Knowledge series

Megacities – Megarisks

Trends and challenges for insurance and risk management

Münchener Rück
Munich Re Group

Traffic and spatial problems in megacities pose a special challenge for city planners. These problems can only be overcome by designing unconventional structures, as illustrated here by the city freeway in Shanghai. Earthquake catastrophes have shown, however, that bridges and flyovers are often highly prone to losses.

Foreword

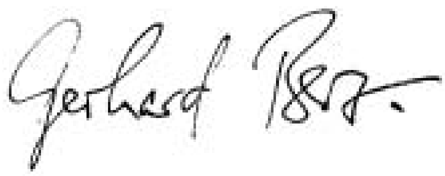
Global urbanisation and rural-to-urban migration are among the megatrends of our time – together with population growth, the overexploitation of natural resources, environmental pollution and globalisation – that will have the most lasting impact on the future of mankind. However, as with other developments, even a model for success – as cities undoubtedly are in view of their positive influence on culture, economic activity, technologies and networks – will eventually reach its limits and, once the negative effects exceed the positive ones, necessitate a change in paradigm.

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. This is especially true where growth is too rapid and unorganic, as is the case in most megacities in emerging and developing countries.

As the trend towards megacities gathers pace, opportunities and risks go hand in hand and undergo major changes over time. Munich Re therefore began to consider these problems at an early stage, beginning in the 1990s and gradually examining a series of important aspects in its publications. The present study tries to cover all the main issues and their relevance to an insurance company's various classes of business, our aim being to give our clients and interested readers from the fields of economics, science and politics an overview of this important subject.

We believe that, because of the megarisks inherent in megacities, the insurance industry has to deal with the subject of megacities more intensively than most other sectors of the economy. Suitable strategies must therefore be developed in good time and incorporated into the overall risk management to ensure that risks can be kept under control in the future too. Otherwise, they might assume proportions that could threaten the industry's existence.

There is no doubt about it: megacities are "where the action is" for (re)insurers – but whether the "action" turns out to be positive or negative will largely depend on the individual (re)insurers themselves.



Gerhard Berz

Contents

Contents

Executive summary

Big cities fascinate us. It is that fascination which has always drawn people to cities. What is more, the bigger the city, the stronger its attraction seems to be. The trend towards urbanisation constantly accelerated last century. Whereas in 1950 only about 30% of the world's population lived in cities, today the figure stands at around 50%. And by 2030, the United Nations expects more than 60% of people to be living in cities. Around 9% of the world's urban population – about 280 million people – currently live in megacities, and this figure is likely to rise to 350 million over the next ten years.

Particularly for companies that operate internationally – be it in the industrial, commercial or financial services sector – megacities offer decisive prerequisites for growth, especially in the areas of infrastructure, distribution channels and labour, to name the most important factors. The figures speak for themselves: today almost one-fifth of the world's gross domestic product is generated in the ten economically most important world cities. No wonder more and more people are moving to megacities in search of work and prosperity – and this is especially true of developing countries.

For the insurance industry too, this development presents major opportunities, because for every high-rise building, every underground railway system and every manufacturing company – and of course also for the people who live and work in the cities – there is a need for insurance. Given that the density of insurance in the megacities of developing countries is still far lower than in the industrialised countries, the business potential for the insurance industry is particularly large there. The risks that go hand in hand with global urbanisation are also large, however.

Owing to the high concentration of people, values and infrastructure in a very confined area, the loss potentials in megacities are very much higher than in rural areas. Consequently, even small occurrences can cause severe losses. For example, the failure of a central commuter train line during the morning rush hour in a major city like Tokyo, London or New York can very quickly lead to tremendous chaos and enormous production losses.

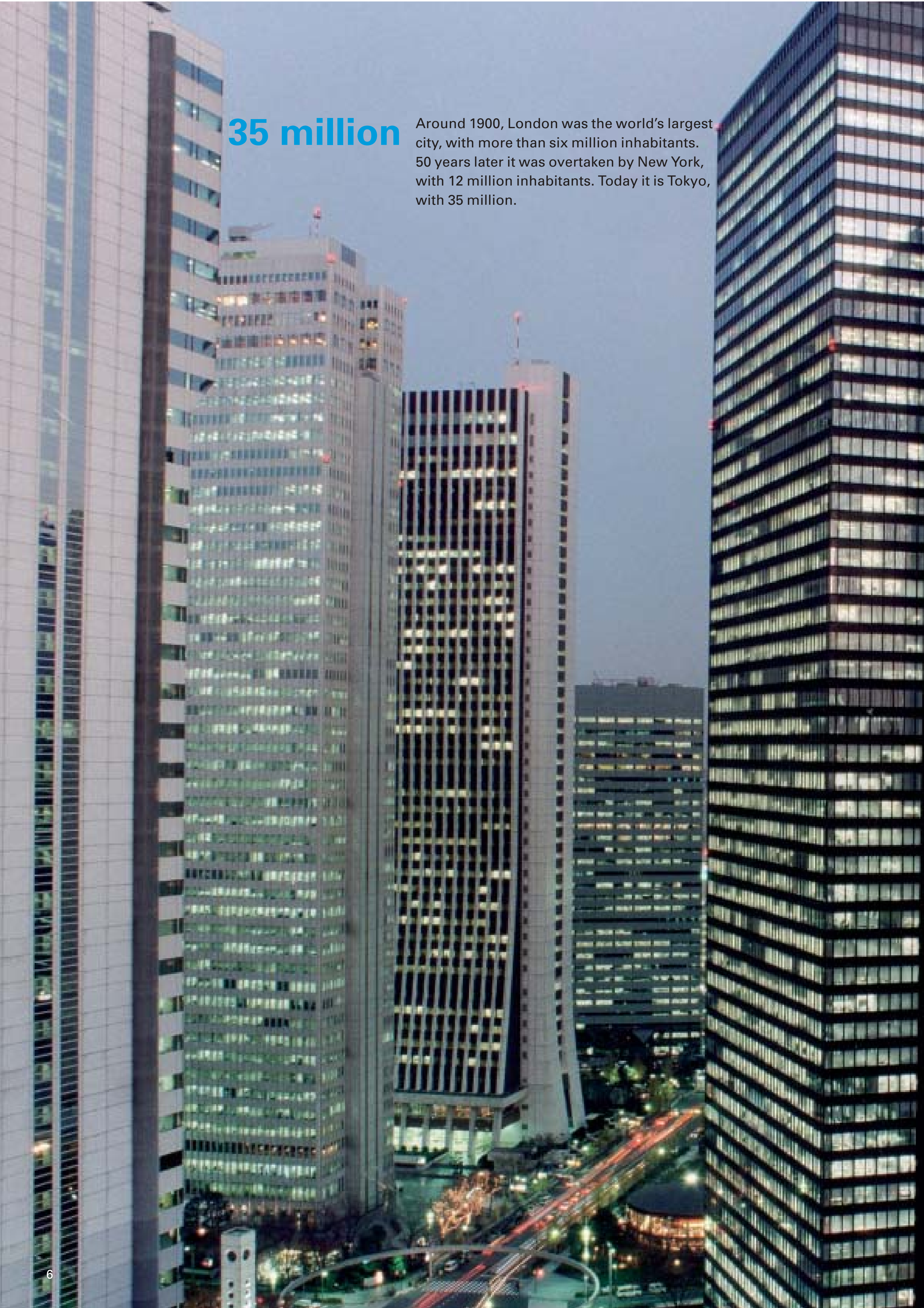
The long-term risks are much more serious though, with many megacities being virtually predestined to suffer major natural disasters. The decisive factors here are essentially their geographical location and their sheer size and vulnerability. Agglomerations of people, industry and trade are also bound to put a considerable burden on the environment, while the deterioration in the natural resources of water, soil and air inevitably has an impact on human health.

From the economic point of view, the ever-increasing global interdependence of flows of goods, finance and information – especially in world cities which are also economic centres – harbours major risks. Depending on the degree of networking involved, a business interruption in an Asian metropolis can lead to production losses in Australia or Europe. And megacities are also particularly exposed to one of the biggest risks of our time – terrorism. Attacks on utility companies or infrastructure can have fatal repercussions, while an attack on a nuclear power plant located near a major city, with all its consequences, is no longer inconceivable.

For international reinsurers, the main risk associated with megacities is the accumulation risk, i.e. when a single loss occurrence can also have far-reaching negative consequences for numerous economic sectors. A prime example of this is an earthquake in Tokyo, which according to economic experts could trigger a worldwide recession. But even less spectacular accidents, such as a tanker collision in a port, would pose major risks for people, companies and the insurance industry. Where a disaster leaves its mark on economic growth and on the financial markets, insurers, as major investors in the capital market, are hit twice.

Growing urbanisation is one of the main challenges of this century. Holistic solutions are called for, and not only from town planners, administrative departments, architects and industrial enterprises. The insurance industry is also faced with new tasks, especially in the area of risk management. This means that forward-looking risk-control tools like geographical underwriting – a precise system of georeferenced liability assessment and control – must be further developed. As yet unidentified accumulation risks – whether in the area of terrorism, liability or business interruption – must first of all be identified and modelled for the most important megacities. An objective ranking based on level of risk can be obtained using a risk index like the one presented here for the overall natural hazards exposure of megacities. Traditional risk-limiting measures like limits of liability or exclusions of certain types of risks or particularly exposed areas must also be applied consistently.

Finally, special attention needs to be paid to risk prevention. The aim of this publication is therefore not only to set out the underwriting risks and measures that have to be derived from them, but also to indicate the various risks and opportunities that megacities present and bring these to our readers' attention.



35 million

Around 1900, London was the world's largest city, with more than six million inhabitants. 50 years later it was overtaken by New York, with 12 million inhabitants. Today it is Tokyo, with 35 million.

Big, bigger, megacities

Megacities are generally characterised by extreme concentrations of people, values and infrastructure. Yet one megacity is not necessarily the same as any other. For example, the ten largest cities in terms of economic strength are all in industrial countries. If population is taken as the yardstick, however, seven of the ten most populous cities are in emerging and developing countries.

Megacities – Complex structures

Around 4% of the world's population – or around 280 million people – currently live in megacities. According to United Nations estimates, this figure will rise to 350 million by 2015. Almost one-fifth of gross world product is generated in the world's ten economically most important cities. For the insurance industry, this development presents numerous opportunities and risks.

When is a metropolis a megacity? In the 1970s the United Nations (UN) coined the term "megacity" to designate urban areas with eight million inhabitants and over. In the 1990s, they raised this threshold to ten million. Today, 22 cities and urban regions have reached this population figure, four of them in industrialised countries.

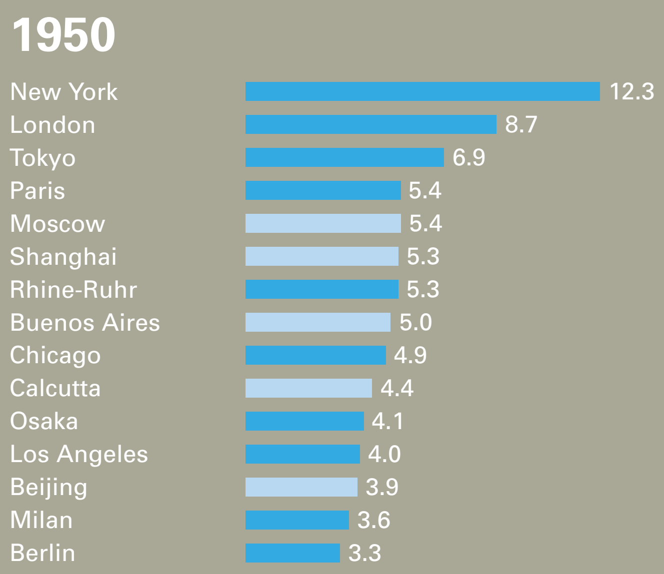
For the insurance industry, the number of inhabitants is only one of many criteria that highlight the significance of metropolitan areas. The most important criterion is their global influence. This is because a large part of economic, political and cultural activity takes place in global economic and commercial centres. There is no uniform definition of these "global cities" or "world cities", however.

In this publication, a metropolis is defined as a "megacity" if it has a population of ten million or more and a high concentration of people, values and infrastructure. The survey also includes cities that have global influence and are globally interlinked, that is to say, truly world cities. However, it is not just a question of cities in the classic sense, but also large, amalgamated mega-urban regions that do not have just one city centre but encompass several individual cities. Examples of these are the Ruhr area in Germany or the Randstad conurbation in the Netherlands (The Hague, Amsterdam, Utrecht and Rotterdam). Based on this definition, Table 1 in the Appendix lists 50 selected megacities and regions, with details of their population, area covered, and gross domestic product.

History of urbanisation

Rome is generally considered to have been the first "giant city". According to estimates, the city already had between 750,000 and 1.5 million inhabitants by the time of Christ's birth. Even then, it was therefore necessary to have complex systems for the distribution of food, supply of water and disposal of waste. For centuries, this size of city was unique and, for a long time, very large cities remained few and far between. Even as late as 1800, the urban population accounted for only 3% of the total population. This changed in the 19th century with the start of industrialisation. Numerous factories were built in cities, as these were mostly conveniently situated on rivers or coasts and offered an abundant workforce. On top of this, there was a large consumer market, proximity to other industrial enterprises, and an efficient infrastructure. In 1900, London was the biggest city in the world, with more than six million inhabitants. Fifty years later, New York was the biggest, with a population of 12 million. Today it is Tokyo, with 35 million.

Figure 1 The 15 most populous cities in the world

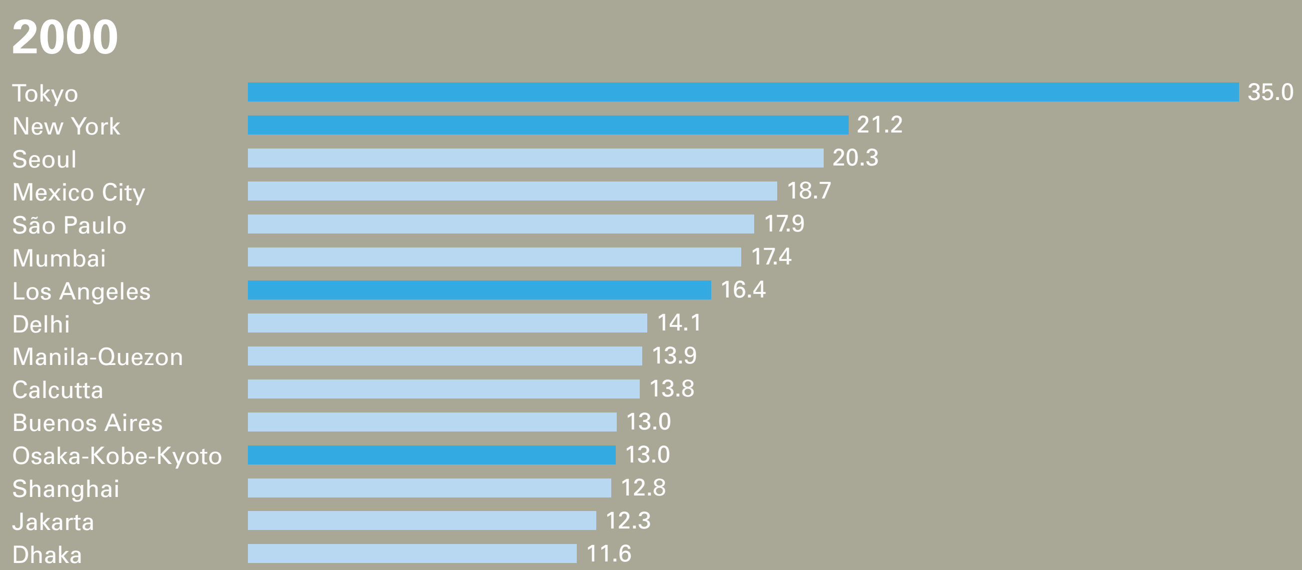


In 1950 ten of the 15 most populous cities were in industrial countries. In 2000 the emerging and developing countries, with 11 of the 15 largest megacities, dominated the picture. According to United Nations estimates, by 2015 there will be only three megacities in industrial countries among the top 15. The drastic increase in absolute population figures is also striking.

