

# Managing Megacities: A Spatial Solution

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## Abstract

Administrations in the world's largest cities are often confronted with a multitude of key problems like high urban densities, traffic congestion, energy inadequacy and managing sustainable development and climate change. In the developing world, add problems such as a lack of basic services, illegal construction both within the city and in the periphery, informal real estate markets, creation of slums, poor natural hazards management in overpopulated areas, crime, water, soil and air pollution leading to environmental degradation, and poor governance arrangements.

It is clear that solutions to problems facing megacities require a concerted response from many agencies. The visionary concept of using an SDI to more efficiently manage, access and use spatial information is evolving and megacities around the world are at different stages of their implementation. However, most cities have no strategic framework to guide and create their SDI. Bodies like GSDI have a role to encourage use of best practices and disseminating information about these practices already developed in some jurisdictions.

**Keywords:** Megacity, urban growth, SDI

## 1. CURRENT SITUATION

### 1.1 Trends in Urban Growth

Urbanisation is a major change taking place globally. The urban global tipping point was reached in 2007 when for the first time in history over half of the world's population was living in urban areas; around 3.3 billion people. It is estimated that a further 500 million people will be urbanised in the next five years and projections indicate that the percentage of the world's population urbanised by 2030 will be 60%.

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This rush to the cities, caused in part by the attraction of opportunities for wealth generation and economic development, has created the phenomenon of 'megacities' that have a population of over 10 million. There are currently 19 megacities and there are expected to be around 27 by 2020. Over half of this growth will be in Asia. This incredibly rapid growth of megacities causes severe ecological, economical and social problems. It is increasingly difficult to manage this growth in a sustainable way. It is recognised that over 70% of the growth currently happens outside of the formal planning process and that 30% of urban populations in developing countries live in slums or informal settlements, where vacant state-owned or private land is occupied illegally and used for illegal slum housing.

Some trends in megacity growth worth noting are:

- ❑ Rising infrastructure costs means that investment is needed from all sectors of the economy, driving the need for public/private partnerships for infrastructure development and maintenance.
- ❑ Transport congestion is a major challenge and growth in megacities is trending towards creation and growth of centres or sub-cities, rather than just growth in the central business district.
- ❑ Over half the growth in megacities will be in Asia.
- ❑ The 20 largest cities consume 80% of the world's energy use and 80% of greenhouse gas emissions come from urban areas. Cities are where climate change measures will either succeed or fail.
- ❑ Informal settlements are especially vulnerable to climate change impacts as they are usually built on hazardous sites in high-risk locations.
- ❑ A city "can be run on information" and cities will be differentiated by their effective use of technology. For example, the Internet will be a tool for city planning, where everything can be connected and there will be increased use of sensor webs as input to city administration.
- ❑ Megacities exert significant economic, social and political dominance over their hinterlands. Mega-urban regions are growing, especially in China (Pearl River Delta) and the US (central east coast) to create clusters of cities or "system of cities" and while not megacities in the traditional form of centre and suburbs, they will form "multi-centre megacities". This form of urban area will exhibit both a strong internal and international spatial-economic relationship. Is a new science of international "spatial econometrics" needed to measure social, economic, environmental and governance outcomes?
- ❑ There is a clear dichotomy between the terms "global cities", which is based on interconnections and economic function, and megacities, which is based on size. It is not just a developed versus developing country paradigm, but rather the reason the city is growing. For example, the growth in Chinese cities is based on an outward looking global focus, while some cities (especially in Africa) are driven by internal population changes. This means

that analysis of needs of cities will be differentiated not just on geography but also on economic function and “connectiveness” with the global economy.

## **1.2 Megacity Problems**

Administrations in the world’s largest cities are often confronted with a multitude of key problems, like high urban densities, transport, traffic congestion, energy inadequacy, unplanned development and lack of basic services, illegal construction both within the city and in the periphery, informal real estate markets, creation of slums, poor natural hazards management in overpopulated areas, crime, water, soil and air pollution leading to environmental degradation, climate change and poor governance arrangements.

