

Developing urban Indicators for Managing Mega Cities

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Key words

governance, infrastructure, megacities, sustainable development, urban growth, urbanization, vulnerability.

Abstract

Managing urban growth has become one of the most important challenges of the 21st century (cf. Cohen 2006, p. 78). As a result of the uncontrolled and unplanned sprawling of the cities, the rapid process causes a lot of different ecological, economic, social and infrastructural problems and risks. Considering the high density and the large number of inhabitants combined with the accelerated urban development, particularly megacities run highest risk in cases of natural and man-made disasters.

On the one hand, this paper identifies the risks of the ongoing form of urbanization, on the other hand, it intends to point out significant opportunities and chances, which cities offer to address urgent issues. In combination with this, the article discusses the importance of Spatial Information Systems which can be used as tools for megacities to communicate different environmental risks, and promote strategies and measures of sustainable urban development and disaster risk management. These systems base on different urban indicators, which will be described in the following. Finally, the article examines the ways in which land use and urban planning is responding to the impacts of urbanization.

1. CURRENT TRENDS OF URBANIZATION

The 21st century is the century of the cities and of urbanization (cf. Hall/Pfeiffer 2001). Urbanization as the process of transition from a rural to a more urban society (UNFPA 2007, p. 6) is increasing rapidly and will continue during the next decades, especially in many developing countries. According to the State of World Population Report 2007, a current report from the United Nations Population Fund, in 2008 for the first time in human history more than half of the world's population will be living in urban areas (cf. UNFPA 2007, p. 1). Today 3.3 billion people already live in cities and by 2030 that number will have risen to almost 5 billion. The total population is increasing by 280.000 people per day, whereas 95 % of the annual population increase between 1994 and 2004 occurred in less developed regions. While in developed countries urbanization has mainly taken place in the second half of the 19th cen-

tury, developing countries are now in the middle of their urban growth now. In Europe already 72 % of the population live in urban areas (cf. UNPD 2006). The urbanization process has come to stand still and a process of dis-urbanization and sub-urbanization caused by a high rate of motorization combined with prosperity and the development of traffic and communication infrastructure is noticeable.