All population figures in millions

- **Cities in countries with high per capita income**
- **Cities in countries with medium or low per capita income**

Source: United Nations, 2004



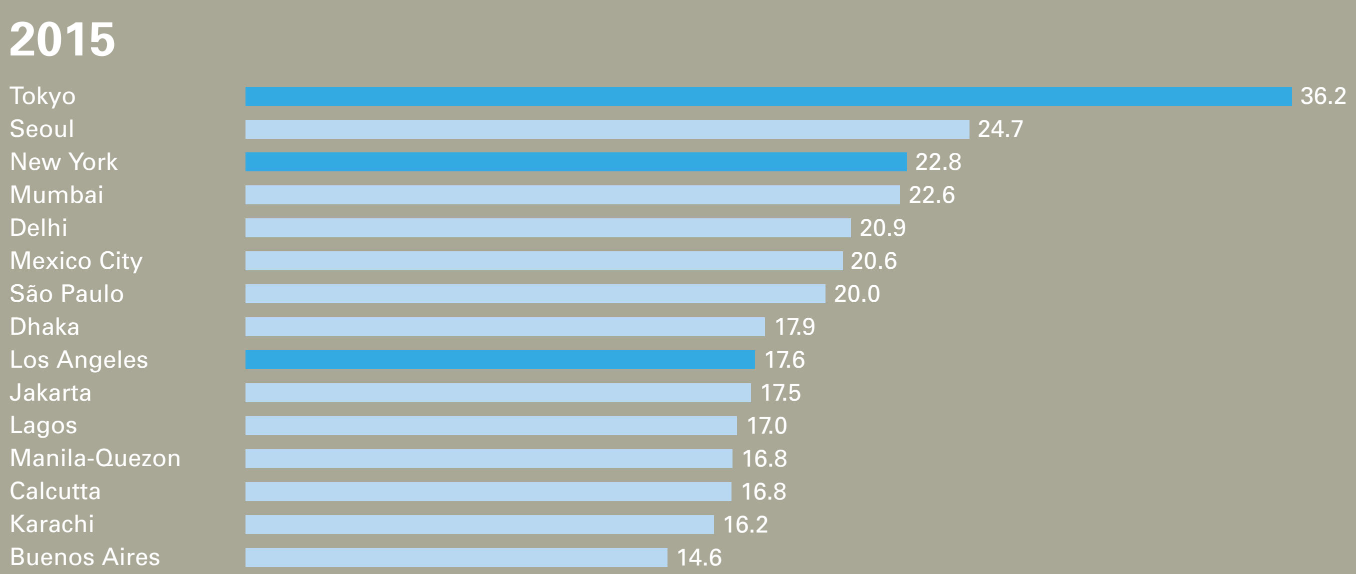
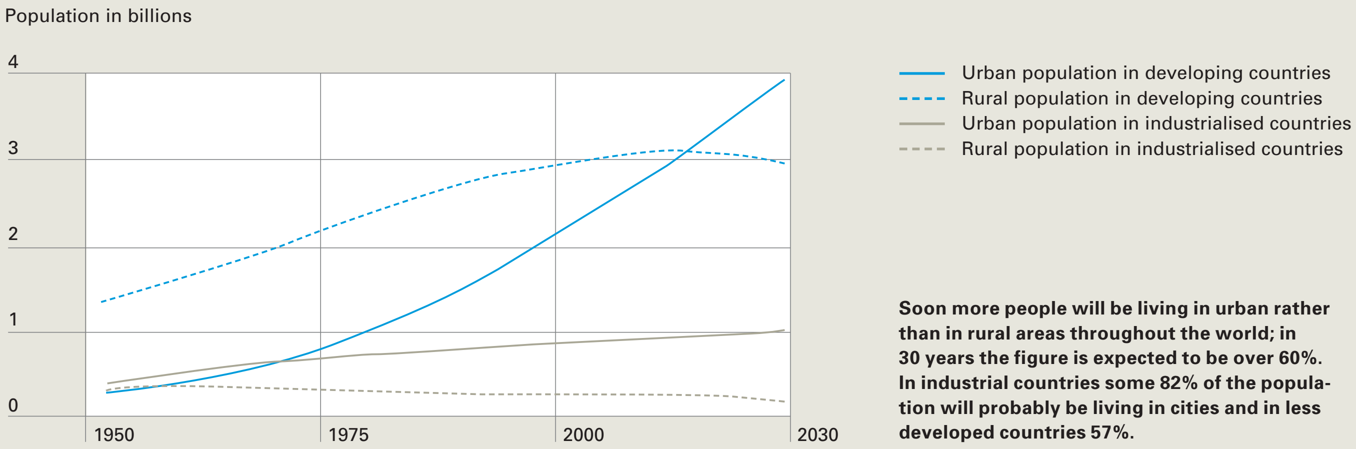


Figure 2 The gap is widening



Soon more people will be living in urban rather than in rural areas throughout the world; in 30 years the figure is expected to be over 60%. In industrial countries some 82% of the population will probably be living in cities and in less developed countries 57%.

Source: United Nations, 2004

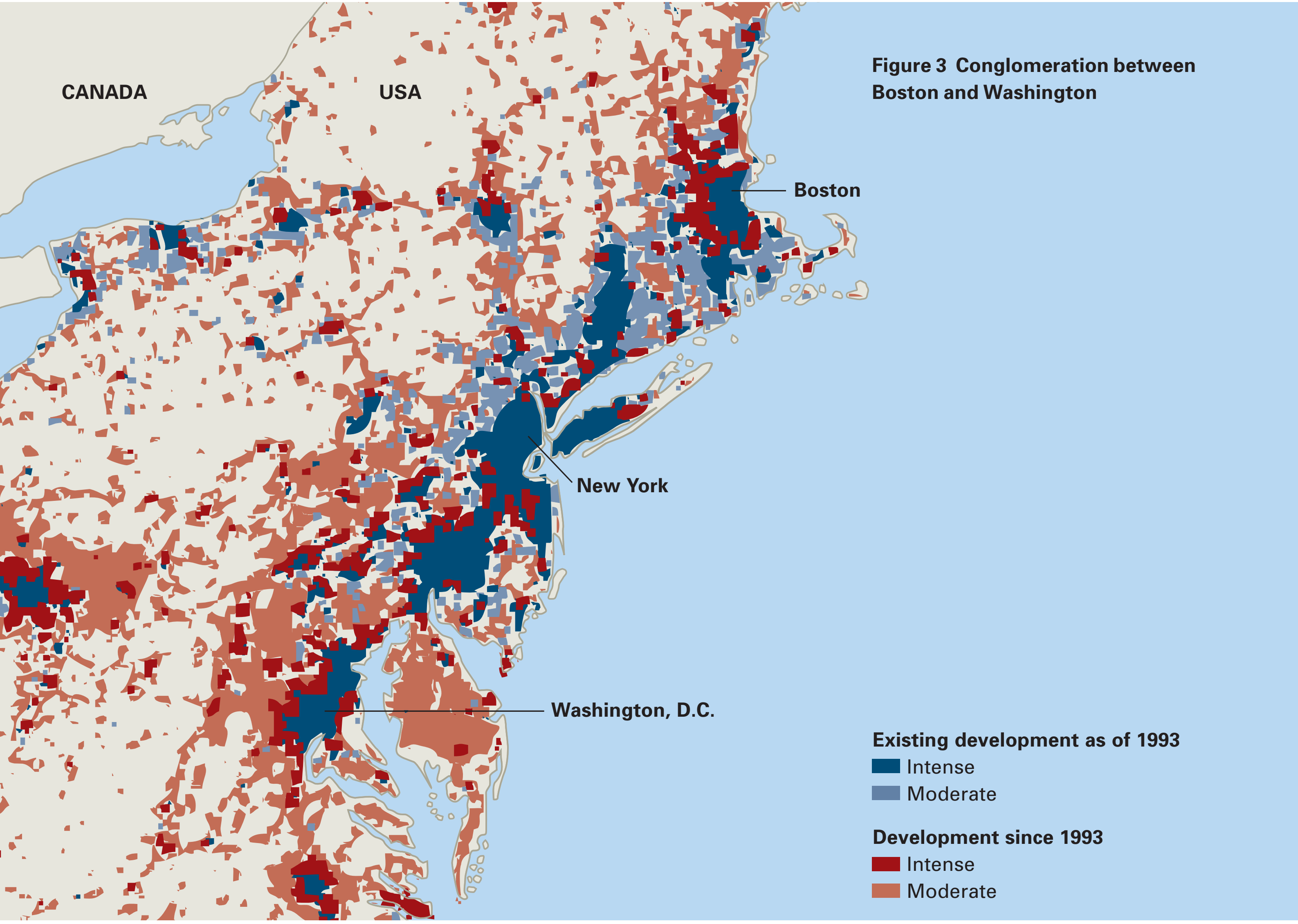
In 1950, more than half the population (55%) of the industrialised countries was already living in cities, whereas in low-income countries the proportion was only just under one-fifth (18%). At that time, most urban agglomerations were still in industrialised countries. Since then, however, urbanisation has increased dramatically, especially in newly industrialised and developing countries: there the degree of urbanisation already stands at 40%, while in the industrialised countries it is now 75%. Around three-quarters of megacities are now to be found in countries that are industrially less developed. As the population in developing countries grows very much more quickly than in industrialised countries, this trend will increase (see Figure 2).

The example of São Paulo clearly illustrates just how fast a small town in a newly industrialised or developing country can grow: in 1900 the city had fewer than 100,000 inhabitants; in 1950, with a population of over two million, it was still considerably smaller than Berlin; today, with a population of around 18 million, it is the fifth biggest city in the world.

One notable fact is that relative population growth generally falls as a city grows in size. Only for a few megacities (Dhaka, Delhi, Jakarta and Karachi) is future growth of 3% or more still expected. In highly-developed cities in particular, the number of inhabitants will not increase any more, or will do so only marginally.

It is a totally different matter with urban areas: in megacities worldwide, we are seeing a process of deconcentration, with private households and companies moving to the outskirts. The areas of cities are therefore increasing considerably, swallowing up industrial areas or airports, for example, that were previously out of town.

Occasionally, however, trends against suburbanisation can also be observed: in order to reduce commuter flows, districts are merged and new quarters are built close to the centre – like "Salitre" in Bogotá, for example.



The giant urban conglomeration between Boston and Washington stretches for 1,000 km. Around 44 million people live in the so-called "BosWash" region. This accounts for 16% of the entire population of the USA.

Source: Based on National Geographic, 7/2001

Administrative boundaries and urban regions

As there are no uniform spatial criteria for delimiting mega-cities, it is difficult to make any comparison of the absolute numbers of inhabitants. Often demographic data relates to administrative units, but these need not necessarily coincide with the actual area covered. Thus the population of the "City of Tokyo" stands at over eight million, whereas that of the "Greater Tokyo" agglomeration making up the "Prefecture of Tokyo" stands at 12 million. The conurbation as a whole, which also includes the cities of Yokohama, Kawasaki and Chiba, is home to around 35 million people.

Increasing urban sprawl means that cities grow in area and merge with neighbouring towns. As a result, although they are administratively separate, in reality they are closely interlinked.

Giant urban agglomerations arise, like the "BosWash megalopolis", which stretches almost 1,000 kilometres along the eastern coast of the USA between Boston and Washington. It consists of a concentration of large cities, industrial and commercial sites, and also infrastructure. One problem though: neither natural events nor man-made interventions stop at administrative boundaries.

Canary Wharf underground station in London: The development of the public transport system was one of the factors that made London a world city in the second half of the 19th century; today this transport system still constitutes the city's main artery.

Global cities: Nodal points in the worldwide urban system

The development of "global cities" or "world cities" already described, which are worldwide business and management headquarters, was helped considerably by new transport and communications technologies. In the second half of the 19th century, London became one of the first world cities of this kind: the construction of railways and underground railway systems and trams made it possible for industrial workers to commute between their homes and their places of work. This gave rise to numerous suburbs – London's six million inhabitants were spread over a catchment area of more than 250 km^2. Soon London became international: workers came on steamships from all over the world, and the city throbbed with commerce and life. Moreover, London stood at the centre of world politics – not only as the capital of British colonial power but also because of its industrial supremacy.

Because of global networking, global cities today can no longer be considered in isolation. For example, disasters in any of these world cities can also leave their mark worldwide.

A typical feature of world cities is the close interdependence between flows of goods, finance and information. As this networking is difficult to record, indicators are defined in order to allow such nodal points to be assessed. These include the number of headquarters of banks, insurance companies and industrial enterprises, the frequency of flights and the presence of international organisations, but also of trading centres like stock exchanges.

These indicators by no means include everything that makes up a world city. Thus, for example, only a few companies have their headquarters in Hong Kong, but the city is still highly connected. Here access to the Chinese market meets the expertise of international firms – the city functions, as it were, as "translator" between the market and the global flow of information and goods. Experts refer to this as a "gateway function".

Figure 4 Important nodes in the world city network

City	Highly connected world cities	Highly connected financial centres	Dominant centres	Global command centres	Regional command centres	Highly connected gateway cities	Emerging city gateways
Amsterdam				■			
Beijing							■
Boston				■			
Brussels				■			
Buenos Aires						■	
Caracas							■
Chicago	■	■	■	■			
Frankfurt		■	■	■			
Hong Kong	■	■	■		■	■	
Jakarta		■				■	
Kuala Lumpur						■	
London	■	■	■	■	■		
Los Angeles	■						
Madrid		■				■	
Melbourne						■	
Mexico City						■	
Miami					■	■	
Milan	■					■	
Moscow							■
Mumbai						■	
New York	■	■	■	■	■		
Paris	■	■	■	■			
São Paulo					■	■	■
Seoul							■
Singapore	■	■			■	■	
Sydney						■	
Taipei						■	
Tokyo	■	■	■	■	■		
Toronto	■					■	
Washington, D.C.				■			
Zurich				■			■

There are various ways of classifying world or global cities. This textbook example identifies "important nodes in the world city network" using various criteria.

Source: Taylor, Walker, Catalano and Hoyler, 2002

Figure 5 Comparison Tokyo – Germany

Rhineland-Palatinate, Hesse, Baden-Württemberg, Bavaria
Schleswig-Holstein

35 million people live in the Greater Tokyo region. This is equivalent to the population of Germany's four large southern states, but concentrated on an area of about 13,000 km² or less than that of Schleswig-Holstein; they generate 40% of Japan's GDP, equivalent to 75% of that of the whole of Germany.

Source: Munich Re, 2004

Dominance of industrialised countries

The nodes of global city systems lie mostly in industrialised countries. Despite their enormous populations, large cities in developing countries do not (as yet) play a major role in the world city network.

The concentration of people and functions in megacities is also reflected in gross domestic product (GDP): a substantial proportion of GDP is generated in megacities – not only in individual countries but also worldwide. If we look more closely at the ten cities with the greatest economic strength, we see that they

- are home to a good 2% of the world's population;
- account for around 5% of the global urban population;
- take up around 4% of the built-up area worldwide;
- generate just under 20% of global GDP; and
- all lie in industrialised countries.

Challenge of developing countries

In developing countries, the situation is different: whereas the concentration of political, administrative, economic and cultural functions is generally to be found in the ever more numerous big cities, their dominant position is mostly confined to the home country or even just to the relevant region.

Megacities in developing countries also have the following distinctive features:
- Social polarisation between rich and poor – a few winners contrast with a disproportionately high number of losers
- A dynamic population trend – as early as 2030, four billion people (twice as many as today) are expected to be living in the cities of developing countries
- Limited financial resources available to deal with the problems

Municipal authorities are faced with enormous problems here: unemployment, housing shortages, nutritional and health problems, inadequate water supplies and sewage disposal, overloaded traffic routes and other elements of infrastructure, environmental pollution and crime.

According to estimates, around half the inhabitants here live in "marginal settlements", i.e. with no connection to the public infrastructure. A large part of the economic activity in these cities also takes place in the "informal" sector. In Mexico City, it is estimated that one-third of gross domestic product is generated in unregulated employment relationships. In Cairo, the recycling of refuse is a source of income for around 100,000 inhabitants – a useful but dangerous and questionable undertaking, given the many different types of toxic waste. In view of various natural hazards, the informal construction sector too holds considerable risks.

100,000 km^2

Natural catastrophes can affect areas of up to several hundreds of thousands of square kilometres. The impact depends on the force of the natural hazard event, the geographical situation and construction factors.

Risks and opportunities for the insurance industry

Megacities are practically predestined for risks. Whether the risks are natural catastrophes, weather, environment, health or terrorism, megacities are more vulnerable than rural areas. In addition, insurance density in megacities is per se higher. The insurance industry has to regard risks as an opportunity, make them transparent and come up with suitable solutions.

Risk and loss scenarios – An overview

With megacities, the main concern for reinsurers are major loss scenarios. It is useful to differentiate between risks and losses, between causes and consequences of loss scenarios.

The causes of losses in megacities are complex, from natural hazards, technological, social, political and infrastructure risks to economic risks. The consequences are equally diverse. Owing to the high concentration of people and values, it is important to keep a watchful eye on the accumulation risk.