The International Federation of Surveyors (FIG) began a project in 2006 to study means of better managing megacities. During 2007-8, initial data about problems facing city administrators were obtained from seven cities (Hong Kong, Tokyo, Seoul, Istanbul, London, New York and Lagos) either by their direct response to a questionnaire (Q) or by personal visits (V) and interviews by the author. Table 1 shows the information derived from that stage of research.

Further research indicated that informal settlements are a problem in most megacities, mainly in countries where development controls, housing policies and tenure systems are immature and land administration capacity is low. A particular problem reported by one city is development being allowed in water catchment areas used by the city, but not under development control of city planning authorities. Some of the experience with planning and development laws, regulations, procedures and systems used in some of the cities may be useful to others.

Traffic management is a common problem. City transport and police agencies were not part of the initial information gathering. Given the commonality of the problem, this may be an area for further study.

Natural hazards and emergency management were high on most cities’ lists. Risk profiles from floods, fires, earthquakes and other hazards differ between cities, but capacity to plan, prepare, respond and recover from disasters is a common issue.

**Table 1: Key Problems Facing City Administrations**

<b>Problem</b>	<b>Hong Kong SAR (Q) China</b>	<b>Tokyo (Q) Japan</b>	<b>Seoul (Q) Korea</b>	<b>Istanbul (V) Turkey</b>	<b>London (V) United Kingdom</b>	<b>New York City (V) USA</b>	<b>Lagos (Q) Nigeria</b>
<i>Informal settlements (land tenure, development approvals, building control)</i>	N	Y	N	Y	N	N	Y/High
<i>Traffic management</i>	Y/Med	Y	Y	Y	Y	N	Y/High
<i>Natural hazards (floods, earthquakes, fires)</i>	N	Y	Y	Y	Y	Y	Y/High
<i>Unclear responsibilities and mandates (within or between administrations)</i>	N	N	N	N	N	N	Y/High
<i>Uncoordinated planning</i>	N	N	-	N	N	N	Y/High
<i>Water management (fresh water supply and waste-water disposal)</i>	Y/Med	Y	N	Y	N	N	Y/High
<i>Provision of continuous electrical power</i>	N	Y	N	N	N	N	Y/High
<i>Visual pollution and garbage disposal</i>	Y/Med	Y	N	N	N	Y	Y/High
<i>Air and water pollution control</i>	Y/Med	Y	Y	N	Y	Y	Y/High
<i>Population growth</i>	-	-	-	Y	Y	-	-

It appears that unclear responsibilities and mandates (within or between levels of administration) are not considered by the administrators interviewed to be a major issue for cities studied. However, all cities appear to have problems with overlapping responsibilities amongst internal and external agencies, leading to operational dysfunction such as a multitude of agencies holding non-accessible spatial data. It is clear that solutions to problems facing megacities

require concerted response from many internal units and regional and national agencies in areas such as planning, infrastructure, development and land use controls, transportation, environmental management and water management. Mandates might be clear, but rationalisation of functions and more effective levels of cooperation may still be needed.

It seems that in many megacities, the city administration does not have responsibility for all matters covering the full area of the city. Several cities reported that their city administration did not have control over development, but rather it was the responsibility of subsidiary local government units (an average appears to be around 30 municipal authorities within the area of the “greater city”). In some cases other levels of government had land use and development control responsibilities. So, even if city planning is centrally coordinated, often city administrations have little control over the implementation (land use and building controls) of these plans. In short, some city administrations have control over key city development functions; others do not.

The influence of megacities reaches well outside their administrative boundaries to the peri-urban and regions beyond. It is essential that the greater region be managed holistically to maximise the economic benefits of the city. Regional planning places even greater emphasis on effective governance of the larger region, cooperation in planning and development control and sharing information.

An area for further study may be the role of infrastructure providers, such as utility services, not being part of the city planning and development process. In many cases, these authorities are not part of the city administration, being privatised or at another level of government.

Environmental management, especially pollution control is another problem area reported by several cities. Again, the experience of some cities in managing environmental problems may be useful to others.

The inevitability of further population growth is likely to be a common issue. Some cities reported that their administrations have little control on population growth. It was a regional or national issue and needed to be addressed at that level. However, city administrations need to address the consequences of growth, which will add further stress to existing systems and facilities, even for those cities not experiencing problems at the moment. Just finding enough housing for people will be a common problem. Monitoring population change effectively and being able to respond through planning and infrastructure development will be major challenges.