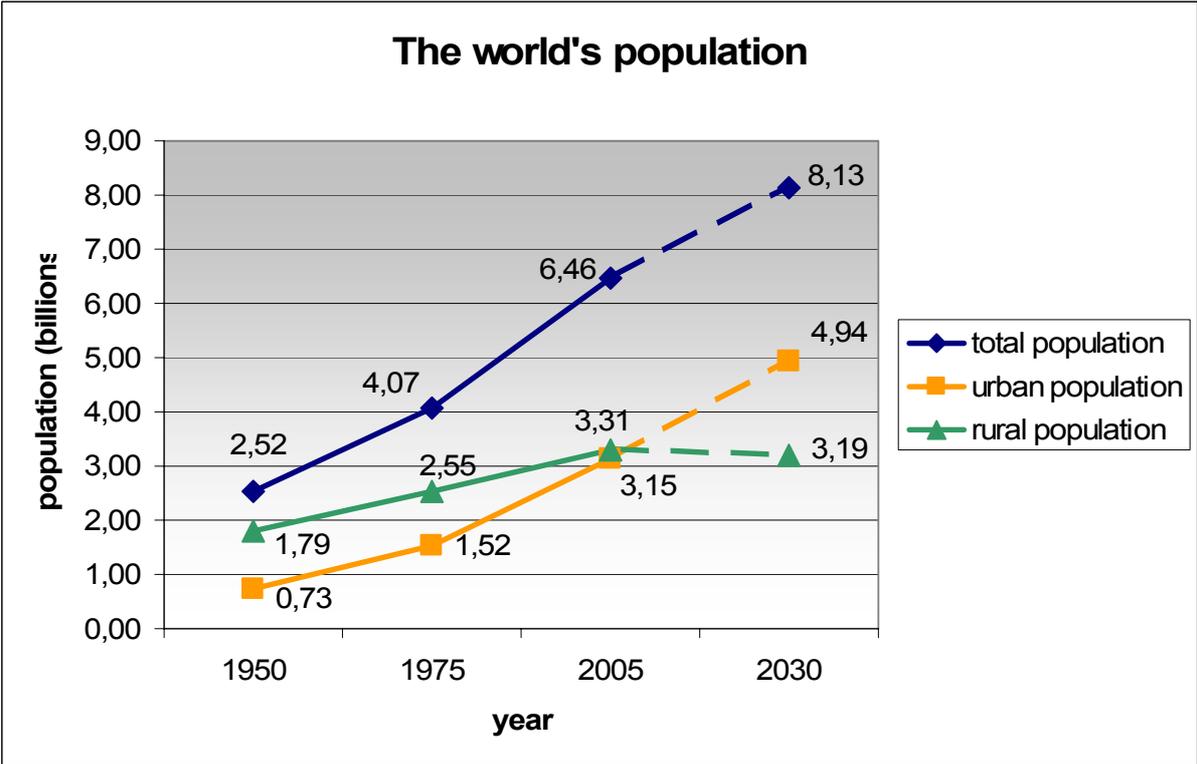


Figure 1: Total, urban and rural populations 1950-2030 (Data from UN Department of Economic and Social Affairs/Population Division. World Urbanization Prospects: The 2005 Revision).

Compared to industrialized countries the urbanization in developing countries is increasing rapidly and will continue to increase in the next decades. The highest growth will mainly occur in the cities of Asia and Africa, in areas that are now more than two-thirds rural and by 2025 will be half urban. Never before has urban population expanded so fast, due to the ongoing progress in agriculture, nutrition and medicine. For example the Eastern African States Burundi and Rwanda have average annual population growth rates of more than 6 % (2005 – 2010), which lead to a doubling of urban population every 13 years (cf. UNFPA 2007, p. 90). A high birthrate combined with an increasing migration from the rural areas that is reinforced by the so called “push-factors” (unemployment, low standards of housing and infrastructure, lack of educational facilities) and “pull-factors” (economical opportunities, attractive jobs,

better education, modern lifestyle) leads to this very dynamic growth process. Most of this urban expansion is taking place in the poor areas of the cities. The number of megacities, usually defined as metropolitan areas with a total population of 10 million or more people, is increasing worldwide: 1950: 2, 1975: 4, 2003: 21, 2015: 23. Two third of them are situated in developing countries, especially in South-East-Asia. In 2003 already 283 million people lived in megacities, 207 million of them in developing countries, more than 171 million in Asia. In the year 2015 the total population of megacities worldwide will be about 359 million and the future rate of growth will be high, as the development of Jakarta, Delhi, Dhaka and Karachi have shown. Their population tripled between 1975 and 2003. According to the estimation of the UN concerning the number of megacities in 2015, Tokyo (36.2 mill. inhabitants), Bombay (22.6), Delhi (20.9), Mexico City (20.4) and São Paulo (20.0) will be the worldwide five biggest megacities each with much more than 20 million inhabitants. 100 years ago, London (6.5) was the largest city (one million more inhabitants than New York), today it is shrinking. The rapid process of urbanization and the growing number of the megacities cause a lot of different environmental, economic and social problems and risks. These impacts cause challenges for urban policies and urban planning strategies while managing the development in a sustainable way, especially when the population in some cities doubles every 10 to 15 years. The reason why the urban agglomerations and metropolitan areas as well as megacities come into the international focus of policy and science are their serious impacts on the global environment such as the enormous land consumption, air pollution, water scarcity, poverty, social segregation and vulnerability. As the numerous national and international networks and research activities on urbanization and megacities show, there is an obvious need for more and better urban development strategies, long term land policy and forceful urban management (cf. Kraas 2007).



Figure 2: Spatial distribution of the world's megacities 2015.

2. IMPACTS OF URBANIZATION AND URBAN INDICATORS FOR MANAGING MEGACITIES

The following characteristics of megacities have to be mentioned as the typical features that bring these agglomerations into the focus of science, policy and economy. These **characteristics** imply a lot of serious risks, but also potential benefits for the regional and global development.

The future goal should be to establish a system of **urban indicators** to monitor and steer the development of the megacities. Based on the main characteristics of megacities, the most important indicators are given in the following parts.

- **Density**: Megacities show the highest density of inhabitants, industrial assets and production, social and technical infrastructure. Metropolitan areas and especially megacities become more and more the centres and junctions of the global economy. With their important role as centres of political and economic decisions they are promoters of national and international developments. Furthermore in these areas lots of highly qualified and “inexpensive” skilled labour are available and also the concentration of capital stock make them attractive for investments. Urban agglomerations and megacities generate a lot of income and their local economies have an importance for their rural surroundings.

