitan areas of Lima (60 %) and Mexico City (80 %) (UNEP 2003). In Buenos Aires, for example, large areas of the city are excluded from waste collection, while in the peripheral neighbourhoods waste is simply dumped onto open sites (Ainstain 1996).

The generation of municipal solid waste in Latin America varies between 0.37 and 2.65 kg/(inhab*day), with an average of 0.91 kg/(inhab*day). Likewise, big cities are the most active generators of municipal waste per capita, with approx. 1.1 kg/(inhab*day), while the small or poor settlements generate waste at an average of less than 0.5 kg/(inhab*day). In 1997, the highest per capita production of municipal solid waste in the above-mentioned vast urban areas of Latin America occurred in Sao Paulo, with a value of 1.35 kg/(inhab*day), increasing to 1.99 kg/(inhab*day) in 2005. Lima in the same year produced the lowest amount of municipal solid waste, with a value of 0.56 kg/(inhab*day), rising to 0.7 kg/(inhab*day) in 2005. In Santiago de Chile the corresponding values are 0.87 kg/(inhab*day) for 1997 and 1.18 kg/(inhab*day) for 2005 (PAHO 2005a).

In Latin America, the formal segregation and recovery of recyclable materials is not carried out on a large scale. On average, only 2.2 % of the materials are recovered. Despite the wide promotion of informal recycling, the subtlety of these activities makes it difficult to identify the magnitude (PAHO 2005b). The solid waste area in almost all Latin American countries is considered at best a subsector or a component of the water and sanitation sector (PAHO 2005a). Investments in municipal solid waste management are minimal compared to other public services, such as electricity, potable water and basic waste water, and concentrate on equipment and infrastructural systems for final disposal. Technological development and research in municipal solid waste management is also low in the majority of Latin American countries.

In the metropolitan region of Santiago de Chile, waste arisings per capita in the population group with the highest income are twice as high as those in the population group with the lowest income. The recent upsurge of waste production is caused, among other things, by rising incomes in all population groups and extended use of non-returnable products. As a result, the fraction of organic matter in domestic waste has declined, while that of plastics has increased (Reyes 2004b; Szanto Narea 2006)

In the metropolitan region of Santiago de Chile, 95 % of domestic waste is collected, transported and deposited in approved land fills. Waste collection is performed by ten different enterprises, albeit 72 % of all domestic waste is collected by only three of them. The

result is lack of competition and potentially higher prices. Waste collection, with a frequency of three times a week in most areas, and daily collection in some, covers the entire metropolitan region of Santiago de Chile.

Three relatively new landfills are used in waste collection. The first began to operate in 1996, the other two in 2002. All of them are equipped with a base seal and a collection system for leachate. Waste that is not collected is either recycled informally or deposited in pseudo legal dumps ("vertedero"), illegal garbage dumps, or simply dumped indiscriminately. According to the National Environmental Commission, sixty-six illegal garbage dumps existed in Santiago de Chile in 2001 (CONAMA 2002). Data on the cost of municipal solid waste collection and transport given in the literature varies between US\$ 10 and US\$ 25 per ton; costs for waste disposal vary between US\$ 10 per ton and US\$ 20 per ton, resulting in an average value for collection, transport and disposal of US\$ 30 per ton. It should be noted that the gate fee of between US\$ 10 and US\$ 20 per ton is extremely low; according to modern standards controlled landfilling is reported to cost US\$ 30 to US\$ 40 per ton (Weinstein 2006).