These causes fall into four risk categories:
- Natural hazards, in particular earthquake, volcanic eruption, flood, windstorm and hail
- Technological and infrastructural risks such as industrial accidents and mass losses arising from road, rail or air transport
- Social and political risks like epidemics, terrorism and war
- Purely financial risks like collapse of financial markets

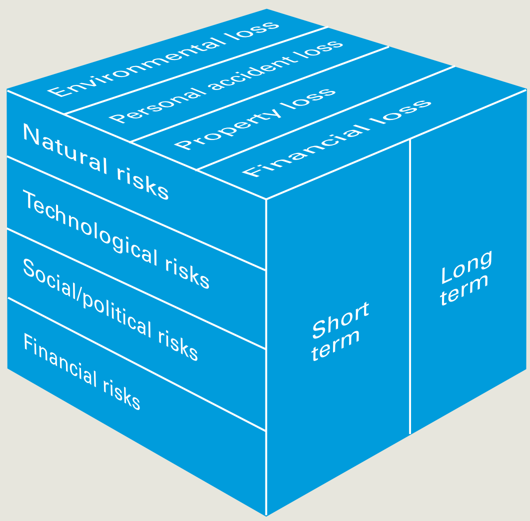
The consequences can likewise be divided into four categories:
- Environmental losses: contamination of air, soil and water; damage to flora, fauna, biodiversity; climate change
- Personal injuries: accidents and diseases
- Property losses: buildings, contents; motor vehicles
- Purely economic losses: financial losses, business interruption, direct and indirect consequential losses

Natural catastrophes, industrial accidents, terrorist attacks, and financial markets harbour enormous risks for insurance markets. They cause bodily injuries, environmental, property and financial losses in various combinations. Another important distinguishing characteristic is the short-term and long-term nature of risks and losses.

A distinction can also be made between disaster scenarios that are accidental in nature (short-term damage processes) and long-term risks of a mostly structural nature (long-term damage processes).

Natural catastrophes, industrial accidents or terrorist attacks usually involve all four categories of loss consequences, albeit to varying degrees, and so give rise to accumulation scenarios across various classes of business in the insurance industry. It may be that all classes of property and liability insurance as well as life, disability, health and accident insurance are affected – as amply demonstrated by the events of 11 September 2001. With catastrophe scenarios in megacities in the industrialised countries, the main emphasis is on property damage and purely financial loss because of the concentration of material assets, whereas for megacities in developing countries all too often it is the scale of bodily injury losses that is high.

Figure 6 Risks and losses, short term and long term



Source: Munich Re, 2004

Natural catastrophes in megacities

Megacities are practically predestined for major natural catastrophes. The enormous concentration of people and material assets in risk zones inevitably leads to particularly large loss potentials, especially as these agglomerations are in most cases extremely vulnerable – something that has unfortunately been confirmed time and again in the past.

We know of major catastrophes from earlier centuries – one has only to think of the Lisbon earthquake of 1755. In the early part of the 20th century, earthquakes in San Francisco (1906) and Tokyo (1923), major economic centres of global importance, caused widespread devastation and paralysed economic activity for a long time. Today, a severe earthquake in the Tokyo–Yokohama conurbation would result in hundreds of thousands of fatalities, damage running into trillions of dollars, and global economic repercussions. The Kobe earthquake of 1995 caused economic losses of well over US$ 100bn, making it (so far) the costliest natural catastrophe of all time. The factors indicated below clearly show why the amounts of loss in megacities are pushed up so high:

- The density of development and the narrowness of the streets made it very difficult to fight the conflagration that broke out following the earthquake
- Capacity bottlenecks made it difficult to fight the fires from the air
- Supplies of drinking water, electricity and gas failed after the supply networks were destroyed
- The capacity of hospitals and shelters for those made homeless was soon exhausted
- Transport and communication links were interrupted over large areas
- The port, the city's economic artery, was out of action for many months

Natural catastrophes run through the history of megacities (see Figure 7) like a leitmotif, which is hardly surprising when we analyse the natural hazard situations of individual megacities (see Appendix).

Decisive factors for a city's exposure to natural catastrophes are its geographical location and the area covered. Most megacities are situated where there are good transport links, e.g. on the coast or on rivers. Whereas the initial settlement of these sites was mostly confined to safe areas wherever possible, subsequent growth often inevitably spread to highly exposed areas too.

Over time, economic centres often also move to more exposed parts of cities. A prime example of this is London, where a new business and commercial centre built in the former docklands area is now at greater risk from storm surges. Los Angeles, San Francisco and Tokyo are continuing to grow in size and population, despite their high earthquake exposure, and it is only a matter of time before disaster again overtakes these cities.

The scale of natural catastrophes in major cities is shaped by numerous factors. The nature and spatial extent (sphere of influence) of natural events, as well as the relevant urban structure and trend in terms of town planning (resistance or vulnerability) thus play a part. The time of an occurrence (time of day or season) can also be significant. With natural catastrophes, the timing can have an impact on the scale of property damage and bodily injury, because it can make a big difference whether people are mainly at home, on their way to work or already at work when disaster strikes, or whether they heat or cook with gas or electricity, for example.

Figure 7 Significant natural catastrophes in cities and conurbations

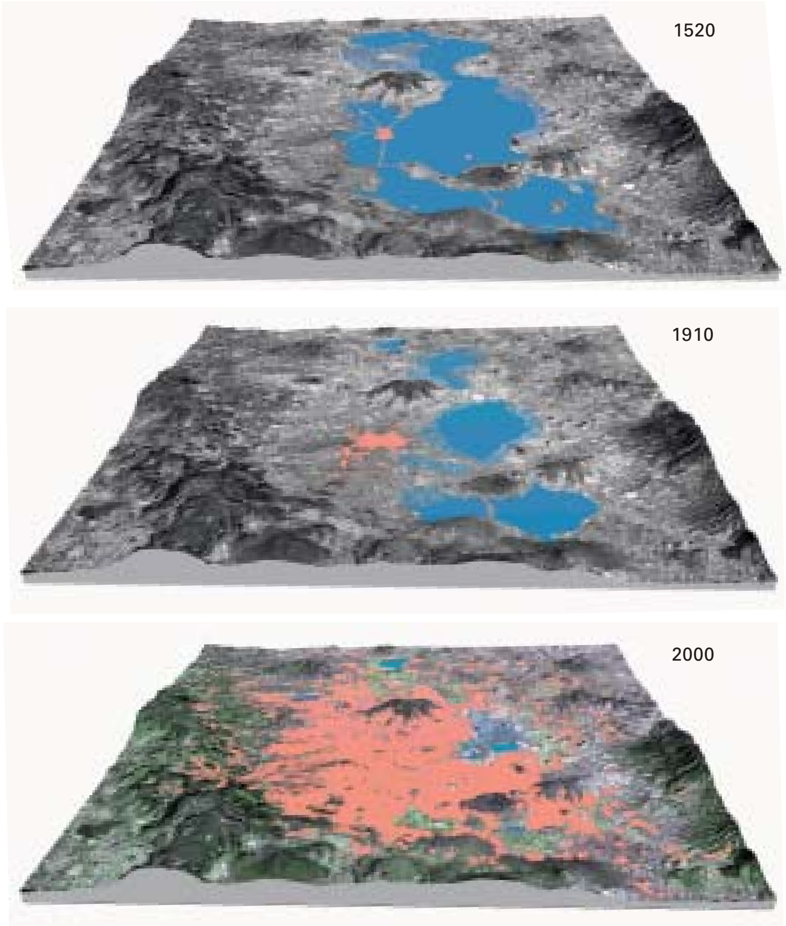
Year	Event	City	Country	Fatalities	Economic losses (US$ m, original values)	Insured losses (US$ m, original values)
2004	Four hurricanes	Florida	USA	> 100	> 40,000	> 20,000
2003	Heatwave	Paris	France	> 14,800	4,400	
2000	Flood	Johannesburg	South Africa	80	160	50
1999	Earthquake	Istanbul, Izmit	Turkey	15,000	12,000	600
1999	Earthquake	Athens	Greece	143	4,200	120
1999	Winter storm Lothar	Paris	France	85	8,000	4,450
1999	Tornado	Oklahoma City	USA	50	2,000	1,485
1999	Hailstorm	Sydney	Australia	1	1,500	1,100
1998	Ice storm	Montreal, Toronto	Canada	28	1,500	950
1998	Flood	Dhaka	Bangladesh	1,050	4,300	
1996	Winter storm	New York	USA	85	1,200	600
1995	Heatwave	Chicago	USA	670		
1995	Earthquake	Kobe	Japan	6,430	> 100,000	3,000
1994	Earthquake	Northridge, L.A.	USA	61	44,000	15,300
1993	Flood	Cologne	Germany	5	600	180
1992	Hurricane Andrew	Greater Miami	USA	62	26,500	17,000
1992	Winter storm	New York	USA	20	3,000	850
1991	Hailstorm	Calgary	Canada	-	500	400
1991	Wildfire	Oakland	USA	25	2,500	1,700
1989	Earthquake	San Francisco	USA	68	10,000	960
1987	Heatwave	Athens	Greece	> 2,000		
1985	Earthquake	Mexico City	Mexico	9,500	4,000	275
1984	Hailstorm	Munich	Germany	-	950	480
1978	Typhoon Rita	Manila	Philippinen	340	115	
1977	Flood	Karachi	Pakistan	375		
1976	Earthquake	Tangshan	China	290,000	5,600	
1972	Earthquake	Managua	Nicaragua	11,000	800	100
1971	Earthquake	San Fernando, L.A.	USA	65	553	35
1967	Flood	São Paulo, Rio de Jan.	Brazil	> 600	10	
1962	Storm surge	Hamburg	Germany	347	600	40
1962	Flood	Barcelona	Spain	1,000	100	
1959	Typhoon Vera (Isewan)	Nagoya	Japan	5,100		
1955	Flood	Calcutta	India	1,700	65	
1954	Flood	Wuhan	China	> 30,000		
1938	Hurricane	New York	USA	600	400	
1923	Earthquake	Tokyo	Japan	143,000	2,800	590
1906	Typhoon	Hong Kong	China	10,000		
1906	Earthquake	San Francisco	USA	3,000	524	180
1882	Tropical storm	Mumbai (Bombay)	India	100,000		
1874	Typhoon	Hong Kong	China	6,000		
1864	Tropical storm	Calcutta	India	50,000		
1755	Earthquake	Lisbon	Portugal	6,000		
1746	Earthquake	Lima	Peru	18,000		
1737	Tropical storm	Calcutta	India	300,000		
1731	Earthquake	Beijing	China	100,000		
1703	Earthquake	Tokyo	Japan	5,200		
1509	Earthquake	Istanbul	Turkey	5,000		
1303	Earthquake	Cairo	Egypt	4,000		
79	Volcanic eruption	Naples	Italy	18,000		

Source: Munich Re NatCat*SERVICE,* 2004

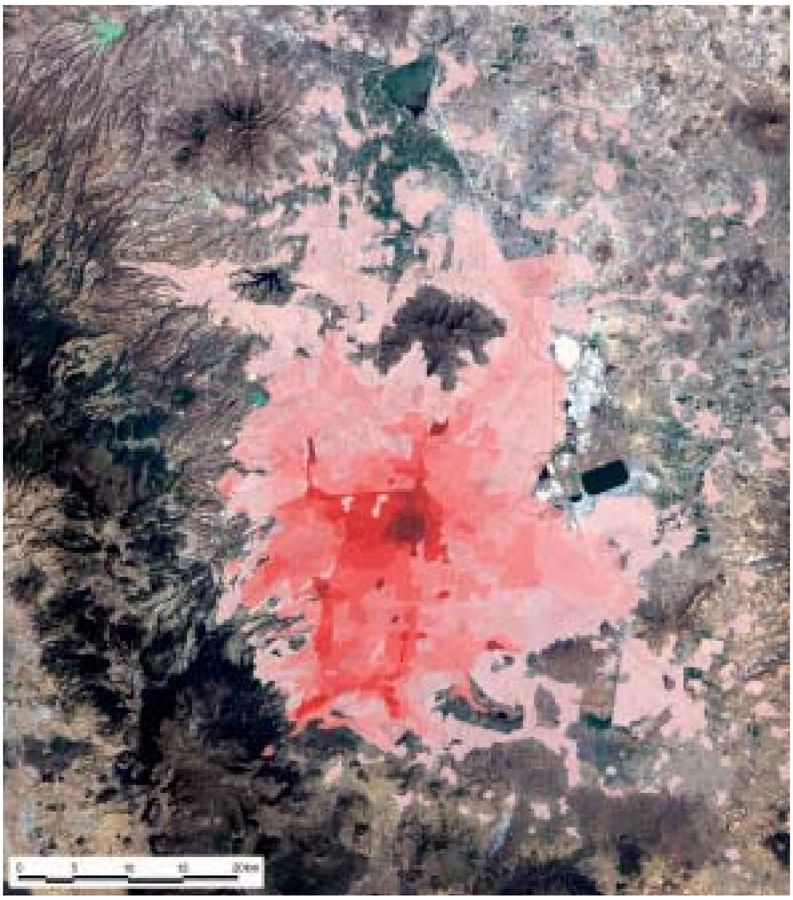
- Flood, flash flood, storm surge, hailstorm, landslide
- Windstorm, winter storm, ice storm, tornado, tropical storm
- Heatwave, drought, wildfire
- Earthquake
- Volcanic eruption

The figures in the table are for the overall losses in the entire affected region; in most cases, however, most of the losses were incurred in the cities.

Figure 8 Historical development of Mexico City



Lake Texcoco
Settlement of Mexico City



Settlement of Mexico City in

1523
1700
1800
1900
1921
1930
1940
1953
1960
1970
2000

Mexico City continues to sprawl, its buildings being constructed on the spongy sediment of an ancient lake. This subsoil can actually amplify the impact of earthquakes in certain areas. The structures worst affected in Mexico City by the 1985 earthquake were mostly 8- to 20-storey buildings, although the hypocentre was more than 350 km away.

Source: HUGIN GmbH, 2002; Global Land Cover Facility

Spatial impact of individual natural catastrophes

– Strong earthquakes can affect areas of up to several hundreds of thousands of square kilometers. The damaging effects and intensities of earthquakes are also heavily dependent on the local subsoil conditions, as the Mexico City earthquake of 1985 demonstrated – over an enormous damage zone, devastated houses stood right next to ones that were almost undamaged. Because of their intensity and the geographical extent of the damage they cause, earthquakes generally pose the biggest accumulation risk in megacities, partly also because the fabric of buildings is not designed to withstand them sufficiently.

– Windstorms can affect entire cities and regions (e.g. tropical cyclones and winter storms) or be confined to small areas (tornadoes and local storms). Where they develop over oceans and lead to storm surges, large-scale storms can cause enormous devastation, especially in coastal cities. Severe weather events (hail tracks, torrential rain, lightning strokes) often cause considerable devastation over a small area. Tornadoes, however, have so far tended to avoid large cities.

– Floods affect mostly fairly small, predetermined areas. Since the technical facilities, stockrooms, heating systems, laboratories and garages of high-rise buildings, hospitals and public institutions often lie in basement levels, high insured losses can result if they are damaged by flooding. Flooded hospitals quite often lead to exceptionally high peak losses (e.g. around US$ 1.5bn) caused by Tropical Storm Allison in Houston, Texas, in 2001). Floods can often cut off roads and railway lines, making it considerably more difficult or even impossible to carry out relief operations or evacuations.

– Heat waves generally affect big cities more than the surrounding area, because of the “heat island” effect. They also have a particularly strong impact in densely built-up centres, the proverbial “concrete canyons”, as no nighttime cooling occurs there, and this is associated with considerable risks for the elderly and the weak.

With catastrophes in megacities, secondary effects like the spread of pollutants and toxins can have a particularly severe impact.

Urban character and town planning

– The high concentration of people, values and infrastructure in a confined area means that even relatively small events can lead to heavy losses. Thus when Typhoon Nari passed over Taipei in September 2001 with relatively low wind speeds, it nevertheless caused insured damage of around US$ 500m. Heavy rains left the city’s underground railway stations flooded after the pumping system failed, paralysing its most important traffic artery for weeks on end.

– The rapid development of metropolitan areas usually increases the vulnerability of these delicate organisms. Complex electricity, telephone, gas, water and transport networks and the interdependence of different urban functions and of the various districts increase the risks dramatically.

– The constant expansion and restructuring of megacities means that very many new buildings are constructed. Old parts of the city still remain, however, or are only partly demolished. This leads to a patchwork of buildings of different sizes, age and construction. This heterogeneity harbours considerable risks and makes it more difficult to prepare for catastrophes.