Further research of other cities concluded that impacts might be briefly classified as following:

- ❑ High urban densities, lack of green areas and buildings reflecting local cultural heritage, of local historic or architectural value
- ❑ Informal development, insecurity of tenure, informal real estate markets, illegal construction both within the city and in the periphery; dilapidated city centres, creation of slums
- ❑ Unsustainable land use
- ❑ Commuting problems, traffic congestion
- ❑ Food, water and energy insecurity
- ❑ Lack of basic services such as public transportation, fresh water, parking areas, waste management, sanitation and public toilets
- ❑ Poor natural hazards (floods, fires, earthquakes) management in overpopulated areas
- ❑ Crime, increase of inequalities
- ❑ Water, soil and air pollution; environmental degradation
- ❑ Climate change
- ❑ Inefficient administration, bad governance

All the above impacts have a clear spatial dimension.

Many cities appear to have problems with unclear and overlapping responsibilities amongst internal and external agencies, leading to operational dysfunction such as a multitude of agencies holding non-accessible spatial information. It is clear that solutions to problems facing megacities require concerted response from many internal units and regional and national agencies in areas such as planning, infrastructure, development and land use controls, transportation, environmental management and water management. Mandates might be clear, but rationalisation of functions and more effective levels of cooperation and information sharing are needed.

## **2. SPATIAL SOLUTION**

### **2.1 Key Findings of Study**

Some key tools needed to address megacity problems were identified by the study. These included:

- ❑ Strengthening planning laws to cover not just the planning process, but the monitoring and implementation of the laws and to ensure that the planning process is guided by economic and environment development strategy.

- Planning and development control over water catchments and other sensitive areas affecting the city.
- Improved governance to provide good communication between all city units and strong partnerships between the city administration and agencies at other levels of government, especially in infrastructure development and maintenance.
- Coordinated planning and implementation involving transportation, utilities and other infrastructure providers.
- Working with the private sector to ensure financial and property markets have the capacity to meet current and future needs for jobs and housing.
- A strong focus on disaster management, including coordinated planning, preparation, response and recovery operations.
- In the developing world, a stronger focus was needed on good governance, institutional development and capacity building.

**Table 2: Use of Spatial Data in City Administration (Source: Spatial Strategies Pty Ltd)**

Inputs					
Base Maps	Imagery	Demo-graphics	Natural and Built Environ-ment Data	Infrastructure/ Network Data	Sensor Webs
Spatial Data Tools					
Data integra-tion	Information access	Visualisation	Spatial Analysis and Modelling	Spatial Planning	
Service Delivery Using Spatial Data					
<b>Urban Design</b> Planning codes Land zoning City-wide environmental plans Smart growth Sustainable neighbourhoods			<b>Utility Services</b> Telemetry SCADA Micro-tunnelling Asset management and inventory Disaster preparedness, response and recovery		
<b>Urban Management</b> Development and building permits Electronic lodgement of applications Automated valuation/taxes			<b>Transport Planning</b> Trip analysis Scenarios Integrated public transport networks Real-time monitoring of movements		
<b>Environmental Justice</b> Siting impacts Best use of land resources Placement of public facilities			<b>Economic Development</b> Find available and suitable land Workforce demographics		
<b>Community Involvement</b> Scenario and impact analysis, option development 3D visualisation Fly-throughs			<b>Public Safety</b> Emergency response management Crime modelling Emergency dispatch and routing		
<b>Environmental Services</b> Optimising waste collection networks Water storage, allocation and distribu-tion Environmental monitoring					
Outcomes					
Performance Monitoring, Evaluation and Reporting					

It should be noted that the needs of cities in the developed and developing world are significantly different.

Locationally referenced information has become indispensable for numerous aspects of urban and rural development, planning and management. The increasing importance of spatial information has been due to recent strides in spatial data capture (especially satellite remote sensing), management (utilizing GIS and database tools) and access (witness the growth in web mapping), as well as the development of analytical techniques such as high resolution mapping of urban environments.