Recycling programmes have not been officially established in Chile. However, the recycling of paper got under way in the 1980s when members of the poorest families walked through the streets separating paper and cardboard from domestic waste as an income-generating activity. The population is now used to collecting paper and cardboard. Glass is also partially recycled. One glass-recycling incentive was to declare the respective revenue proceeds for charity. In recent years the recycling of paper, cardboard, plastics, glass and metals has increased steadily, and a growing number of communities in the metropolitan region of Santiago de Chile have incorporated the duty of recycling these materials into contracts with enterprises responsible for waste disposal. In 1997, only 1 % of total domestic waste was recycled. This value rose to 9 % in 2003 (see Figure 12). Approx. 28 % of paper and cardboard, 6 % of plastics, 13 % of glass and 56 % of metals were recycled in 2003. Meanwhile members of the Regional Environmental Commission of the Metropolitan Region (COREMA RM) have put the *Regional Recycling Strategy* into effect (Reyes 2004b). This strategy aims at the implementation of a permanent recycling system for the region, which is self-preserving and will lead to a recycling rate of 20 % of the arising from domestic waste after 2006.

The law regulating income in the communities allows them to charge fees for the disposal of domestic, commercial and industrial waste. Fees charged for each household are calculated on the basis of total waste disposal costs divided by the number of households. However, because of the many exceptions to this rule and the number of households unwilling to pay, cost coverage is a mere 30 % of the total cost of waste disposal. There is an obvious lack of steering with regard to waste arising, since waste disposal charges are not related to the amount of waste produced by individual households, and most households are even unaware of these fees.

In Chile, the handling of domestic waste is regulated by several laws, remittals, regulations and enactments, and the authority to supervise compliance with these regulations is divided between several ministries and public institutions. Nevertheless, the individual communities have the responsibility of deciding how waste disposal should be organized and controlled. There are juridical gaps in important fields, control mechanisms are either inefficient or entirely absent, and in many cases the implementation of the law is unclear. Hence, violation of existing laws cannot be excluded. The issue of waste disposal has been discussed controversially by the public, the various communities, the NGOs, and the media. The debate

centred on lack of transparency and public support for decisions on landfill sites and the technology required for their operation.