– Migration from the land and immigration, especially in poor countries, also increase the risks in megacities. People are pushed into highly exposed peripheral areas (fluvial plains, sloping sites, etc.) and live in makeshift structures that offer no protection at all. Furthermore, because they lack personal experience, people underestimate the risk situation. However, in an emergency, the traditional network of family and village society no longer works here.

– The headlong, uncontrolled growth of cities means that municipal administrations often already find that they are unable to guarantee basic supplies and services. There is often no metropolis-wide disaster management, or where there is, it fails, for example, because several separate cities have grown together into unregulated conurbations. This gives rise to problems with coordinating aid from home and abroad. The severe earthquakes in Turkey in 1999 are prime examples of this.

– Because of their economic strength and their inhabitants’ greater need for protection, megacities in industrialised countries mostly have good safety systems in place. But this supposed safety can in fact be dangerous, lulling people into a false sense of security and leading to less sensitivity to risks. People sometimes forget that protective structures are only designed to withstand certain probabilities of occurrence in connection with natural events. Building dykes or embankments that will withstand 100-year floods tends to result in values becoming concentrated behind them. Should a bigger event occur, the losses are then even higher.

Fujiyama, Japan's 3,776-m-high sacred mountain, is located about 100 km to the southwest of Tokyo. The volcano last erupted in 1707, covering the Greater Tokyo region in a thick layer of ash.

Globalisation and the increasing interdependence of commerce and trade can cause economic and insured losses on a scale that is difficult to assess. Losses may not necessarily have an impact on the megacity alone. Depending on how metropolises are connected, worldwide losses can arise. The spectrum of possible effects ranges from the slower economic development of a country, or the total loss of various key industries (e.g. semiconductor production), all the way up to a worldwide collapse of the capital markets, as is predicted if there should be a repeat of the major earthquake that hit Tokyo in 1923.

More than ever, the insurance industry therefore has to keep an eye on natural hazards, concentrations of values, vulnerabilities and connectivities if it is to meet the special challenges that megacities pose (in this connection, see also "Natural hazard risk index for megacities", page 40).

Weather and climate in megacities

Megacities have their own weather or, to be more precise, their own individual city climate. On the one hand, they influence the weather and are therefore a causative factor. On the other hand, the weather and climate in megacities have different effects to those in rural areas.

Local effects can turn out to be different from one district to the next. In large conurbations, there are, for example, areas of high and low rainfall, "good weather" districts and "bad weather" districts, and districts with frequent winds. From the bioclimatic point of view, life in city centres is more stressful than in the suburbs, for example. Urban settlements even affect the weather of entire regions. The "heat islands" that are clearly recognisable in satellite pictures impact convection and so have an effect on the wind system in the surrounding area. What is more, cities influence the climate on a global scale, for around 80% of the greenhouse gases that affect the climate are emitted in cities, even though these cover only 0.4% of the earth's surface. However, conurbations have a special role not only where causes are concerned but also when it comes to the impact of the weather factors of wind, precipitation and temperature. Here, torrential rainfall can soon lead to local flooding, and even to devastating flash floods and landslides, which then affect mostly the poorer social strata. But what we find above all in megacities are enormous values in a very small area, which in the event of thunderstorms can result in high insured losses. Hail damage in many of the world's big cities – which in recent years has caused insured losses of US$ 1bn and more – have regularly demonstrated this loss potential to us (see Figure 7, page 21).

Megacities – Effect on the local climate

- Megacities are pronounced heat islands. The mean temperature at the centre can be several degrees Celsius (up to 10°C) higher than in the surrounding countryside. Extreme weather is moderated in the cold season (e.g. cold snaps, snow); in addition, considerably less dew, fog and frost develops there. In the warm season, the weather extremes are often significantly intensified (e.g. heat waves, thunderstorms, hail).

- Concrete buildings and paved areas heat up considerably when they are in the sun. This effect is particularly serious when there are long heat waves, because it considerably reduces night-time cooling. The elderly and the sick suffer most from this, which is why the death rate in megacities is particularly high during pronounced heat waves. Secondary effects can also occur. For example, the number of (sex) crimes, burglaries and accidents goes up during heat waves.

Extreme precipitations in December 1999 caused hundreds of landslides in the Greater Caracas area. Whole hillsides with settlements were simply washed away and huge landslides rolled several kilometres from the mountains of the El Avila National Park into the valley below. More than 20,000 people were killed. Economic losses were put at US$ 15bn.

– High concentrations of aerosols, exhaust gases and dust are emitted in megacities. On the one hand, these substances are hazardous to health and, on the other, they contain the condensation nuclei for the formation of haze, fog and clouds, and so affect the radiation climate in conurbations (screening of solar radiation, bioclimatic and radiation-climatic effects). Summer smog, which forms when there is a combination of strong sunshine and high levels of nitrogen oxide emissions from traffic, places considerable strain on health in the big-city environment. In the winter months, inversion weather situations arise more frequently in cities than in the surrounding countryside, with air quality deteriorating significantly as exhaust gases and other pollutants are trapped in a layer close to the ground.

– As well as forming urban-to-rural and rural-to-urban wind systems, megacities develop their own internal wind climate, with long, straight canyon-like streets generating jet effects with high wind speeds. In this environment, mostly in high-rise districts, strong turbulence and gusts can occur. Wind tunnel tests are therefore carried out on models during the design phase in order to minimise the effects by means of constructional measures. Convective updrafts strengthen storm systems, hailstorms and heavy rainfall – often right in the lee area of megacities.

Special weather effects in megacities

– As urban areas are mostly paved with concrete and asphalt, a large proportion of rainwater runs away on the surface. The sewerage systems are often not designed for this, with the result that torrential rainfall in big cities regularly leads to local flooding.

– High-rise buildings, towers, masts and antennas regularly attract lightning. In storms, the towering buildings of many megacities act like magnets for lightning. As electronic equipment is increasingly vulnerable to overvoltages, losses occur not only at the place of the lightning strike but also within a surrounding area of up to several square kilometres.

– Whenever there are violent hailstorms, a large percentage of the buildings and cars concentrated in cities can be damaged. Because the entire area of a city can be affected by one and the same hailstorm, enormous loss potentials can arise for insurers, e.g. through accumulations of car storage depots and large-scale horticultural enterprises in the surrounding area.

– Although the wind is slowed down over cities by the increased surface roughness, roof tiles and cladding may be torn off when wind speeds are high, sometimes leading to a domino effect in which flying debris damages neighbouring buildings, from which further debris in turn falls onto surrounding streets and buildings.

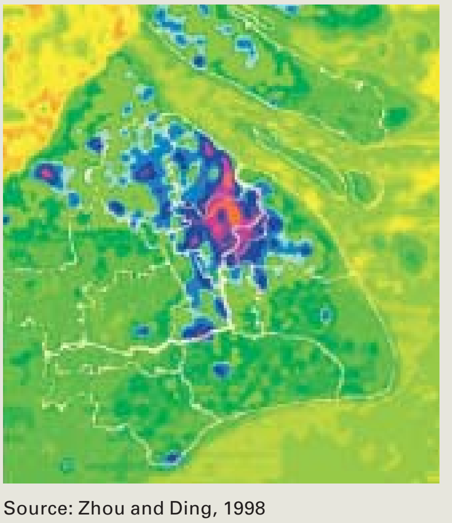
It is therefore very important in urban planning to take possible city-climate effects into consideration very early on. Insurers have to expect large loss accumulations in megacities and take particular account of highly insured urban and suburban districts in their scenarios. They must be aware that the weather and climate in megacities often obey their own laws.

Figure 9 Heat island Shanghai

Satellite image in visible range

Source: GEOSPACE Verlag, Salzburg

Thermal image



Source: Zhou and Ding, 1998

The difference in temperature between the city and the area around the heat island can be as much as ten degrees Celsius. As a result, severe weather with torrential rain, lightning and hail is often significantly intensified in the summer.

Temperature (July 1996)

- 35°C
- 34°C
- 33°C
- 32°C
- 31°C
- 30°C
- 29°C

Infrastructural and technological risks

Megacities are exposed not only to natural hazards. As industrial locations with public utilities, transport hubs and complex infrastructure, they pose a risk to themselves, the surrounding countryside and entire regions through air pollution and climatic effects. A few examples demonstrate the short- and long-term risk scenarios.

Production and storage facilities

Hazardous production facilities have always been sited outside urban areas, only to be regularly absorbed again as the cities expand. The older the plant, the more central its location. A centrifugal trend can be observed here, with old manufacturing facilities being continually shut down and relocated further on the periphery. More and more capital cities are now losing their role as the dominant industrial location, as the example of Mexico clearly shows: the capital's share of national industrial production has halved over the last 20 years.

Utility companies

The most complex risks in megacities are those involving utility companies and include: accidents affecting the distribution system; failures in the energy and water supply industries, as well as in communications systems; ruptured pipes and damaged cables also fall into this category, as do catastrophe losses affecting tunnel and dam projects, or accidents like the one in Guadalajara (Mexico) in 1994, when explosive substances spread via the sewerage system, blowing up entire streets.

Typical fire and explosion events

– A dynamite explosion at a barracks in a very densely populated area of Lagos (Nigeria) on 27 January 2002 resulted in over 500 fatalities. A similar accident in Cali (Colombia) in 1956 left over 2,000 dead.

– A fireworks explosion at a large informal market in Lima's old town on 29 December 2001 caused 463 fatalities and destroyed four entire blocks.

– An explosion on 21 September 2001 in the ammonium nitrate store of a fertiliser factory operated by the Total FinaElf Group in Toulouse resulted in 100,000 claims, 27,000 damaged homes and 10,000 bodily injury losses, including 4,800 occupational accidents and 30 deaths. The overall loss, most of it insured, came to more than €2bn. Suspected terrorism was mentioned but not pursued further, indicative of the difficulty of proving such situations. Exactly 80 years earlier, on 21 September 1921, a similar ammonium nitrate explosion at a BASF plant caused the biggest civil accident in German industrial history – 561 dead and 1,952 injured, with windows apparently being shattered as much as 90 km away in Frankfurt.

– Fire at a plastic toy factory in Bangkok in 1991 in which more than 200 workers – mainly young women – were killed. This case also serves as an example for numerous industrial fires that occurred in the 1990s in the industrial areas of Southeast Asia.

– Fire and explosions in petrochemical plants, like the explosion on 19 November 1984 in a storage facility for propane and butane situated within the municipal area of Mexico City, in which more than 500 people died and around 7,000 were injured. Most of the dead were found within 300 m of the plant. Since 1962, 40,000 people had moved into the originally uninhabited area surrounding the storage facility. Some dwellings were only 130 m away, whereas some vertical gas tanks were hurled up to 1,300 m through the air. A comparable accident at a Petrobras plant in São Paulo in 1985 also claimed more than 500 lives.

Where liability and insurance are concerned, business interruption losses are particularly contentious. On the one hand, the scope of the contractual and extracontractual liability of the utility companies themselves differs, as does that of companies dependent on them vis-à-vis their customers. And on the other hand, the scope of the business interruption insurances held by the companies affected can also vary.

The water and energy requirements of cities create risks in their hinterland, such as accident risks and ecological damage caused by the construction and operation of dams, or erosion damage caused by increasingly wider network of aqueducts.

Utility companies also include nuclear power plants, many of which lie close to major cities, some in the catchment area of metropolises like Paris, Tokyo, New York and Los Angeles. Here, the limits of disaster planning become clear: evacuation is simply not possible, either as a practice drill or for real. Moreover, the underinsurance of the obligatory nuclear pools is notorious, with their capacity now standing at barely more than that of the free liability insurance market for severe industrial risks. Opponents of nuclear power point to the totally insufficient liability sums insured: those responsible for any loss or damage are saved the costs of such cover, while uninsured losses are either not indemnified or have to be borne by the public at large.

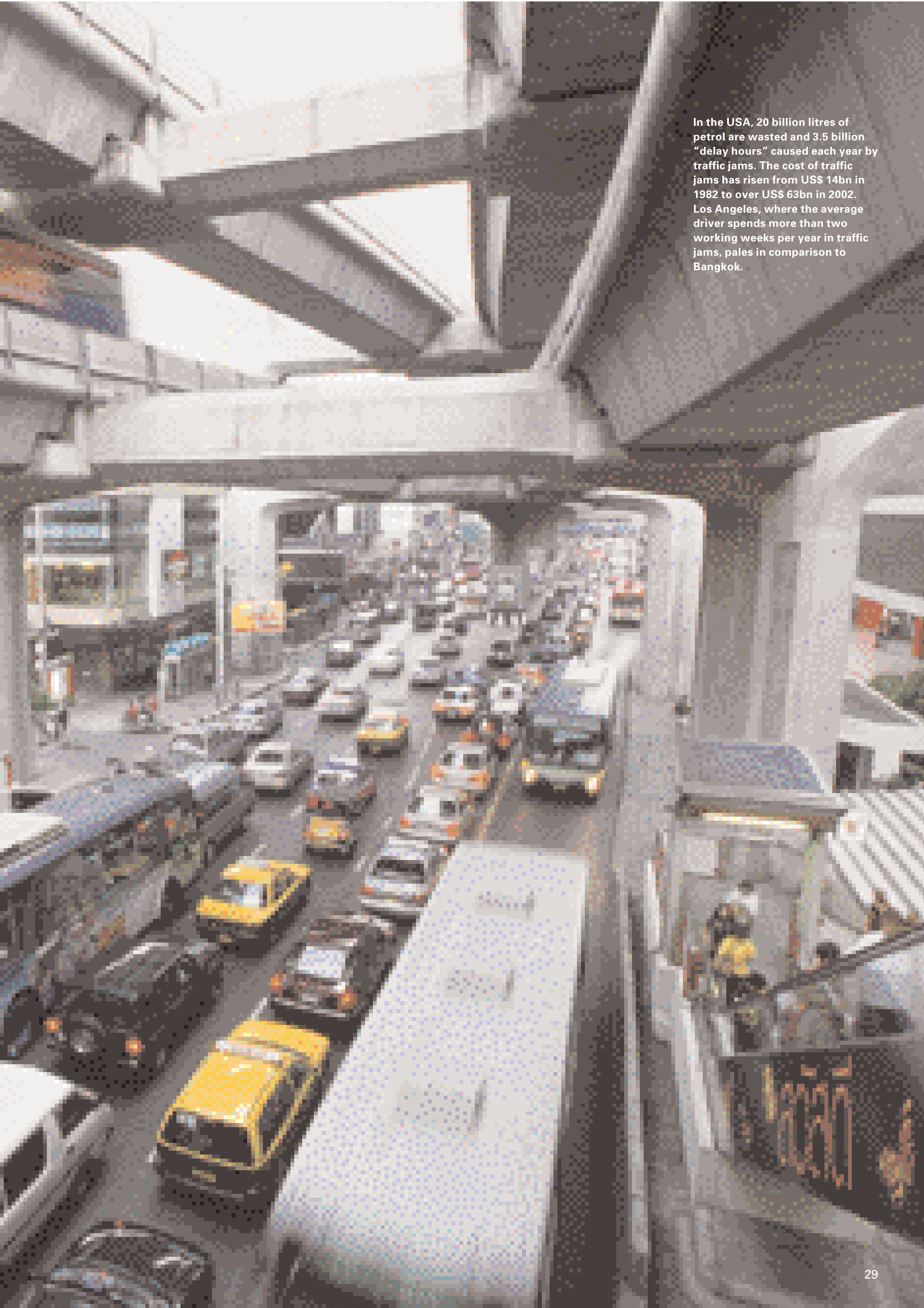
Transport

Transport accidents pose the risk of a major loss where people and hazardous goods are carried by road, rail, water or air, for example in the case of planes crashing into landing paths, or fires in tunnels and underground railway systems. As transport capacities increase, the greater the accumulation risk becomes. Particularly critical in passenger transport are departure and arrival areas at stations and airports (because of the crowd concentrations) and the large number of planes in holding patterns circling above city airports.

In private transport, accidents are primarily a frequency risk: the frequency of road accidents in individual countries lies between 100 and 600 per million inhabitants each year. For a set number of cars, the accident risk falls as traffic density increases. In highly motorised countries with strictly regulated traffic in the cities and a high proportion of public transport, urban areas account for a relatively small proportion of accidents – in Germany, for example, only one-fifth of fatal accidents. In the more complex street scene of many big cities in developing countries – pedestrians, motorised and non-motorised traffic at very high density, informal transport companies and microbuses – the picture is different. Here, road accidents place a considerable burden on healthcare systems that already have shortcomings.