## **2.2 Need for New Spatial Tools**

The incredibly rapid growth of megacities causes severe social, economical ecological and problems. How can this growth be nurtured in a sustainable way? The challenge for spatial professionals is to provide megacity managers, both political and professional, with appropriate 'actionable intelligence' that is up-to-date, citywide and in a very timely manner to support more proactive decision making that encourages more effective sustainable development.

New tools, techniques and policies are required to baseline and integrate the social, economic and environmental factors associated with megacities, to monitor growth and change across the megacity and to forecast areas of risk – all within shorter timeframes than previously accepted. This will lead to more proactive urban planning and environmental management.

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A key factor for success will be utilisation of spatial information and technologies to support the operation of the allocation of property rights, housing needs, land use planning, land management and taxation. They will also support management of key problems such as disaster management, flooding control, environmental management, health and transportation.

Just as importantly, managing performance of cities including monitoring, evaluation and reporting functions is a key challenge. This includes data

collection and analysis and a conclusion reached was that performance couldn't be monitored without relevant quality (spatial) information.

The study has found that spatial information and technology is being recognised widely as one of the tools needed to address the big urban problems, but there is still a general lack of knowledge amongst communities of practice about how spatial solutions can be used. The key action required is knowledge transfer, especially amongst city administrators. Use of case studies demonstrating current best practice in selected cities could be a way of showing other cities what is possible. However, detailed solutions will need to be tailored by spatial professionals in each instance.

### **2.3 Use of SDI**

The concept of spatial data infrastructures (SDI) has been developed to encompass the efficient and effective collation, management, access and use of spatial data. SDI has been adopted in many countries around the world, notably at national level, but frequently found at sub-national levels based on regional or local government areas. SDI has been seen as a purely governmental mechanism and it is true that government agencies constitute the greatest collectors and users of spatial information. However, there is a clear trend to involve diverse user communities that incorporate elements of the private sector and non-governmental organisations to ensure that investments in spatial data development yield the greatest possible benefit.

Developing and implementing an SDI should be seen as an integral component of a jurisdiction's overall social and physical infrastructure planning.

However, the development of an SDI is problematic. Key issues have been the diversity of data sources and management of spatial data, usually spread across a multitude of agencies and organisations focused on single mandates. A challenge has been to develop new institutional arrangements to allow implementation of appropriate integration of data, adoption of relevant data standards and meet a growing range of needs for spatial data products. These arrangements vary from choosing an existing agency to lead SDI development (such as the agency responsible for land administration), through formal coordinating committees to formation of a specialist "SDI" agency. The choice will be based on prevailing administrative, legal and social cultures found in a jurisdiction.

The role that SDI initiatives are playing within society is changing. SDI was initially conceived as a mechanism to facilitate access and sharing of spatial data for use within a geographic information system environment. This was achieved through the use of a distributed network of data custodians and stakeholders in

the spatial information community. However, users now require the ability to gain access to precise spatial information in real time about real world objects, in order to support more effective cross-jurisdictional and inter-agency decision-making in priority areas such as emergency management, disaster relief, natural resource management and water rights. The ability to gain access to information and services has moved well beyond the domain of single organisations, and SDI now requires an enabling platform to support the chaining of services across participating organisations.

Providing information is a key government function. Information is essential to enable agencies to produce the government's expected outcomes and to meet community expectations. Increasingly, effective sharing of information is critical to the success of whole of government outcomes. Information technology underpins and enables improved information sharing and information management approaches by agencies.

The need to share information among agencies or across the whole of government broadly falls into four categories:

- ❑ *Dealing with an emergency* - the need to pull together all available information about a specific issue such as responding to hurricanes or bushfires.
- ❑ *Integrating information holdings* - the need to inform policy development and foster effective policy outcomes by acquiring, integrating and analysing available information holdings across government agencies, for example the Social Inclusion initiative.
- ❑ *Integrated service delivery* - the need to provide services across agencies in a seamless way, for example using street address to link various systems and databases.
- ❑ *Managing areas of joint activity* - the need to encourage sharing of information and investment within and across jurisdictions or with the private sector.

Improving agencies' capability to transfer and exchange information, aimed at improved decision-making and community services and with appropriate privacy protection, is critical and will require improved interoperability between agencies' information systems. In the longer term it will require agencies to adopt and implement common information policies, standards and protocols. Potential common frameworks, policies and standards will need to be flexible enough to respond to agencies' varying business requirements.