Most important Indicator:

- Population density (=concentration of the human population in reference to space)

- **Dynamism of growth:** Megacities are characterized by the highest dynamics in the fields of spatial and demographic growth, change of land use and consumption of land for settlement purposes that mostly takes place in absence of urban planning. Also the formal and informal urban economic sectors are on a high dynamic level. The local, regional and global markets and the connection with the international economic circulation induce various increasing economic activities, so that megacities have the economic potentials and power to initiate economic growth also in the regions around the urban areas.

Important “growth” indicators:

- Society: Population growth rate
- Economy: Real GDP growth rate
- Land: Suburbanization rate, land sealing rate

- **Settlement, infrastructure and land tenure:** In the most agglomerations and megacities urban planning and public infrastructure can only partially guide the urban development in order to achieve a proper sustainable structure. The extension of cities is always in advance of urban development work and the provision of public facilities. Different to conventional urban planning the development in megacities proceeds outside the law with absence of land use planning. Especially the informal housing areas and in many times also illegal housing areas (squatters) that are build up by the migrants themselves lead to an extensive settlement structure. The illegality of those residential areas results mainly from the land tenure system. In many cases the infrastructure, public and private transportation, garbage removal and sewage systems with waste water purification are not efficient or not available. Most urban dwellers have no sanitation facilities and the rainwater drainage systems are totally inadequate. This situation has serious consequences on the environment and public health.

Important urban indicators:

- Number and dimension of informal settlements (=residential area occupied by formal settlements)
- Change of land use (contaminated land, derelict land, new developments, loss of protected sites etc.)
- Quality/quantity of urban infrastructure

- **Socio-economic disparities:** In megacities we can recognize a wide range of social standards and social fragmentation as well as social-cultural conflicts because of the different backgrounds of the immigrants. A great number of urban poor are badly provided with public facilities and infrastructure and their housing areas are often edged out by stronger economic purposes and land use. The development and extension of cities is accompanied with rising urban poverty. Roughly a quarter of the population of the developing countries (1.2 billion people) are living in situations of absolute poverty on less than one dollar per day (cf. World Bank: World Development Report 2005). A resident in a poorer housing area in Chicago has better living conditions than about 80 % of the megacity-dwellers in the developing countries. E.g. in Calcutta, Madras, Bombay and Delhi more than 50 % of the inhabitants are living in informal settlements. The growing socio-economic disparity within the megacities and the lack of social cohesion is the most serious explosive charge (cf. UN-Habitat 2004).

Important socio-economic indicators:

- Poverty Rate
- Unemployment rate (= average of unemployed men and women during the year)
- Mortality rate

- **Risks and vulnerability:** Megacities are highly vulnerable to natural and man-made disasters: Most of them are concentrated in disaster-prone areas where floods, earthquakes, landslides etc. are most likely to happen (Wisner 2003, UN Office for the Coordination of Humanitarian Affairs 2005). It is obvious that the major part of the damage will take place in developing countries with a dramatic impact on poor people and ethnic minorities. Countries with low human development account for 53 percent of recorded deaths from disasters even though they are home to only 11 percent of the people exposed to natural hazards worldwide (UNDP 2004, p.10). Primarily the unplanned urban growth causes a lot of different ecological, economic and social problems and risks. Considering the high density and the large number of inhabitants combined with the accelerated urban development, megacities run highest risk in cases of disasters. It is expected that the vulnerability of the society and the human environment as well as the threat by disasters will intensify continuously in the future. Due to the fact that worldwide the loss potential from natural catastrophes is increasingly dominated by megacities, the insurance company Munich Re has developed a megacity risk index to make risks and loss potentials transparent and to allow a comparison between the cities (Munich Re 2004).

Important disaster risk indicators:

- Risk of mortality
- Risk of economic loss
- Vulnerability rate, identified for each hazard type

- **Urban Governance:** Urban Governance includes the state, but transcends it by taking in the private sector and civil society. So it means both, government responsibility and civic engagement (cf. UNFPA 2007, p. 67). One of the greatest challenges of megacities is their governability and one can recognize a crisis of urban government in this. The experiences show that the possibilities of solely orientated forms of centralized governance with top down strategies are restricted because of the extension, highly dynamic and highly complex interactions within the megacities and also with their surroundings. In the case of spatial planning, decentralization and innovative planning processes with intensive participation of the population are necessary (cf. Magel/Wehrmann 2001).