Bhopal

The biggest civil industrial accident ever – the escape of methylisocyanate (MIC) from a Union Carbide plant in Bhopal on 3 December 1984 – was unique in many respects. The case, which has not been fully documented, is instructive in many ways. It started with an incorrect assessment of the requirements of Indian and Southeast Asian agriculture – after a brief period of euphoria, the oversized production plant was soon neglected. On the day in question, 67 tonnes of MIC was being stored – in Europe only half a tonne would have been allowed. MIC has to be stored in a cool place, but savings had been made on cooling systems and maintenance staff. Unlike with pharmaceuticals and pesticides, the health risks of an industrial chemical like MIC are generally not investigated as a matter of priority. It was clear that MIC quickly reacts with water, and that people's faces and breathing could have been protected with wet cloths. The company had not pointed this out either preventively or when the crisis arose. For the latter, the loudspeakers of the city's many minarets would have provided a suitable infrastructure. While obvious preventive measures were thus not taken, treatment for the damage to health caused by the MIC remains unexplained to this day. The number of victims is estimated at between 12,000 and 20,000 dead and 200,000 injured. Hardly any experience gained from treating victims has been published. The US concern, which at the time managed to arrange a settlement of US$ 470m (US$ 200m of which was insured), has since been taken over by the world's largest chemical group, Dow. Indian legislators responded to the disaster with laws on industrial accidents, information requirements and compulsory liability insurance.



In the USA, 20 billion litres of petrol are wasted and 3.5 billion “delay hours” caused each year by traffic jams. The cost of traffic jams has risen from US$ 14bn in 1982 to over US$ 63bn in 2002. Los Angeles, where the average driver spends more than two working weeks per year in traffic jams, pales in comparison to Bangkok.

Long-term risks for environment and health

Agglomerations of people, traffic, trade and industry burden the environment. All three environmental media – water, soil and air – are affected. Pressure on these natural resources causes health risks both in cities and their hinterland.

Soil and groundwater

Industrial and commercial enterprises emit heavy metals that reach the soil via the air. Leaded petrol is also relevant as a source of pollutants. Because the soil acts like a filter, the heavy metals mostly do not reach the groundwater. Unlike organic compounds, however, they are essentially non-degradable and therefore build up in the soil. Plants growing there take up the heavy metals to some extent through the soil, although some pollutants are deposited directly on their leaves. Plant and soil studies carried out using the raster scan principle showed, for example, that lead, zinc, copper, chromium, nickel and mercury levels in Manila have reached critical values over large areas. Close to industrial enterprises, the levels can increase dramatically.

Liquids are often not retained by the soil and pollute the groundwater. Industrial and commercial enterprises, and also petrol stations and landfills, tend to cause localised pollution, whereas leaky sewers cause pollution over a wide area. Chlorinated hydrocarbons (CHCs) like tetrachloroethylene, which is often used in metalworking firms and dry-cleaning shops, spread in the groundwater as plumes of contaminants that may be several kilometres long.

Since the late 1990s, the trend in industrialised countries has been to make derelict contaminated industrial areas (brownfield sites) usable again. The resettlement of industry and commerce on recycled areas can be seen on the one hand as more cost-effective and, on the other, as making better ecological sense than building on greenfield sites.

Sewage

For sewage disposal, the flush method of waste transport with a downstream sewage treatment plant was developed in the northern hemisphere, because sufficient water for this is available there. However, at up to €150 per inhabitant and year – according to a comparison of costs in Europe – this type of disposal is cost-intensive. Even in Europe, some cities therefore discharge their sewage untreated into rivers. For poorer countries, this disposal technology is on the one hand prohibitively expensive and, on the other, many developing countries simply do not have enough water. Consequently, a large part of the population of megacities is still not connected to a public sewage disposal system.

In the year 2000, 400 million city dwellers worldwide had no toilets. This, combined with poor supplies of drinking water, leads to deaths from diarrhoeal diseases. For children under five years of age, these are the most common cause of death, along with diseases of the respiratory tract. Developing new technology tailored to the needs and basic conditions of developing countries is therefore more urgent than ever.

Air pollution

For many megacities, the “bad atmosphere” caused by traffic and industry is proverbial. This is especially true of vehicle emissions of carcinogenic diesel exhaust particulates and nitrogen oxides. During periods of intense sunshine, nitrogen oxides react with other chemical compounds in the air to form ozone, thereby giving rise to “photochemical smog” or “summer smog”. Thus on 160 days of the year the level of ozone pollution in Santiago de Chile is almost three times higher than the critical threshold value of 160 micrograms per cubic metre of air.

One of the biggest problems of metropolises is air pollution from particles of dust and soot. These are mainly caused by traffic – in Kuala Lumpur, they account for half of all air pollution and in Seoul for one-third. The main vehicles responsible for this are diesels – especially lorries and buses. Lead pollution in the air is also a problem, with WHO standard values often being exceeded more than twofold, as in Jakarta.

In the cities, this leads to considerable damage to health. According to a study by the US Agency for International Development (USAID), 1,400 deaths a year in Bangkok may be attributed to the dust burden, while a 1989 survey concluded that around 900,000 people suffer from diseases of the respiratory tract.

There are marked differences between the city and the countryside. Thus the death rate from lung cancer in Chinese cities is six times as high as the national average. But even in Germany, the risk of developing cancer as a result of air pollutants is around five times higher in conurbations than in rural areas.

Figure 10 The spread of SARS from February to May 2003: New and highly infectious viruses against which there is (still) no antidote or inoculation, can spread rapidly from conurbation to conurbation. SARS spread very quickly throughout the world, but fortunately comparatively few people were affected.

Sources: Stich et al., 2003; Kamps and Hoffmann, 2003

Refuse

The volume of waste increases rapidly as societies becomes more industrialised and sophisticated. In Germany, for example, each person generates 430 kg of waste a year. A prerequisite for dealing with refuse and the associated threat to public health is its collection and removal. Where this is not done, there can be consequences for health. Thus in recent years, megacities have seen the spread of yellow fever, malaria and dengue – diseases that were previously mainly endemic to the countryside. Mosquitoes, which transmit the pathogens, find breeding grounds in cities too. Once filled with rainwater, carelessly discarded used plastic bottles or drinking cups provide ideal breeding grounds.

Infectious diseases

Having lots of people living together in a crowded area makes city dwellers susceptible to infectious diseases. Air pollution, poor nutrition and lack of medical treatment means that many people's health is already seriously impaired.

Children, the elderly and HIV-infected persons in particular therefore have very little resistance to tuberculosis and other infectious diseases. Each year, around three million people worldwide die from tuberculosis. A person suffering from tuberculosis in the poorest neighbourhoods infects an average of ten to 15 people each year – often family members. Resistant strains of the pathogen and also long and costly treatments mean that this disease is also becoming a problem in cities in rich countries.

The increase in travel and trade and also the drift to the cities favours the rapid global spread of diseases, especially sexually transmitted ones like HIV, hepatitis B and C, or papilloma virus infections, which can cause cancer.

Social and political risks

Friedrich Engels described the social problems of English cities at the time of the industrial revolution in 1842. In the meantime, the sheer volume of sociological studies on a city like Mexico City is overwhelming. The same goes for São Paulo and Lima, as well as for African and Asian megacities.

What continues to stand out in many descriptions of the deplorable state of affairs is the apocalyptic undertone, most recently found in “La Ville Panique” (“Panic City”) by the French philosopher and town planner, Paul Virilio (2004). In his view, even in the industrialised countries, the urban trends of megacities and the disintegration of the western concept of the city threaten to lead to the disasters of the 21st century: the depopulated, purely business world of city centres; and social flashpoints on the urban fringes populated by outsiders who cannot afford to move into the exclusive residential areas of the upper middle classes. He also critically examines the trend towards gated communities – privately operated residential developments closed to the general public. The residents of such communities benefit from the cities in which they work but pay their taxes in suburban municipalities that do not have to pay for the infrastructure.

Where health aspects are concerned, the diseases caused by today’s lifestyle are coming to the fore. The decisive factors here are environmental influences, dynamic changes in lifestyle and the working environment, as well as the struggle to survive in the informal economy. Typical big-city diseases are becoming the main problem in the health policies of developing countries. “By the third decade of this century, depression, traffic accidents and heart disease are predicted to become the leading disease burdens in developing countries”.

For disaster scenarios in megacities, commercial, sporting and cultural events play an ever greater role. Efforts to ensure that hotels, conference centres, stadiums and stages are utilised as much as possible oblige organisers and security services to come up with prevention strategies for the event of a disaster – keyword: crowd management.

Crime

Crime is one of the risks of a city’s “normal operation”. Security is often not a public commodity that the state guarantees its citizens, but a private one that they have to buy. In many developing countries, more people are employed by private security services than by the police service. The economic costs are accordingly high. According to estimates, the total cost of private security in Brazil amounts to 10% of GDP.

Studies carried out by the United Nations Interregional Crime and Justice Research Institute (UNICRI) show that documented violent crimes in the cities of developing countries are on the up. Top of the league are Latin American and African cities, while Asian cities are at the bottom. Traditional mechanisms of social control like Buddhism and upbringing in Bangkok appear to be withstanding the impact of modernisation, migration and unemployment for longer than is the case in Latin America (Catholicism, family, “personalism” in social relationships) or in Lagos (religious and citizen communities, the traditional conflict-solving mechanisms of Yoruba society).

At Atocha Station in Madrid people mourn the 200 victims of the terrorist attack in March 2004.

The relatively reliable figures for cases of wilful homicide (per million inhabitants) lie between five in Tokyo and over 500 in Johannesburg and some municipalities of São Paulo. There is generally an urban-rural gradient, though there are exceptions to this, like Bogotá (150) as compared to Colombia as a whole (over 500). This can be explained by the "violencia" in rural areas, which is traditionally akin to civil war, and also by successful policies introduced in the capital in recent years.

Responses to crime in cities range from the various prevention strategies of the 1970s and 1980s to more repressive methods based on the example of New York in the 1990s (zero tolerance). The latter, like the questionable development of gated communities tend to just shift the problems and not solve them. So although violent crime in New York did fall, at the same time there was an increase in police violence – and therefore also in liability claims, which are largely covered by liability insurance. Often only limited control is possible: in Karachi, for example, the army withdrew from the city in 2003, after trying unsuccessfully for ten years to restore law and order.

Terrorism

Megacities have always had to contend with terrorism. Post-colonial terrorist movements found targets in the traditional centres of power, like Paris and London. In London, the financial and banking centre was at particularly high risk during the time of IRA attacks. The trend towards monitoring private transport in the City was speeded up for security reasons and was then irreversible – ultimately a positive side effect.

In New York, Wall Street as a symbol of western capitalism had already been threatened on 16 September 1920, when an American anarchist tried to bring down the Morgan Building with a whole truckload of explosives, evoking memories of the iron-frame towers that collapsed during the Chicago Fire of 1871. This did not slow down the skyscraper boom in the USA, however. The religiously motivated terrorism that broke out towards the end of the 20th century had already tried to destroy the World Trade Center back in 1993, succeeding some eight years later at the second attempt.

Since 11 September 2001, in view of more stringent measures introduced to prevent terrorism, we are now seeing a change in trend towards "softer" targets which are almost impossible to monitor. It was not by chance that, exactly two-and-a-half years later, on 11 March 2004, Madrid's Atocha station became a terrorist target during the busy morning rush hour.

War

For centuries, major fires in cities were the biggest conceivable accident, whether caused by natural catastrophes, blast or war. The new strategy during the Second World War was the large-scale destruction of entire cities. Goering dreamt of the total destruction of London by fires scattered right across the city, while Hitler conceived of attacks on American cities. Initially, the town of Guernica and the cities of Warsaw, Belgrade and Rotterdam were actually destroyed by bombing. Then, towards the end of the war, the Allies carpet-bombed German cities and Tokyo. Finally, atomic bombs were dropped on Hiroshima and Nagasaki.

Even after the Second World War, capital cities have continued to be at the centre of wars, for example Hanoi and Belgrade, and more recently Kabul and Baghdad. Efforts are now made to achieve greater accuracy when bombing targets. The term "collateral damage" has come into use: civilians are only inadvertent casualties and no longer the target of attacks. Certain liability issues arise in this connection: in the case of long-term damage, say in connection with enriched uranium in Baghdad, manufacturers' liability may be possible, following the model of US class actions against the manufacturers of the Agent Orange herbicide for loss or damage suffered as a consequence of the Vietnam War.

On 6 August 2004, the 59th anniversary of the dropping of the first atomic bomb, the Mayor of Hiroshima said that the number of deaths had since risen to 237,062. With reference to collateral damage, he also criticised the USA's current plans to develop "user-friendly" atom bombs – "bunker busters" or "mini atom bombs" with an explosive force of up to 5,000 tonnes of TNT, one quarter of that of the Hiroshima bomb.

Criminal attacks by gangs of youths are very difficult to keep under control.

Opportunities for the insurance industry

For the insurance industry, the low insurance density in the megacities of all developing countries is one of the big challenges of the 21st century.

Only a fraction of the population covered by social insurance systems has so far taken out any private life, health or personal accident insurance, and these are mainly in the middle- and higher-income bracket. But even social insurance systems cover only about 20% of the world's population. During the 20th century, governments and UN organisations endeavoured to introduce obligatory workers' compensation, pension, disability and health insurances following the Bismarck Model, i.e. employment-contract-based systems, and the comprehensive Beveridge Model. However, these models were ultimately only a limited success. In rural areas, there are often no social insurance institutions at all. But also in the megacities of developing countries, even today large sections of the population continue to be excluded from such insurance systems, despite the presence of the authorities and hospitals.

For private life, health and personal accident insurance, the insurance density in megacities is dependent on several factors: How strong is the role of private insurance – alternative or complementary – compared to public insurance schemes? What is the threshold at which private "add-ons" come into operation, and to what extent? Here, private providers of life, health and personal accident insurance in the megacities of the industrialised countries are heavily exposed in the event of urban disasters – Japanese life insurers, for example, or Korean group personal accident insurers. And to what extent does the "formal" – private and public – insurance system cover the population overall?

Whereas in the life, health and personal accident insurance sector there have been systematic attempts to establish comprehensive social insurance systems, considerably less effort has been made in the property insurance sector. Property insurance is consequently a traditional domain of the private insurance sector. Catastrophes in megacities are therefore often more heavily underinsured with respect to property insurance than with respect to life, health and personal accident insurance: on the one hand there is no basic cover and, on the other, specific risks like earthquake or terrorism are often excluded. Obligatory insurances like earthquake insurance in Istanbul are the exception rather than the rule, in order to create the necessary balance in the case of exposed risks. The intention here is twofold: to make these risks insurable and to fulfil a social-insurance-like mission. There are, however, provisos under competition law with respect to insurance monopolies and pool solutions.

Liability insurances can help provide systematic protection for the population of megacities that has little direct, "first-party" insurance cover. The prerequisites for this are:

It must be possible to prove that liability exists, and this is easier with accidents than with long-tail risks.

Those liable must be solvent, which means the options are: the state, large companies and obligatory liability insurances, especially for motorists or the operators of hazardous enterprises. Here, local motor insurers must be able to force through prices that are commensurate with the risk in order to be able to finance an adequate level of compensation. International insurance programmes covering hazardous manufacturing facilities in megacities tend to make higher insurance capacities available, yet these risks are often underestimated by group headquarters and their liability insurers.

1,000 years

For the insurance industry the probability of a loss event occurring – a "return period" of 1,000 years is generally taken – is of fundamental importance. This is used as the yardstick for assuming risks and setting the premium level. Although Taipei is seriously threatened by earthquakes and typhoons, this is where you can find the world's tallest high-rise building today.

Risk management – The essence for the insurance industry

Megacities are particularly prone to losses because of their high concentration of people, values and infrastructure. The risks inherent in such concentrations in megacities call for tailor-made methods, especially from reinsurers. Two approaches help to make the risks transparent: bottom-up and top-down. On the one hand there is geocoding, which allows risks to be recorded also for small areas, and on the other hand there is an index that makes it possible for the potential extent of a loss in a megacity to be assessed in its entirety.