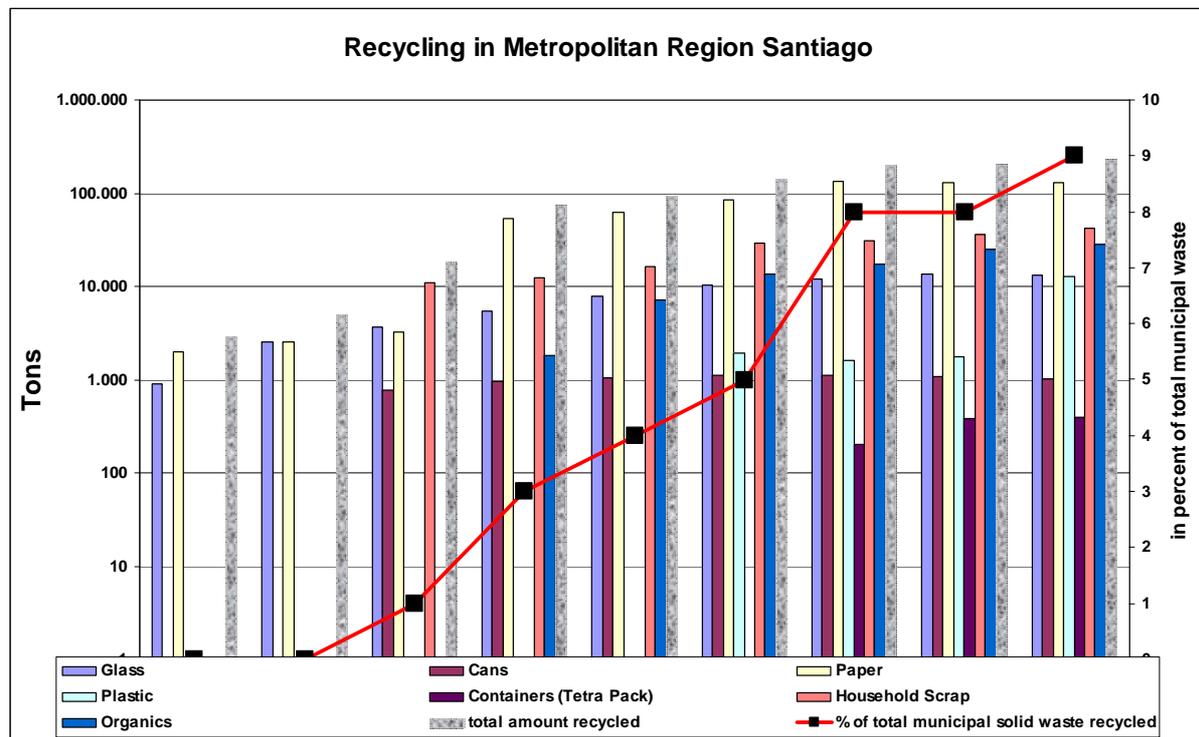


Figure 12: Recycling of municipal solid waste in the metropolitan region of Santiago de Chile: amount of different fractions (left axis) and percentage of total municipal solid waste arising (right axis) (Weinstein 2006)

Objectives and research questions

Up to now municipal solid waste management both in Latin American countries and megacities has not always been successful. Neither has it been analysed from a sustainability perspective. Therefore, the aim of the research work is to build up a data inventory for the management of municipal solid waste in the metropolitan region of Santiago de Chile, to evaluate this system under sustainability aspects and to identify its risks for sustainable development. In order to achieve these tasks the *Waste management* research team, in cooperation with Chilean stakeholders, will:

- work out guidelines for action and indicators for waste management in the metropolitan region of Santiago de Chile
- analyse the current waste management system with respect to these indicators
- develop scenarios and work out strategies to accomplish a more sustainable system of waste management

The analysis of the waste management system's current status will identify sustainability deficits related to the management of municipal solid waste in the metropolitan region of Santiago de Chile. These deficits will then be analysed with respect to the risks they pose for the sustainable development of Santiago de Chile. Several scenarios are to be developed on this basis. They will take into consideration the future development of waste arising, composition, collection, treatment and disposal. A variety of technical options for waste management and institutional and economic boundary conditions is to form the basis of these scenarios, which will be designed to reduce the sustainability deficits and risks

identified. Furthermore, conditions for implementation of these scenarios (economic, social and institutional) will be analysed.

Activities and expected results

Work Package 1: Development of indicators

Based on the ongoing FZK ITAS study *Waste management and Sustainability* (Kopfmüller et al. 2005), and in cooperation with the partners and stakeholders from Chile, sustainability rules, indicators and targets will be discussed and modified according to Latin American conditions.

Work Package 2: Analysis of the current waste management system with respect to waste-related sustainability indicators

In order to analyse the actual state of these indicators, it is necessary to build up a consistent database for municipal solid waste management. This will comprise data about quantity and quality of waste, social state of population groups as well as an analysis of the current waste management system (collection, transport, waste disposal, recycling activities, measures for waste prevention). Due to the fact that in the future special waste fractions might be used as an energy source (e.g., the organic fraction) data for these fractions might serve as an input for the *Energy system* field of application. In addition data on emissions into air and water resulting from the management of municipal solid waste will be collected and the impact of these emissions on health and the environment will be analysed. This will include health impacts for people involved in the collection of wastes, especially for people from the informal sector. Should the data show that the groundwater is contaminated as a result of landfill operations, it will serve as an input for the *Water resources and services* field of application. Collection of data will be achieved by reviewing the available literature, questioning the relevant people and organizations and if necessary by investigations of this research team in close cooperation with our Chilean partners.

The urban sanitation system, including waste management, is mainly financed by the municipal budget and to a lesser degree via the collection of charges for the various services carried out. As a consequence the allocation of costs to individual services is not known. In addition, the cost of land filling in Santiago de Chile seems low in comparison to values from other countries. This work package will compile cost data for the various stages of waste management (collection, transport and disposal) and analyse in depth the reasons for the low costs of waste disposal.