The visionary concept of using a SDI to more efficiently manage, access and use spatial information across megacities is evolving and megacities are at different stages of their implementation. However, most cities have no strategic framework to guide and create their SDI. This reflects the difficulty of the task to create an SDI within megacities that are organisationally complex and involve a

large number of stakeholders with diverse sets of spatial information; a microcosm of the national problem.

City administrations have different interpretations of what constitutes an SDI, but most reported that they had at least some elements of an SDI already in place. Cities like Paris and New York have a more mature and comprehensive implementation of a megacity SDI, managed by dedicated resources. However, most cities reported that they had only small “central GIS units”, under-resourced and generally incapable of providing a comprehensive citywide SDI. Missing capabilities included no spatial data policies and standards, common metadata, formal data sharing arrangements between units or agencies, or shared data access mechanisms. It could be many years before mature and fully populated SDI emerge in megacities. However, it is important for megacities, especially in developing countries, to develop SDI capabilities in areas that will deliver the most benefits to their current pressing needs.

Most do not have a formal “spatial information strategy” across the whole administration. However, most countries covered by this project have national (and in some cases regional) SDI strategies. At this stage it is not clear what connection there is between national and local strategies or how national strategies will meet the needs of cities. Some cities, for example New York, have developed an intranet that could be used to access spatial data held across multiple units. Other cities, such as Buenos Aires, have invested in providing access to spatial data as part of their public websites, reporting information about aspects of city administration such as land tenure, use, planning, environmental and disaster management information. Approaches like these should be used as exemplars by other cities. Although Norway does not have megacities, the Norwegian SDI provides one model for an application of spatial data infrastructure in a democratic society enabling citizen participation in policy and decision-making for city management.

## **2.4 Management response**

Whole of city administration action that would improve access to spatial data includes:

- Implementation of protocols to share data between governments.
- Common licence agreements that facilitate efficient access to spatial data held by governments.
- Comprehensive and up-to-date catalogues of metadata.
- Online access to data through standard interfaces.
- Bulk purchasing arrangements for access to important data.
- Stronger implementation of spatial standards.

Because city programs and their executive agencies often depend on data collected by other levels of government, transparent and cost efficient access to jurisdictional data is becoming an increasingly important issue in effective delivery of national programs. Indeed, structural inefficiency in access to spatial data could have an increasing impact on national economic activity and delivery of social and environmental outcomes.

Current problems for agencies finding, accessing and using jurisdictional data can be summarised as:

- ❑ Transactional inefficiency created by diversity of access and licensing requirements, varying data quality and jurisdictional systems that do not interoperate.
- ❑ Duplication of data collection and management effort due to inability to easily discover and access existing jurisdictional data.
- ❑ Barriers to integrating data across jurisdictional boundaries due to varying data standards, levels of investment, terminology and practices.
- ❑ Lack of clarity in defining data needs when dealing with jurisdictional suppliers.

City administrators also need to look at use of emerging practices, such as:

- ❑ Encourage the use of crowdsourcing to capture spatial information to complement the official sources.
- ❑ Ensure that all contributors to the city SDI, especially aid agencies and agencies at other levels of government delivering projects within the city provide spatial data based on international standards.

### **3. CONCLUSIONS AND FURTHER WORK**

The advances in developing megacity SDI will only occur when senior management within megacities are convinced of the benefits, through robust business cases based on evidence derived from experience, and the SDI implementation is guided by a supportive megacity information strategy. This support is difficult to achieve in the complex and multi-layer governance structures that exist around megacities.

The study has found that spatial information technology is being recognised widely as one of the tools needed to understand and address the big urban problems, but there is still a general lack of knowledge amongst communities of practice about what spatial solutions exist and how they can be used and prioritised.

Bodies like GSDI have a role in encouraging use of best practices and disseminating information about these practices already developed in some jurisdictions.

A list of recommendations from the FIG publication is shown in Appendix 1.