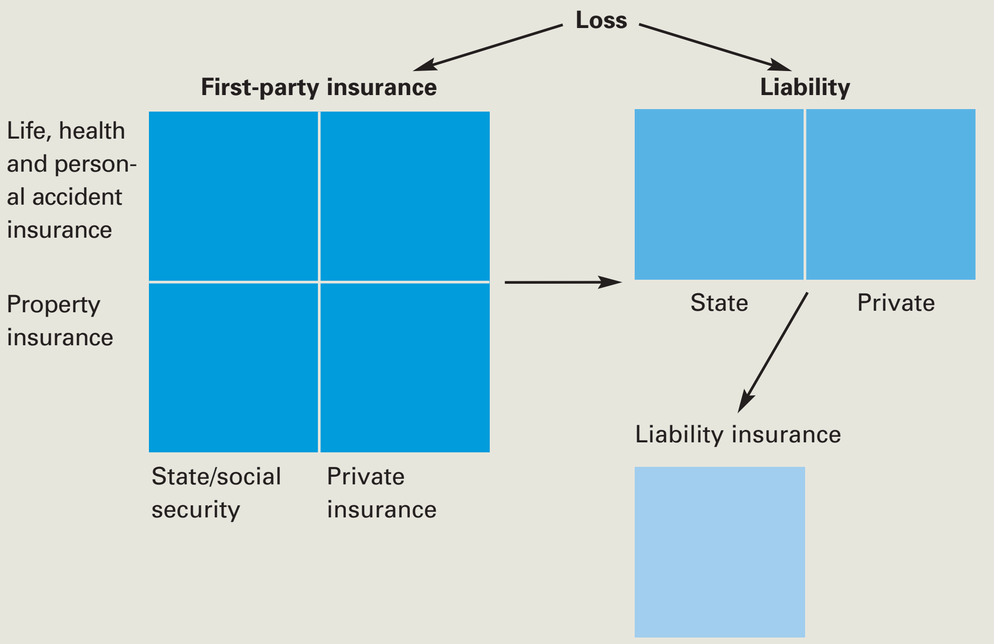
Management of individual and accumulation risks

In property insurance as well as in life, health and personal accident insurance, accumulation risks, i.e. the total insured values at risk, increase in line with insurance density. In liability insurance, mass losses are attributed to a single responsible party or group of responsible parties. The liability insurance accumulation can be calculated relatively easily from the total liability insurance of the parties responsible.

Disaster scenarios such as natural catastrophes, industrial accidents or terrorist attacks cause bodily injuries, environmental damage, property damage and pure financial losses in various combinations (see Figure 6, page 19). Life, disability, health and workers' compensation insurances, property and liability insurances can therefore be affected in different ways. For the purposes of accumulation control, scenarios affecting various classes of business can be anticipated at two levels, from which conclusions can also be drawn with respect to prevention and the protection of victims:

- Disaster scenarios – The central question here is: what bodily injury, property damage, pure financial losses and environmental damage can be caused by natural events or man-made disasters? From analysing the facts and comparable historical cases, the insurance industry can come up with ideas for prevention.
- Insurance markets – Here the question is: how do the insurance markets handle disaster scenarios? It is essential to look at market structures, which vary from country to country. These structures are characterised by varying forms of interaction between private and state prevention, social security and private insurance, private and public liability law, and also by various ad hoc government aid programmes and compensation funds. Not only are there differences from one country to another, but market structures also change over time, often following spectacular losses that prompt political pressure to take action. Analysing market structures helps identify weak spots, such as currently exist in Germany where the protection of victims of violence is concerned.

Figure 11 Insurance market structures



As a rule, the party affected has to bear the loss unless the loss is insured (first-party insurance) or another party is liable which in turn can have liability insurance. The issues are dealt with differently on every insurance market in response to losses of a similar nature.

Source: Munich Re, 2004

Natural hazard risk index for megacities

Worldwide, the loss potential from natural catastrophes is increasingly dominated by megacities. This affects the insurance industry in particular, as the density of insurance in urban areas is traditionally significantly higher than in rural ones. A comprehensive analysis of the risk potential in conurbations that incorporates all natural hazards is therefore more pressing than ever. In order to get one step closer to this goal, Munich Re has developed a megacity risk index.

When the risk index was being set up, there were two main aims: we wanted to make risks and loss potentials transparent and to allow a comparison between megacities. The study was based on 50 megacities, the selection criteria being number of inhabitants, and global significance (see Appendix). The Munich Re risk index differs from previous work on this subject in two ways. Firstly, it adopts an absolute approach, i.e. the aim is to establish not only a relative classification but also a relation to at least the order of magnitude of the absolute loss potential. Secondly, it is the first risk index to consider all the relevant natural hazards at once. As soon as data of the required quality are available, it can be converted into an absolute index that directly reflects a megacity's loss potential.

Components of the risk index

The Munich Re risk index is geared to the risk of material losses, without including the insurance density or the insurance terms and conditions, which vary by region and hazard. However, its modular structure means that the index can easily be adapted for either underwriting or other purposes. As the index is intended to be a measure of loss potential, it embraces all three components: hazard, vulnerability and exposed values. The hazards considered in the calculation were earthquake, windstorm, and flood as the main hazards, and volcanic eruption, bush fires, and winter damage (frost) as the most important secondary hazards.

The three main components are in turn made up of several sub-components. These components or indirect indicators are allocated to four or five classes. In order to be able to derive an absolute measure of risk, these classes are, whenever possible, assigned absolute values which reflect their influence on the risk. Absolute values have the advantage that the weighting of individual components can be objectified if they are combined to form indices and sub-indices.

Hazard

As far as exposure to hazard is concerned, the various natural hazards are best weighted objectively by allocating average annual losses (AAL). These can then simply be added together. A catastrophe loss with a low occurrence probability is then calculated. Here the uniform basis of a 1,000-year loss (probable maximum loss = PML) is used. The values are allocated to the various exposure classes on the assumption of equal vulnerability.

The quantity used as a starting point for the earthquake risk is the earthquake zone in Munich Re's World Map of Natural Hazards. The earthquake zone is derived from the intensity of ground motion that is to be expected on average once in 475 years, without considering secondary effects. The zone value was therefore modified for the following secondary effects: change in shaking intensity according to the subsoil conditions, liquefaction of the ground, tsunamis (sea waves triggered by earthquakes), fire following earthquake.

However spectacular their manifestation may sometimes be, these effects generally only occur in small parts of urban areas, so the shaking intensity carries the greatest weight in the index. In a further step, AALs and PMLs were assigned on the basis of the modified zone values using worldwide loss statistics.

Unlike earthquakes, there are various kinds of windstorm that need to be observed – tropical storms, extratropical storms and local storms (e.g. tornadoes, hailstorms). For tropical storms we again used the original classes in the Munich Re World Map of Natural Hazards. The criterion for classification is the storm strength on the five-stage Saffir-Simpson Scale that is to be expected once in 100 years, this being ultimately the wind speed. Extratropical storms are classified in the same way, but the number of categories is reduced from five to three because of the wind speeds being lower. In the case of local storms, other factors such as hailfall and driving rain also play a role besides wind speed, so that the exposure is much more difficult to quantify. As in the case of earthquake, AALs and PMLs were allocated to the zones. The AALs for the various windstorm phenomena were added together, whereas in the case of the PMLs the highest value was selected, as adding them together makes little or no sense.

Different forms of manifestation also have to be considered in the case of flood, namely river flooding, flash flood/torrential rain and storm surge. As flood is not shown on the Munich Re World Map of Natural Hazards because of the small size of the exposed areas, the classifications were developed specially for this index. The initial classification is qualitative but it could be refined considerably with detailed data. When allocating AALs and PMLs, it is important to remember that the urban areas affected are relatively small as a rule.

Volcanic eruption, bush fire and frost were included as "other hazards". However, these make only a relatively small contribution to the total hazard. The allocation of AALs and PMLs and the production of the overall index were performed in the same way as for the other hazards.

The total exposure to hazard is derived in the following steps:
- Adding the AAL values for the individual hazards
- Selecting the highest PML value for all hazards
- Weighting the AAL total at 80% and the highest PML at 20%, then adding the two values.

The weighting of AALs and PMLs is subjective but may be adjusted for each respective use.

Vulnerability

In order to determine the index for vulnerability, three main components were examined; two of them are related to exposure, the third is of a general nature: hazard-related components include vulnerability specific to the building class, i.e. the vulnerability of the predominant form of residential construction to natural hazards. For commercial and industrial risks, a similar type of construction (but not quality!) was assumed throughout the world. The second hazard-related component is the standard of preparedness and safeguards. This includes, for example, building regulations and town-and-country planning in respect of specific hazards, as well as flood protection.

The general component is made up of general quality of construction and building density. The indicator of building density is population density. The greater the density, the greater the risk.

Figure 12 The natural hazard risk index for megacities

The natural hazard risk index for megacities makes it possible to identify the risk potential quickly and to improve comparability and transparency.

Risk index
(Circle size corresponding to risk index value, not true to scale)

Relative share of risk index components:
Hazard
Vulnerability
Exposed values

Source: Munich Re, 2003

In order to calculate the vulnerability index, vulnerability, preparedness and building quality were split into four classes: "very good", "good", "average", and "below average". To obtain the index, a range of percentage losses to be expected was allocated to the classes. This is an expression of the degree to which the loss varies for the respective criterion when all other criteria remain unchanged. The building density is considered in the form of original values, standardised to a range of 0 to 4.

In order to calculate the total vulnerability index, the three main components were each given the same weighting and added together. On account of the sometimes poor quality of the available data, the weightings here are less objective than in the case of hazard, but they still appear plausible on the whole.

Exposed values

As the derivation of genuine value inventories goes beyond the scope of this study, indicators were defined for the total value of an urban area in the form of a relative grading. The average value per household was used as the indicator for the residential building sector, while for commerce/industry gross domestic product (GDP) was used. Value in the overall context was based on global economic significance. The average values of households were derived on the basis of an average relation between values of households and GDP for federal states in the USA and Germany, and then extrapolated worldwide.

The global significance – graded in four classes from "very high" to "low" – reflects the role of the individual urban areas in the global economic network. The class value is included in the calculation to the power of 2.5. This means, for instance, that Tokyo has a 32-fold weighting compared to Abidjan. In the calculation of the total value index, all three subcomponents are added together with the same weighting.

Calculating the total risk index

In order to produce a total index, the three main components of hazard, vulnerability and exposed values must be standardised. For this purpose, the maximum values in each case were set to 10 and the other values calculated proportionally based on this. The last step is combining the components. The most meaningful and practicable results are obtained by multiplying the main components.

All in all, the index is most heavily influenced by the exposed values, followed by hazard. Vulnerability plays a lesser role. This may seem surprising at first. The explanation: at 0.5 to 10, there is a much broader spread in the index in values and hazard than in the case of vulnerability (3 to 10). Greater Tokyo, with its combination of high exposure and peak position in terms of exposed values, therefore leads the field by a wide margin. There is only one megacity from a non-industrial country in the top ten, and that is Manila. On the other hand, some cities with comparatively low hazard, like New York, Paris and London, come very high up in the ratings because of their high concentrations of values.

Regardless of all the limitations and inexactness of the input parameters, Munich Re's megacity index provides a realistic comparison between the loss potentials of various megacities. For insurers, this result is of great importance, as it offers an initial indication of the risk potential. If data on the insurance density or direct information on the exposed liability are available, it is possible to prognosticate the insured loss potential. Although they are no substitute for the results of individual risk models, they can provide a usable initial indication, particularly for areas where no such models are available or where markets are in the process of developing.

Outlook

The natural hazard risk index for megacities is to be seen as a basis for discussion. It enables the risk potential to be identified quickly and makes risks comparable and transparent. Assessments of vulnerability can be confirmed and objectified through specific surveys. The RADIUS (Risk Assessment Tools for Diagnosis of Urban Seismic Disasters) and GESI (Global Earthquake Safety Initiative) projects were an important step in this direction. Both were initiated by the Californian non-profit organisation GeoHazard International. As far as hazard is concerned, one weak spot is flood. For a sound assessment, more detailed data is needed here. As far as total exposure is concerned, earthquake plays a surprisingly important role that requires more detailed examination. There is further need for research with regard to the analysis of main components, with the aim of objectifying their weighting.

Precisely against the background of ever-faster-growing megacities and mega-urban regions, this top-down approach is an effective tool for obtaining a preliminary and broad assessment of the risk and loss potential as quickly as possible. The advantage of the megacity index lies in its modular methodology. It can be expanded and developed as required and applied to smaller towns or even to entire countries.

For further information, see Munich Re publication:
– topics ANNUAL REVIEW: NATURAL CATASTROPHES 2002: A natural hazard index for megacities

Sustainable risk management with geographical underwriting

Transparency in the underwriting process is a prerequisite for sustainability and long-term efficiency in risk management – this is especially true in the case of megacities. The key to success is a new method: geographical underwriting.

Only someone who knows the risk situation and concentration, together with the classes of insurance involved and how they are interconnected, is in a position to manage catastrophe risks in megacities – and this applies to insurers and reinsurers alike. It is therefore vital to identify and analyse the geographical location of risks. In geographical underwriting, the geographical location of insured property is stored in a database; this data can then be actively used.

Methodology

Geographical underwriting is based on insurers' portfolio/loss data. Many companies in the insurance industry have already recorded this information. Geocoding, or "georeferencing" as it is also known, uses information such as the town or address and converts it into geographical longitude and latitude coordinates which can then be further processed.

Geocoding may be performed using various levels of detail – countries, postcodes, towns, addresses. For megacities, however, "coarse" geocoding, e.g. at country or regional level, is not sufficient. Even risk allocation on the basis of CRESTA zones (see www.cresta.org), often used today in property insurance, is frequently too coarse for megacities.

It is precisely for assessing fire, flooding, business interruption and workers compensation insurance that accurate input data are required. This is the only way in which exposures in small areas or spatially concentrated exposures such as hazardous industrial plants or potential terror targets in megacities can be modelled. Identifying and breaking down so-called master policies or multi-location policies is all part and parcel of this. Thus the reference addresses for chains of companies or housing associations often only refer to the headquarters, while the policies often include other risks at different locations as well. This can lead to a situation in which exposures are not identified or are incorrectly evaluated.

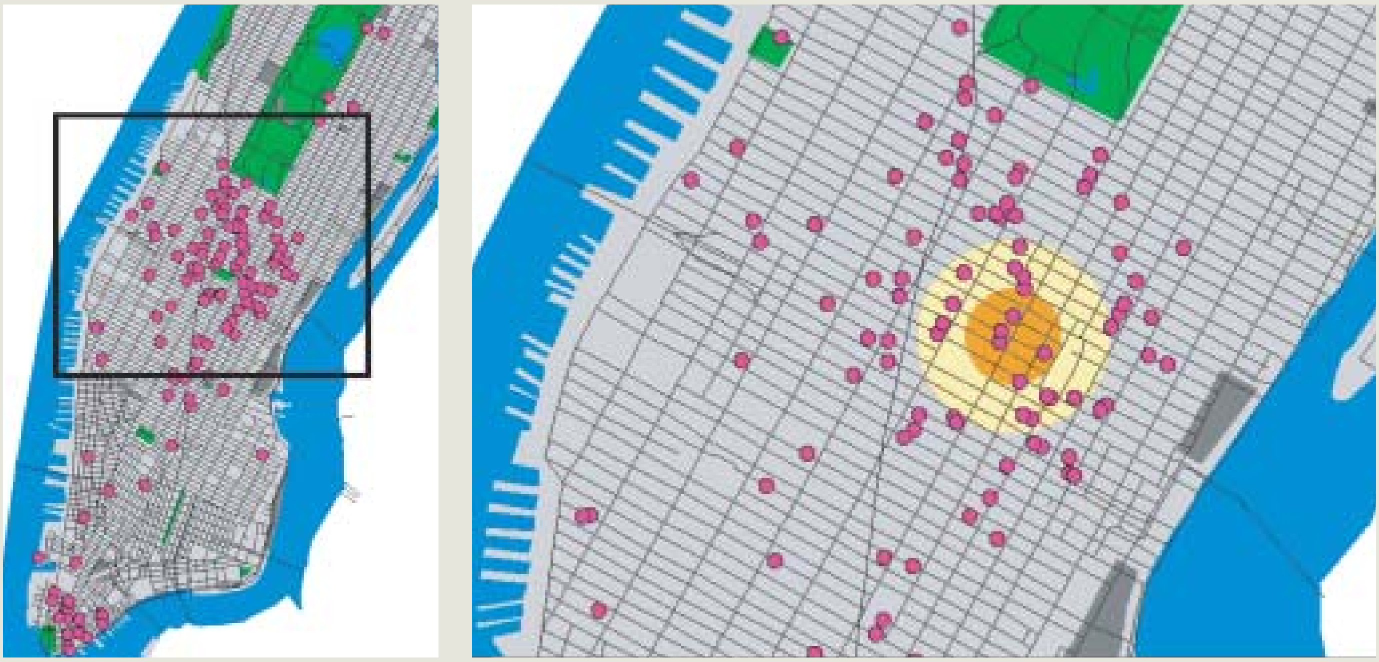
Geocoded data is used to prepare analyses, computer models and scenario calculations for specific portfolios; these form an important basis on which underwriting and risk management decisions are taken. These tools can also be used to calculate the accumulation risk of insurers and reinsurers.