Urban/good governance characteristics:

- Participation, rule of law, transparency, responsiveness, consensus orientation, equity, effectiveness, efficiency, and accountability
- Indicators: i.e. corruption index

Especially the characteristics of good governance are a precondition for sustainable development and effective disaster risk reduction (cf. Magel/Wehrmann 2001). In addition, good governance can be seen as an effective instrument for poverty alleviation and to achieve the UN Millennium Development Goals.

In the following table the **core indicators** to assess the spatial development of a megacity are given (cf. table 1).

Certainly, the development of these megacity indicators has to be based on **quality criteria** that support the selection of accurate indicators. Standard criteria for these variables are validity, reliability, specificity, measurability, comparability, cost-effectiveness and redundancy (cf. for further information Birkmann 2006, p. 64ff.)

Indicator-based Checklist for Megacities	
Social indicators	<ul style="list-style-type: none"> ▪ Population growth rate ▪ Population density ▪ Life expectancy rate ▪ Migration rate (migration from rural areas and immigration) ▪ At-risk-of-poverty rate ▪ Social polarization rate ▪ Inequality rate of income distribution ▪ Crime rate ▪ Dimension of housing shortages; ghettos, slums, squatters ▪ Unemployment rate ▪ Rate of people with unhealthy living conditions
Economic indicators	<ul style="list-style-type: none"> ▪ Development of the local economy/economic structure ▪ Real GDP growth rate ▪ Unemployment rate ▪ Accessibility of public transportation infrastructure ▪ Quality of transportation network ▪ Infrastructure deficiencies; overtaxed infrastructures ▪ Risk of economic loss in case of a disaster
Ecological indicators	<ul style="list-style-type: none"> ▪ Air pollution from vehicle emissions, industry etc.; smog ▪ Groundwater and drinking water pollution ▪ Quality of sewage treatment ▪ Capacities of waste collection and disposal services ▪ Land sealing rate ▪ Suburbanization (urban sprawl) rate ▪ Number and dimension of brownfields ▪ Destruction of original vegetation; deforestation; damage to flora, fauna, biodiversity per year ▪ Risks to natural disasters or industrial accidents

Table 1: Selected environmental megacity indicators.

3. APPROACHES FOR SUSTAINABLE URBAN DEVELOPMENT OF MEGACITIES

3.1 Considerations on the Necessity of Spatial Information Systems for Megacities

Most of the megacities are prone to severe natural disasters such as hurricanes, floods and earthquakes. Besides, the ongoing process of urbanization has to be taken into account, too. On the basis of this situation, **monitoring and analysis of urban areas** are very important tasks in today's megacity control and disaster risk management.

Therefore detailed spatial information about urban land cover and land use, population distributions and density, socio-economic characteristics and other urban dynamics is required. Chapter 2 has given a variety of indicators to describe these urban changes and developments. With regard to the **data collection** it is very important that the different data have to be clearly structured to the operational scale of urban change process (cf. Herold 2006, p. 274). Figure 3 shows a conceptual approach with possible level of details in case of monitoring urban development driven by population growth. Of course, a more detailed scale on which the analysis performs may lead to additional costs for data acquisition.