Waste management in Santiago de Chile is determined by a legal framework composed of a heterogeneous set of laws, decrees and regulations. However, the existing legislation for the solid waste sector is frequently dispersed in different legislative provisions. The lack of complementarity among the various legal provisions and the often constitutional contradictions in the designation of authority at the individual governmental institutions at national and local level hampers its effectiveness. The work will focus on the following questions:

- which regulations are relevant for collection, transport, handling and disposal of waste?
- which regulations are relevant for the selection, approval and acceptance of sites for the purpose of land filling?
- how do these regulations influence waste management and what are the deficits in implementing these laws?
- what incentives are given to increase recycling and waste reduction?
- who are the players involved in the system of waste management?

Work Package 3: Evaluation of the waste management system and elaboration of recommendations for a more sustainable waste management system

On the basis of the findings in Work Package 2 sustainability deficits and the ensuing risks will be identified. To accomplish this, it will be necessary to identify the causes. On the basis of these findings recommendations will be given on how a more sustainable waste management system can be achieved.

Work Package 4: Creation of scenarios for a future waste management system and their evaluation with respect to *Sustainability, Risk and Governance*

On the basis of results from Work Packages 2 and 3, scenarios will be developed in close cooperation with the other researchers and Chilean stakeholders. These scenarios will take into account the future development of waste arising and waste composition, as well as waste collection, treatment and disposal. This development will be affected by economic development, changes in population figures and the implementation of new technologies. Evaluation of the scenarios will indicate the most appropriate combination of technologies for the achievement of a more sustainable waste management system. The conditions for the implementation of these scenarios will also be analysed.

Depending on the results of Work Package 3, several options and technologies will be taken into consideration, of which the following could be of particular relevance:

- use of landfill gas
- biogas/ anaerobic digestion plants
- composting
- separation of waste for recycling and/ or composting
- waste to energy plants (incineration, co-incineration)
- organization of the waste management system and role of the informal sector

Biogas from the organic waste fraction could be generated in combination with biogas from the sludge of waste water treatment. This option will be analysed in close cooperation with scientists from the *Water resources and services* field of application. The use of special waste fractions as a source of energy will be analysed in close cooperation with scientists from the *Energy system* field of application.

Methods, data requirements

Data will be taken mainly from the literature and interviews with the relevant stakeholders and organizations in Chile. It should then be assessed and merged appropriately. Data gaps will be reduced by additional measuring programmes (if possible) or model calculations. If the data gaps cannot be closed, the need for further research will be pointed out.

The starting point for the compilation of sustainability indicators and related target values is the ongoing *Waste management and Sustainability* ITAS study (Kopfmüller et al. 2005). In cooperation with the research team from the cross-cutting concept *Sustainability* and the partners and stakeholders from Chile, these indicators and target values will be modified and adjusted to the situation in Chile and especially the metropolitan region of Santiago de Chile.

The creation of scenarios for the future development of municipal solid waste management towards greater sustainability will again be carried out in cooperation with the partners in Chile.

Involved organizations and key scientists

- Forschungszentrum Karlsruhe, FZK ITAS:
Klaus-Rainer Bräutigam, Nicola Hartlieb
- Forschungszentrum Karlsruhe, FZK ITC-TAB:
Helmut Seifert, Jürgen Vehlow
- Pontificia Universidad Católica de Valparaíso, UCV:
Marcel Szanto

Preliminary Time Frame

Months						
	1-6	7-12	13-18	19-24	25-30	31-36
WP 1						
WP 2						
WP 3						
WP 4						

Resources (in person years, implementation phase 1)

Person Years (scientific staff) 2007-2010	Key scientists ---permanent staff---		Additional resources --- to be funded ---	
	FZK ITC-TAB; FZK ITAS	UCV	At Helmholtz	In Chile
	2	0.5	1.6	3

Additional resources will be allocated for travel, fieldwork, workshops and consumables.

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