Figure 13 Geographical underwriting

The insurance companies' portfolio and/or loss data are geocoded on the basis of the different levels of spatial detail. This is crucial for analyses of specific portfolios, computer models and scenario calculations. These ultimately provide an essential basis for underwriting and risk management.

Source: Munich Re, 2004

Figure 14 Portfolio analysis and scenario generation in Manhattan (New York)



Geocoding at address level (red dots) produces a highly accurate picture of potential liability concentrations. Using various scenarios (e.g. yellow circle), critical areas can be identified and the risk management improved. Analysing several classes of business at the same time also opens up further opportunities for analysis.

Source: Munich Re, 2003

Multi-class risk management

Many companies have their own portfolio databases for individual classes of business. With geocoding, policies can be combined and analysed at will. Different spatial resolutions within megacities can be combined with each other. For example, treaty and facultative business can be examined at the same time and a multi-class assessment of the risk situation at corporate or divisional level carried out.

Geocoded liability data is also helpful in evaluating risks of change (e.g. risk of thunderstorm in connection with climate change) or hitherto unknown risks in the area of terrorism: the current portfolio can be linked with new scenarios at any time and new loss potentials calculated. One important result of this methodology is optimised pricing, which in many cases makes it possible to apply smaller risk and safety loadings. If this detailed information is not available, mostly conservative assumptions must be used.

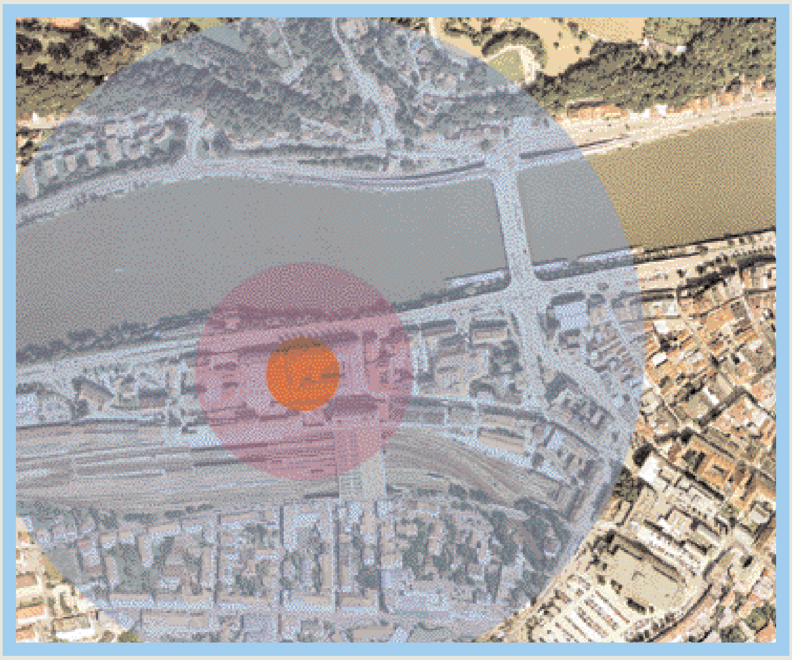
Geographical underwriting also offers new opportunities when it comes to allocating insurance capacity. For example, in highly exposed megacities, potential exists for development and expansion which can only be used if detailed portfolio data is available.

If a loss has occurred, the anticipated amount of loss for all classes of business affected can be estimated quickly and accurately. If the area of the loss is known, such as in the case of flooding, losses reported outside the loss zone can be clearly identified and clarified in cases of doubt.

Current status of geocoding

All geocoding services at address level are currently based on data collected for vehicle navigation and route planning purposes. The data have a high level of coverage, particularly in the important industrial countries, and above all in the USA and Europe. They will soon be joined by the Asian markets.

Figure 15 Integrated risk management



Explosion at an industrial site

Potentially affected classes of insurance business

Property/Engineering
Life/Health
Workers' compensation
Marine
General liability
Contingent business interruption (CBI)

Geographical underwriting can be used to simulate multi-class scenarios. For example, following an explosion at an industrial site, losses in other classes of business can also arise due to geographical networking.

Source: Munich Re, 2004

Geocoding is technically quite mature nowadays and has been sufficiently tested for it to be used in practice. What is more, external services can be used via the internet or integrated into a company's own IT landscape. From the insurance point of view, not only risk and loss analyses but also clients' master file data can be examined to ensure that their postcodes are correct and can be used for geomarketing activities.

Conclusion

Geographical underwriting is an important new tool that can be used to better assess premium requirements and the risk of losses. Experts at Munich Re are therefore vigorously pursuing the development and implementation of such projects. More and more primary insurers are also recognising the added value of geocoding, namely improved risk management. Consultants are using these techniques too as a basis for their numerous modelling tools. The work and expense that geographical underwriting entails for the individual company is justifiable when measured against the results the method brings. And all the more so, as geoinformatics has undergone extraordinarily dynamic development in recent years and is now on the market with a number of flexible, user-friendly applications and services.

See the following Munich Re publications for further information on the subject:
- topics ANNUAL REVIEW: NATURAL CATASTROPHES 2002. Getting to the "point" – Does geographical underwriting improve risk management?
- TOPICS geo ANNUAL REVIEW: NATURAL CATASTROPHES 2003. Geographical underwriting – Applications in practice

1666 The Great Fire of London that destroyed five-sixths of the city is often cited as the event that triggered the introduction of fire insurance. A year later the first fire insurance was available in London.

Implications for individual classes of insurance

Life, health and personal accident insurance, as well as property and liability insurance are all affected to different degrees by the high growth dynamic of megacities. The demand for property insurance in particular is increasing rapidly in megacities. Alongside traditional reinsurance tools, accumulation control is becoming increasingly important. In life, health and personal accident insurance, this has played a subordinate role so far.

Life, health and personal accident insurance

For life, health and personal accident insurance, all major very large risks and accumulation scenarios in megacities and metropolises are relevant. For life and health insurance, epidemics constitute an additional risk.

What is the exposure actually like in life, health and personal accident insurance? Natural catastrophes like earthquakes, windstorms and floods are generally covered under life, health and personal accident insurance. Only in a few individual countries are these risks excluded. A differentiated approach is required with political risks. For example, personal accident and health insurance traditionally exclude war risks, whereas life insurance normally excludes active war risks only. Terrorism risks, on the other hand, are usually covered under life, health and personal accident insurance, although this is not standard in private health insurance.

High exposures also exist in the following areas: nuclear risks, big events like major sports fixtures, pop concerts or annual general meetings, traffic accidents – especially air or train disasters – and, finally, fire and explosion losses. Life, health and personal accident insurances, with the various types of benefits involved, are particularly affected by death and disability payouts, as well as by known and unknown accumulations of people and policies. Epidemics represent an additional risk, especially in life and health insurance.

Countervailing effects are observed in connection with mortality in megacities: on the one hand, health and environmental risks are greater but, on the other, medical care is better than in rural areas. These different effects are not (yet) explicitly considered in life insurance, but are to be found in the relevant mortality and disability tables for the individual countries.

In private health insurance, experience shows that the higher density of doctors and the better availability of treatment in conurbations cause a rise in average costs per insured. Increased health and environmental risks can also mean greater expenditure in the private health insurance sector. For example, more pollutants in the air leads to an increased incidence of allergies and respiratory diseases.

Particularly in emerging markets, the low purchasing power and the low level of risk and health awareness of the rural population results in a far lower insurance penetration than in the metropolises. A contributory factor here is often the sales/marketing structure of the insurance companies, which often concentrate on megacities in emerging markets. Thus the take-up rate for private health insurance among the rural population in some growth markets is virtually zero, whereas insurance penetration is rising sharply in the major metropolises, although in absolute terms it is (still) relatively low. In private health insurance, this has to be taken into account when calculating the premium, for instance. This is because the available economic data and bases for calculating the premium often relate to a country's overall population – at least in the absence of individual insurers' claims experience. The spread in insurance penetration within a country can only be accommodated if this factor is incorporated in the premium calculations.

Situation in risk management

Although megacities and other major cities have high exposures, not enough attention has been paid so far to accumulation and risk control in life, health and personal accident insurance. It is possible to identify some of the reasons for this:

- The mobility of risks in life, health and personal accident insurance makes accumulation control far more difficult. Thus, for individual insurances, the home address may well be known but not the place of work. However, financial districts, manufacturing plants or city centres are generally prone to accumulations. Residential areas, on the other hand, are less affected by political or big events risks.
- Due to its premium/risk profile, personal accident insurance only allows for a simple risk assessment.

Despite the high population density in megacities, accumulation and risk control was largely ignored in life, health and personal accident insurance up to now.

– The insurance density requires a differentiated approach: for life and private personal accident insurance, the insurance density is less in developing countries than in industrialised ones. The insurance density overall is lower for personal accident insurance and private health insurance than in other classes of business. Despite the higher insurance density in industrialised countries, the scale of the loss in the event of a disaster is relatively small for life insurance compared to property insurance.

In order to ease the problem of accumulations, life, health and personal accident insurers normally use the following traditional risk-limitation tools:

– In personal accident insurance, and often also in private health insurance, key exclusions such as the exclusion of loss or damage due to war, radiation, infection and poisoning are agreed. This means that nuclear and biological risks are largely excluded. However, the dirty-bomb scenario (a combined biological and chemical attack) is covered. In order to be able to exclude most losses due to epidemics, the definition of "accident" should be clearly formulated to ensure that it is distinguishable from health-related coverage components that are not insured.
– Control systems must be set up for accumulations of people and policies. For example: with large group personal accident policies, the insurer should restrict its underwriting to specific members of staff. In life insurance, the sum insured on a person's life should be limited. Previous insurances should therefore also be checked when a new proposal is received.
– In life and private health insurance, a detailed medical and financial risk assessment is required.
– Accumulation limits should be agreed for higher sums insured.
– Liability must be limited for group life insurance business.
– In reinsurance, Cat XL covers are particularly suitable.

Recommended additional risk management tools

In our view, the remaining high loss potential in life, health and personal accident insurance, combined with the difficulty of accumulation control (mobile risks), makes it desirable to use further risk management tools:

– Regional portfolio concentrations can be identified from post codes in the insurance proposals.
– Experience shows that many insurers underestimate known and unknown accumulations that may be concentrated within regions. For conurbations, it is advisable to carry out portfolio scenarios as a form of stress test.
– Unknown accumulations should not be taken as read, i.e. discernible accumulations in the portfolio can be identified and limited by reinsurance and accumulation limits. This includes group insurances for businesses in high-rise buildings, for staff in pharmaceutical and chemical production plants, and for big events of any kind.
– Payroll business in particular, i.e. group insurance for big companies with large workforces, should be examined closely with regard to possible exclusions (terrorism) and accumulation limits.
– The use of debit and credit cards, especially those issued by airlines, can be investigated and assessed with regard to travel personal accident insurance. Accumulation limits are particularly important for special events for credit/debit cardholders (e.g. pop concerts), as in these cases extremely high combined totals can accumulate.
– In life insurance, mathematical models of the epidemiology can be used to predict certain characteristics of a wave of infection. It is thus possible to calculate the maximum number of people falling ill at the same time or the total number of people who may fall ill.
– Accumulation control spanning all life, health and personal accident insurance is certainly advisable.

Workers' compensation insurance

For workers' compensation insurance, as a special line of insurance business, the hazard potential that has to be taken into account is greater than for other types of life, health and personal accident insurance. More extensive risk management tools are therefore required.

Workers' compensation insurance normally takes the form of group insurance, whereby an employer arranges an insurance policy for all the employees in his company. By its very nature, this model involves a considerable risk of accumulation, which is greater in megacities and conurbations than in rural areas.

Due to statutory requirements, as well as industrial/employment risks, most workers' compensation systems also cover natural hazards, political risks and traffic accidents. The regulations vary from country to country, however. A general exclusion of these risks is not normally possible. Here are some examples:

- Under political risks, for example, some systems exclude war risks while others do not. For staff travelling abroad on business, however, passive war risks are generally covered. Since many business travellers stay in megacities, this arrangement takes on great significance.
- The situation is similar for natural hazards. Whereas these are totally excluded in some countries, in others some or all are covered. This risk is also often covered for employees staying abroad on business.
- Two aspects are decisive as far as traffic accidents are concerned: a distinction is made between commuting accidents, i.e. accidents on the way to or from work, and accidents en route that happen away from the place of work but during working time. In many countries, commuting accidents are excluded or covered only to a limited extent, whereas no exclusions normally apply to traffic accidents in general. Due to the large volume of traffic in conurbations, this point is particularly important for many workers' compensation systems.

Situation as regards risk management

So far, the insurance industry has had little experience with which to calculate and control the accumulation scenarios for such risks. This is understandable, given the particular features of these types of risk and the structure of workers' compensation insurance. Workers' compensation insurance covers non-economic, i.e. health consequences, as well as economic consequences. Another special feature is that "moving targets" are insured, making it difficult to estimate many consequences:

- Some future health consequences of existing risks are as yet unknown (e.g. in the case of biological attacks).
- It is impossible to predict the longer-term psychological consequences of a terrorist attack or earthquake (e.g. fear of returning to the place of work).
- It is virtually impossible to predict the area affected by dirty bombs containing hazardous substances (biological, chemical or nuclear) that spread via air or water.

Recommended risk-management tools

The tools outlined for the risk management of personal accident insurance can also be applied to workers' compensation insurance. Due to the complexity of workers' compensation insurance, in some systems special risk-limitation tools and strategies based on theoretical models and practical experience are also used:

- Natural hazard scenarios have been developed in order to enable the worst-case scenario in a portfolio to be approximated.
- In various markets, risk-pooling mechanisms have been created for workers' compensation insurance in cases where the market specifies on its own or together with the government which risks are to be separated and covered by joint funding (e.g. terrorism pools or pooling models for occupational diseases).
- National legislation has been redefined or revised in order to define the precise scope of cover for these types of risk.
- In order to keep the impact of such risks as low as possible or eliminate them altogether, special occupational safety measures have been adopted which improve health and safety (for example emergency response and evacuation plans).

Property insurance

In many megacities, the population is growing faster than the national average, while material assets to be insured are growing even faster still. Although this trend represents huge potential for growth in the insurance sector, it also involves large risks.

Big cities have always been prone to heavy property damage losses. Large fires destroyed entire districts because the buildings were packed very closely together and the main building material used was timber. Arson also happened in the past, like the fire that devastated Rome in 64 AD under Emperor Nero. The Great Fire of London in 1666, which is said to have destroyed five-sixths of the city, is generally credited with giving rise to fire insurance, the first fire cover being offered in London one year later. The biggest losses in major cities have mainly been caused by natural catastrophes. The earthquakes in San Francisco in 1906 or Tokyo in 1923 are striking examples of this. Tornadoes that have hit major North American cities in recent years – particularly Dallas, Oklahoma City and Edmonton – have also caused large losses.

Almost all megacities are seeing rapid growth in the material assets that are to be insured, such as residential buildings, workplaces and other goods (e.g. cars). Particularly during economic booms, the demand for property insurance policies shoots up. This inordinate rise is not only to be seen in industrialised countries. In developing countries too, a substantial middle class is emerging that wishes to insure its property. There are also administrative and commercial districts in city centres with high concentrations of values. This trend affects the individual classes of property insurance in different ways.

Fire

Even though large conflagrations are generally no longer to be expected these days, fire is still a major accumulation risk. Fires spread to neighbouring buildings, and there can be delays in fighting them because the fire brigade is stuck in traffic. This is because the expansion of the transport network often fails to keep pace with the growth in population.

In office blocks with many tenants, both a master policy for the building and also individual policies are arranged which cover the value of the fixtures and fittings in the rented premises and the business interruption following property damage.

In view of this trend, the demands on accumulation assessment are constantly growing. With megacities, it is therefore essential to record all liabilities on a small scale and based on precise addresses. This data must be constantly analysed with regard to fire, earthquake and small-scale natural hazards such as flooding. Only then can it be ensured that the loss scenarios are realistic and the insurer's capacity is not exceeded (see "Geographical underwriting", page 43).

As 11 September 2001 showed, a major loss affecting a few high-rise buildings in a megacity can have consequences that extend far beyond the building in question and the immediate fire insurance, especially as far as business interruption is concerned. Examples of such indirect losses not covered under normal property policies are: fall in the number of hotel guests and airline passengers, production plants shutting down and retail businesses suffering loss of income.

If those working in commercial centres in megacities are unable to get to their places of work due to extreme weather conditions, the risk of epidemics, or bomb threats, the business interruption loss can be huge although there is no property damage. A major fire at a central commuter station has the same effect. A long strike by refuse collectors can also make the city centre unacceptable as a place of work.