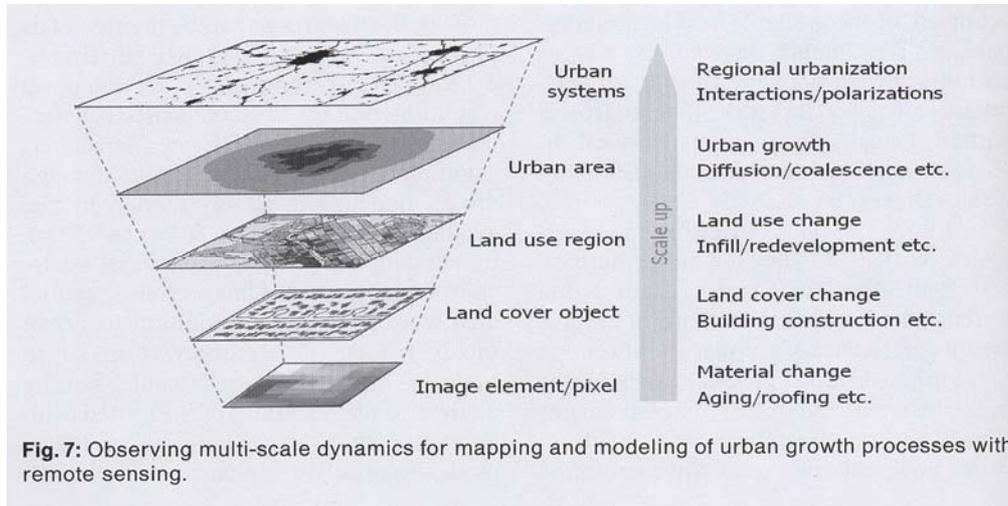


Figure 3: Monitoring urban growth processes in a multi-scale approach (Source: Herold 2006, p. 274).

But only to collect and analyze the data of urban metropolitan areas is not enough. A **geospatial information system** based on these data is needed to assess the urban dynamic processes and the different hazards and risks in respect of their complex dependencies, and to visualize them. For example remotely sensed data can be combined with other data or indicators (i.e. population growth rate) to create urban growth scenarios. Furthermore, especially hazard

maps might be useful as a basis for local planning decisions of local governments and also for emergency planning in case of a disaster. In certain cases, 3D visualizations with more self-explaining information can help to illustrate a better impression compared to maps.

Figure 4 shows an example for the design of a spatial information system for megacities as a powerful tool to mitigate disasters.

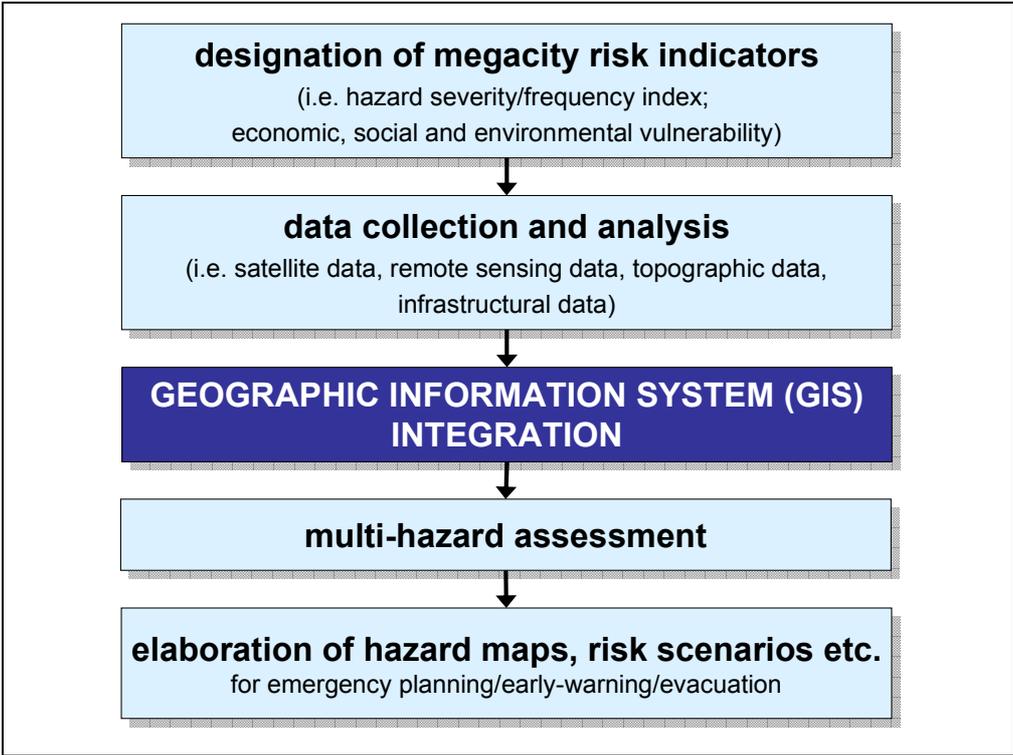


Figure 4: Workflow of a megacity information system for disaster risk management.

3.2 Models and Strategies of Sustainable Development

The development of megacities on the one hand and sustainability on the other hand seems to be oppositional, that cannot go together at the same time. The high rates of land and energy consumption, the severe pollution of air, water and soil at present and the ongoing social fragmentation are not in compliance with the aims of a sustainable development. To cope with these risks and challenges, considering the unplanned growth, a **spatial concept based on a decentralized structure** should be introduced that includes the urban and the surrounding rural areas. In the past, different models of sustainable development have been discussed, but there is no generally admitted structure that makes megacities less vulnerable to the described complex processes in chapter 2. Undoubtedly, a regional settlement structure has to be designed which focuses on the elements density, combination of different land uses, polycentral-

ity and provision of mass transit systems and public facilities. These are the prerequisites for putting urban sustainability into practice.