## **APPENDIX 1 RECOMMENDATIONS FROM FIG PUBLICATION 48**

### **1. Widen the awareness of rapid urbanisation with Land Professionals, and FIG members in particular, to better achieve solutions.**

Rapid urbanisation is a global issue that is setting the greatest test for Land Professionals in the application of land governance to support and achieve the MDGs and to mitigate the negative social, economic and environment consequences of this development. An awareness programme for Land Professionals, especially FIG members, is required to ensure that Land Professionals can respond to and help resolve issues such as climate change, food insecurity, energy scarcity, environmental pollution, infrastructure chaos and extreme poverty increasingly prevalent in urbanisation.

### **2. Present the benefits of SDI to megacity management to accelerate their implementation.**

Investment in the use of spatial information and the development of megacity SDI will only occur if there are strong business cases. Further research is required to gather evidence on the range of benefits to justify these investments. This should then be shared to allow megacities to strengthen their business cases for investment. In addition, awareness programmes should expose all stakeholders, especially civil society, to the opportunities provided by spatial information and SDI's to guild user demand.

### **3. Include spatial information best practice in the agenda of relevant international bodies to promote the benefits of SDI**

Several global organisations exist to support the agendas surrounding megacities; such as UN Habitat, peak bodies in the spatial professions and urban-focussed forums like Metropolis. FIG should work in partnership with these key organisations to ensure that the role and benefits of use of spatial information and development of SDI is understood across the megacities communities to encourage their adoption and exploitation.

**4. Highlight the opportunities for spatial information tools to megacity professionals to accelerate their adoption.**

The study has found that spatial information and technology is being recognised widely as one of the tools needed to address pressing urban problems, but there is still a general lack of knowledge amongst communities of practice about how spatial information solutions can be used. Knowledge transfer, especially amongst practitioners in city administrations is a key action required. This sharing of case studies to demonstrate current best practice in selected cities would be a way of showing other cities what is possible.

**5. Apply interventions to informal settlements in the context of wider economic and social policies to provide scalable, sustainable solutions**

The solutions for reducing informal settlements in many cities will only be achieved through a range of appropriate interventions being applied within the broader context of economic growth and poverty reduction policies. To achieve solutions around this combined and complementary policy approach it is essential that spatial information can be integrated and analysed with wider economic and social information. It is recommended that information strategies and standards are developed to achieve this more holistic approach to information management in megacities.

**6. Create a megacity information strategy, including spatial information, to guide the development of a megacity SDI.**

Spatial information should not be considered a separate information asset to be managed in isolation within megacities. Guidelines on spatial information need to be tightly integrated into the overall 'corporate' information strategy and informed by national spatial information interoperability standards. This 'corporate' approach will facilitate collaboration and multi-professional solutions to problems. Best practice in information strategies should be shared across megacities.

**7. Open access to the megacity SDI to civil society to support participatory democracy**

The creation of megacity SDI and spatially enabled web services can provide citizens with direct access to megacity information and to support a dialogue with the megacity administration. It is recommended that megacities should open these channels to the citizens and provide web based access to information and services, wherever possible. This will facilitate and expand civil society's participation in the running of megacities.

## **8. Extend the skills of all professionals involved in megacities to enable the increased exploitation of spatial information tools**

Too often the skills surrounding the use of spatial information tools is limited to a small group of what are usually called 'GIS experts'. This severely limits the understanding and use of these valuable tools across megacity organisations. It is recommended that training programmes on spatial information tools are developed for a wide range of professionals across megacities to create a self-service model.

## **9. Proactive Information to Manage Complex and Dynamic Urban Environments**

The traditional approaches to the capture and maintenance of spatial information across megacities involve a static view of what layers of spatial information are captured and their quality (usually high and expensive). The spatial information is normally maintained on a cyclical basis. In the context of many megacities, especially in developing countries, where there is high and sporadic growth of urbanisation and limited resources then this traditional paradigm is no longer valid. It is recommended that these megacities adopt a new spatial information management paradigm that still has the longer term aim of developing a fully populated megacity SDI, but in the short term applies new spatial information tools, techniques and policies to more effectively monitor and model growth and change across the urban area to better target their limited resources. The outputs must be achieved within shorter timeframes than previously accepted and be much more supportive of the immediate information needs and priorities of each megacity.