To achieve a sustainable megacity a **comprehensive plan** is indispensable, that provides guidelines and principle goals for the urban development as well as the basis for the construction of immediate plans for economic and social development, area plans, district plans, detailed plans etc. In accordance with the sustainability, the integration and coordination of urban and rural areas with the central city should be a main principle. This requires a “multi-centre”, “multi-axis” and “multi-level” urban spatial structure.

In case of the urban development of megacities a **shift of urban policy** and also of **planning strategies** is fundamental. Security of tenure and access to land is a central issue to minimize vulnerability of the population to future crisis. This includes a legalisation and registration of informal settlements, slums and squatters. Furthermore considerable social improvements and an access to schools and other educational institutions are necessary. Self-help housing improvements must be strengthened combined with the access to land to enhance the living condition, the identification with the neighbourhood and at least a dedication to the (local) community.

The final declaration of the Heads of State and Government and the official delegations from the countries attending the 2nd United Nations Conference on Human Settlements, Habitat II, held in June 1996 in Istanbul, proclaimed the “right to adequate shelter for all” as one of the key themes of the conference (UN-Habitat 1996). A billion people are today without a decent home and a hundred million are completely homeless. This gives a measure of the needs and the singular importance of the housing problem. Access to housing is now recognized as being vital to social cohesion and a key factor for development.

3.3 Land Use and Urban Management Strategies

Long-term land use and urban management strategies need reliable economic conditions and authoritative legal regulations. Therefore the **reform of land tax** must be discussed considering land policy, fiscal, social and ecological aspects. Sustainable urban development is required to prevent land fragmentation and also social fragmentation. Considering the rapid growth and that 60 to 70 % of the urbanization are uncontrolled, a comprehensive urban planning has to be developed and monitoring systems must be established (McLaren/Coleman/Mayunga 2005). Therefore the designation and mobilization of building land is one of the long-term tasks to be addressed by the local authorities.

To improve the housing situation on the long-term, first the problems of urban management and land use have to be solved. This requires **legal instruments** for more secure access to land and **planning techniques** for urban development and facilities. This frame must be provided at the national level by the State. If an adequate political, legal and institutional frame has been established, civil society can play an enabling role to implement the land policy and land administration (Keiner/Schmid 2003).

In practice the greatest challenge is not to elaborate a comprehensive plan of the city or regional development, but providing sufficient urban land for housing and other purposes at a reasonable price and also providing the indispensable technical infrastructure. Urban land managers must be capable of developing a coherent vision of the cities future and also of mobilising private investment both for housing and for urban facilities and services.

3.4 Urban Infrastructure

The provision of infrastructure for the purposes of transport, communications, energy, drinking water, sewage purification and waste treatment contribute to the economic development, make the territorial areas more competitive and attractive and promote regional economic integration and social cohesion (cf. Federal Office for Building and Regional Planning 1999). But the developing countries cannot support their cities in these fundamental tasks, because they have to cope with severe, long-term budgetary problems. That is why there will be a widening gap between the growing demand and the current provisioning of water and sanitation in the megacities with serious problems for the health of the residents. Especially **public-private partnerships** can bring efficiency gains and cost-effectiveness in the water sector.

To influence the urban dwellers' living conditions and economic development the public authorities have to be involved in producing and managing technical urban infrastructure facilities and services such as roads, transportation, electricity, telecommunications, water, sanitation and waste treatment and also social facilities and services in the strategic fields of education and health. In the megacities of the developing world there is considerable leeway to be made up and it will take a long time to achieve this with the 200 billion dollars invested each year by developing countries (4 % of their national product). E.g. only the needs of India have been estimated at 50 billion US \$ per year. The main problem is to mobilize new external resources to finance gradual improvements of the urban infrastructure. Funds for new infrastructure are required and also for the maintenance and rehabilitation of existing infrastructure to avoid deficiencies. In these fields priorities must be chosen: Financing and management of existing facilities or investments in future facilities?

The systematic extension of **public transit systems** (e.g. subways and busses) into the surrounding is necessary to slow down the migration from the rural areas. A rail transit network with different speed levels and high capacities, passenger transit pivots and parking lots are important elements of an efficient mass transit system. E.g. Shanghai has designed an urban transportation plan which consists of high speed rail lines, urban metro lines and urban light railways in order to limit the quantum of cars, motorcycles and powered bicycles. By means of high-tech, the research and development of intelligence transit systems should be forced. This is at the same time a policy to reduce energy demand and also the emission of greenhouse gas. However, efficient public mass transport systems are inevitable for these cities.

3.5 Good Governance and Disaster Risk Reduction

Good Governance is perhaps the single most important factor in eradicating poverty and promoting development (Kofi A. Annan, Secretary General of the United Nations). A comprehensive response to natural and man-made disasters and the impacts of urbanization is often constrained by institutional fragmentation and organizational deficiencies. In order to create a healthy environment for future generations, especially good governance is an area that needs to be established globally. Governance brings together the actions of several actors at all levels including government, ministries, international organizations, NGOs, research institutes, universities and finance institutions (cf. FIG 2006).

In connection with this the issue of **decentralization** poses an important institutional challenge. In accordance with this concept megacities have to co-ordinate their activities by local units. To shape policy in a local way it will be necessary to divide them in manageable territorial areas and to decentralize some responsibilities to the local actors and initiatives. At the same time it is important to ensure and to organize solidarity between all urban territorial areas, the rural surroundings and the central government. But there is still a need for city or even regional bodies responsible for city-wide or region-wide tasks like mass transit, waste disposal or structural planning.

In many countries decentralization of urban government is in progress and forced with heavy emphasis. The aim of this comprehensive movement is to improve urban living conditions by addressing needs as directly as possible and to enable urban dwellers to participate in city matters. It is a question of efficiency of administration and also of political strategies that involves reorganizing the political authorities and administration responsibilities between the central and the local authorities. In the decentralizing process a balance must be found be-

tween internal socio-political concerns and the common development strategy of the megacity.

But decentralization on its own is not yet a guarantee for good governance. Decentralization requires also **capacity building** for an efficient local urban management. Inadequate mobilization of local resources is a major obstacle for managers in the performance of their tasks. Local tax levying capacities are poor due to the lack of any organized collection and control system. Taxation methods are often discretionary and do not encourage taxpayers to comply. House and land tax legislation and tax of urban economic activities tend to be unproductive because they have not kept pace with economic and social development.

This strategy is largely determined by the objectives and requirements of city-economic and budgetary balances, by the land use planning strategy, the financial policy, credit regulations, education and health policy, land and tax legislation. No foreign model of decentralization is transferable but it is possible for countries to be enriched by other experiences and best practices, but they have to develop their own appropriate model.

4. CONCLUSIONS AND OUTLOOK

Megacities and massive conurbations are **complex and dynamic systems** that reproduce the interactions between socio-economic and environmental processes at a local and global scale. Despite of their importance for economic growth, social well-being and sustainability of present and future generations, urban areas have not received the level of attention they require in the study of global environmental change. The increasing number and extent of recent natural and man-made disasters illustrate the devastating consequences of some of the above mentioned trends and impacts. Since a significant proportion of the megacity population is poor and lives in informal urban settlements, the challenges of urbanization are likely to grow, and with them the opportunities for disaster reduction (Wisner et al 2004).

Global environmental change covers a diverse and broad range of issues. Megacities and urban agglomerations are certainly major sources for changes in land use and land cover, and they are major users of energy, natural resources and food but they offer a unique set of opportunities to advance the creation of a new conceptual framework for research. Especially an integrative approach of the physical, social and environmental aspects of urban growth on the one hand and urban planning and land management on the other hand is missing so far. Moving forward, interdisciplinary and multidisciplinary perspectives may improve a better understanding of the process of urbanization and megacities and their governance.

All things considered megacities are not only risk areas of the global change, but they also hold best chances for a sustainable future. They are the engines of economic growth and social development (cf. World Bank 2000) and in many cases they are also precursors of the urbanization. The article has shown that **spatial information systems** could be **very important tools** for monitoring megacities and mapping vulnerability, as well as for the application of disaster risk management measures. Consequently, a lot of work still needs to be done in order to take appropriate actions for the prevention or mitigation of catastrophic events in megacities.

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