The consequences for property insurers

The scope of cover of all risks policies must be checked carefully for all policyholders in cities. Every company must determine how far the cover should extend, and accumulation risks must be limited or excluded.

San Francisco 1906: The large-scale destruction of this "boom city" by the earthquake and the following conflagration shook the insurance industry like no other catastrophe event in history.

San Francisco earthquake scenario ("1906 earthquake – Today")

The major earthquake in San Francisco in 1906, which measured 7.8 on the Richter Scale, was one of the biggest losses in the history of insurance, resulting in 3,000 deaths, economic losses of US$ 524m, and insured losses of US$ 180m. What scale of losses could be expected for property and workers' compensation insurance if such a large earthquake were to happen again today? A quake of this size can be expected every 250 to 300 years.

Consequences for property and workers' compensation insurance

The expected loss to the economy as a whole would be somewhere between US$ 100bn and over US$ 200bn. The gross insured property damage is estimated at around US$ 40bn. However, as it is usual in California for the policyholder to pay a deductible of 5–15% of the sum insured, the amount payable by the insurance industry would be reduced to about US$ 20–25bn.

The number of casualties and the resultant estimate of the amount of the loss for workers' compensation insurance vary greatly, depending on when the catastrophe strikes. If the earthquake were to happen at night (2 a.m.), it is expected that around 3,000 workers would be affected (making a loss of about US$ 130m). In the late afternoon (5 p.m.) it is estimated that 45,000 people would be affected (almost US$ 2bn), while at the worst possible time in the early afternoon (2 p.m.) it is assumed that there would be over 110,000 casualties (US$ 4.5bn).

However, this high workers' compensation loss (amounting to a good 10% of the property damage loss) only arises in the case of extreme events. For smaller magnitudes, the relative proportion of the overall loss accounted for by workers' compensation insurance is far lower.

Blackout in New York: On 9 November 1965 the lights went out in North America. 30 million people sat for 14 hours in the dark or were stuck in the underground or in elevators.

Broadly worded all-risks policies occasionally cover such losses as those caused by denial of access. In less densely built-up areas, this rarely causes a problem, but in megacities losses like these have high accumulation potential. Such extensions of cover should therefore be avoided. If in exceptional cases the insurer grants an extension of cover after a thorough check, additional provisions should be agreed.

– Separate limit of indemnity (e.g. 2–4 weeks)
– Separate time excess of at least 48 hours
– Property damage as the cause of the denial of access
– Geographical limitation of the causal event (e.g. 2–5 km from the insured's location)
– Appropriate additional premium

Power failures

Without electricity, (almost) nothing in a city works: underground railways, lifts, air-conditioning systems and other technical plant and equipment need electricity. Even just the failure of traffic lights can lead to total gridlock. The causes may be technical problems or overloading of the supply network; in 2003 alone, this resulted in large-scale power failures in Italy, the UK, Norway and North America. Power failures also occur regularly after large storms if the power lines are installed above ground on pylons. If the failure of a power line results in other networks being overloaded and ultimately failing, the conditions are perfect for the domino effect. Due to the large number of consumers in conurbations, interruption losses resulting from power failures can be very high.

Interruption losses resulting from a power failure are therefore almost always excluded in all regions that are at risk from storms. Only a few policies offer this extension of cover – and even then only against payment of a higher premium with tighter limits.

Underground cables are also frequently damaged during building work in cities. If telephone lines fail, the internet is also paralysed. This may hinder securities trading by banks, stock exchanges and other financial service providers, which are traditionally located in the centre of megacities. In view of the huge volumes of money traded, there is a risk of high losses.

If communications networks fail, very many insurance policies in a city may be affected. Such perils are therefore considered to be uninsurable in all of the major markets.

Industrial buildings are mostly built on the outskirts of megacities. However, if the conurbation continues to expand, hazardous industrial installations such as petrochemical plants may threaten the health of the population, since over time they end up being surrounded by residential areas. With business cover, the emphasis is usually on the fire, explosion and business interruption risk.

Engineering

Major construction projects in megacities must be planned and executed with particular care. Potential hazards are not confined to the construction site itself and its immediate vicinity. Megacities may be subject to threat from structures located far from the city.

Here is an example from the Cairo/Alexandria conurbation in Egypt: in the middle of last century, the Nile, the country's lifeline, was dammed by the Aswan dam to form a huge lake extending beyond the country's border. The annual flooding of the Nile is now a thing of the past. If the dam were to fail after overflowing, it would send a flood wave rushing downstream with the potential to cause substantial damage to the conurbation 800 km away.

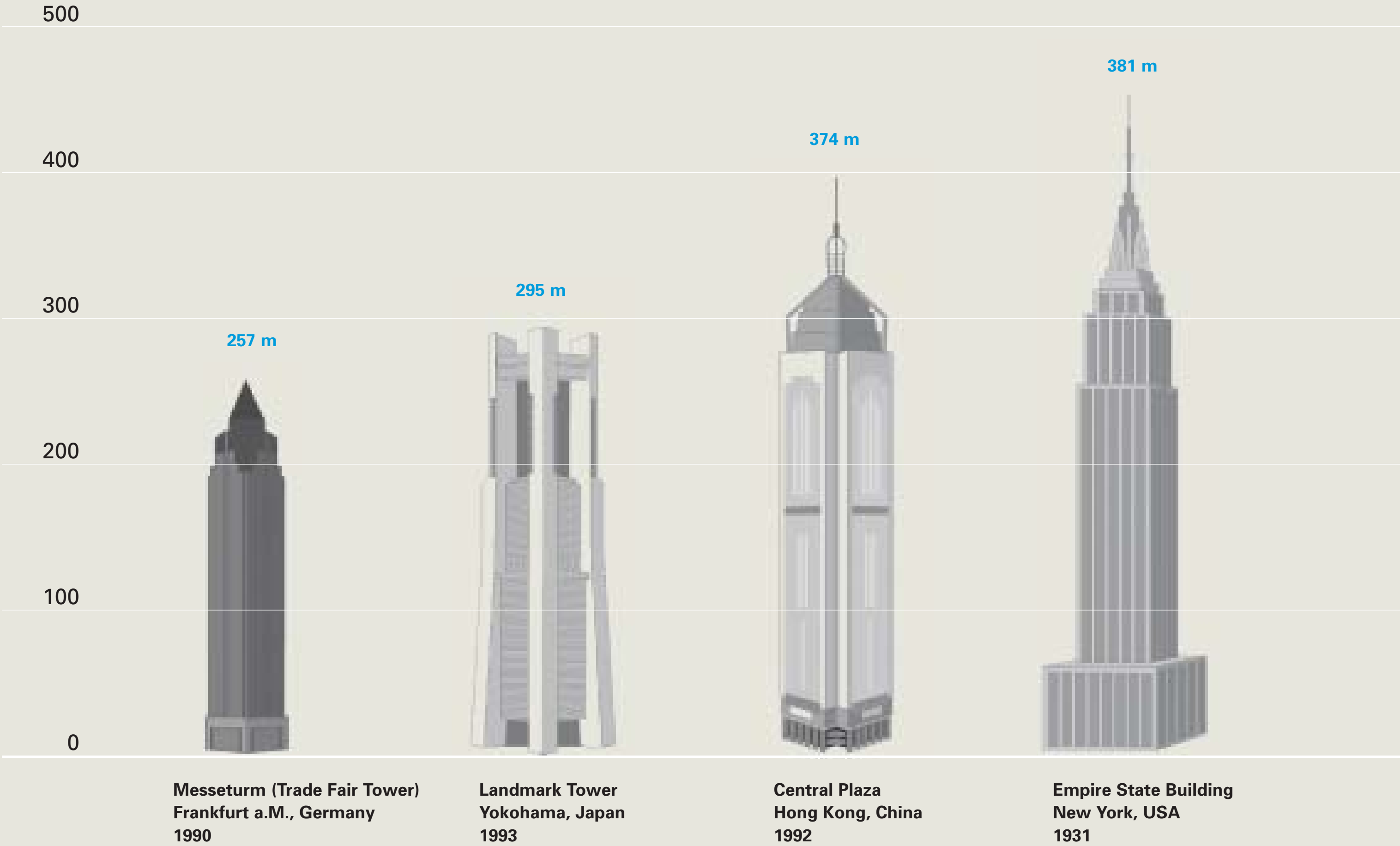
In megacities, structural and civil engineering works pose a risk around the construction site. Due to the high cost of building land, the smallest possible areas are used for construction, with the result that higher and higher structures with expensive foundations and multi-level basement areas are erected. Even after 11 September, the trend to build skywards appears to be undiminished.

Structural engineering

In 2003, the 508-m-high Taipei Financial Centre set a new record. By 2008 though, it will be overtaken by the 705-m-high "Burj Dubai" skyscraper, currently under construction. The current view is that the technically and economically feasible height limit for skyscrapers is about 800 m. As well as these extreme construction projects, hundreds of high-rise buildings are currently under construction worldwide, mainly in the metropolises of Asia and North and South America. High-rise buildings are generally defined as having more than 12 storeys above ground level or as being higher than 35 m. According to this definition, there are some 500 skyscrapers being built in São Paulo alone and around 300 in Tokyo.

Due to restricted space and ever-shorter construction periods, the logistics for construction sites are difficult. It is only possible to keep to tight construction schedules by continually transporting materials according to the just-in-time principle. The requirements for planning the construction work are complex.

Figure 16 Skyscrapers are getting higher and higher



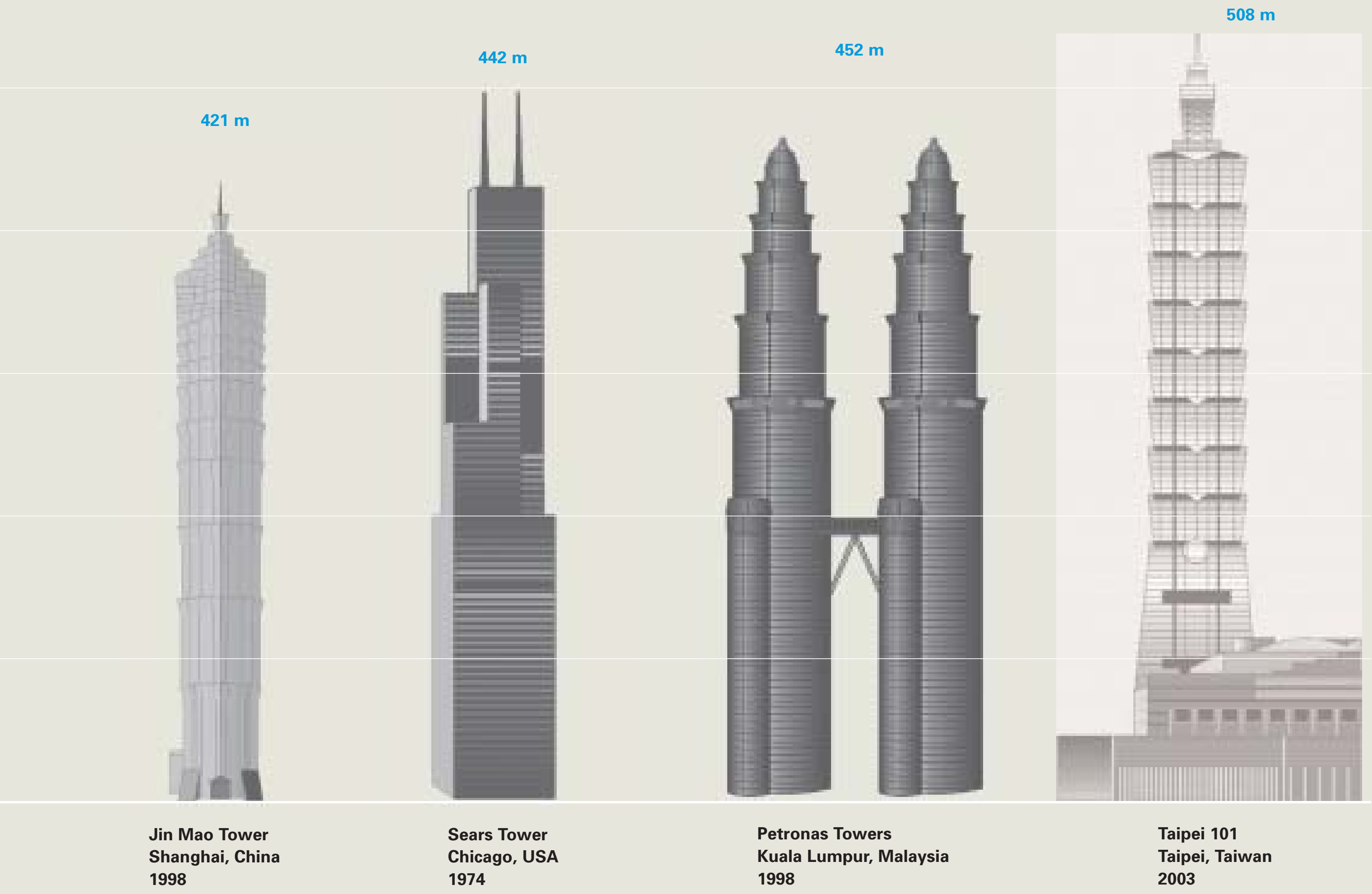
The limit in terms of technical and economic feasibility is currently estimated at 800 m. In order to protect against earthquakes, windstorms, explosions, and fires, the design of buildings for static and dynamic loads has been steadily further developed over the past decades.

The subsoil conditions are often very difficult and it must also be ensured that the building and outer façade can withstand extreme loads such as earthquakes and typhoons.

During construction, the Taipei Financial Centre had to withstand a quake measuring 6.8 on the Richter Scale. Two out of four construction cranes crashed down from the building, one of them onto a public road. A steel ball weighing 660 tonnes now hangs in the upper part of the skyscraper – between the 87th and 92nd floors – to absorb the vibrations caused by earthquakes or typhoons. Even at the planning stage, sophisticated stairway and lift systems had to be devised to ensure that the building could be quickly evacuated in sections in the event of a disaster.

Specific action recommended

- Define the construction site area precisely, including storage and delivery areas
- Ensure that fire protection requirements are adequate
- Grant design and delay in start-up (DSU) covers only after careful risk analysis



Civil engineering

In civil engineering, particularly high demands are placed on underground transport, distribution and waste disposal systems. The construction of underground railways is a prime example of this: the population of Singapore is constantly growing and currently stands at about four million. The area of the island has been steadily expanded through land reclamation on the periphery. The government's far-sighted plans to keep on adapting the capacity of the transport systems to keep pace with long-term demand are exemplary. In contrast, Bangkok was on the verge of collapse due to traffic congestion in the 1990s; it was only about ten years ago that work began on the long-term expansion of the underground railway system as an alternative to private transport.

There are also numerous hurdles to be overcome when planning and executing shallow sections of underground transport, water supply and sewage systems, as there are often no details of the nature and depth of the foundations of neighbouring structures. When cities grow rapidly, existing supply pipes for water, sewage and gas, as well as power and communications cables, are often inadequately documented. This leads to false assumptions when planning new construction measures, so that expensive sounding work has to be carried out at the construction stage. However, even where a lot of effort has gone into exploratory work, digger shovels still often hit pipes and cables in unexpected places, resulting in repair work and business interruption losses affecting third-party facilities.

Specific action recommended

- Apply the Tunnelling Code of Practice (TCOP) developed for the UK to international risks; the insured agrees to work closely with the insurers
- Decline extensions of cover such as "additional cost of working" or "unbuilt portion" or offer these on a strictly limited basis
- Treat design covers with caution
- Grant DSU cover extremely restrictively or only after a detailed risk analysis
- Carry out detailed preservation of evidence measures on surrounding structures before construction begins (e.g. check whether buildings nearby already have cracks)
- Monitor construction work

During construction work on an underground tunnel in Munich in 1994, a large crater opened up on a main road, plunging a city bus into a water-filled hole. Three people died and 36 were injured.

Marine

Where megacities are situated in areas at particularly high risk from natural hazards, earthquake, tsunami, volcanic activity, windstorm, hail, inundation and storm surge represent the greatest risks for concentrations of values. Container ports in particular are affected.

Specific action recommended

– Ensure a balance of risks, i.e. do not neglect the volume of bread-and-butter business by only writing peak risks (e.g. isolated storage and hail covers) with high risk-capital requirements
– Carry out comprehensive, up-to-date accumulation controls

Aviation

As with marine insurance, tidal waves caused by seaquakes also pose risks here. For instance, the airports of Tokyo (Haneda) and Osaka (Kansai) are situated on artificial islands in the sea, and San Francisco airport is right by the sea, barely above mean sea level. Enormously valuable fleets of aircraft stand in the open, day and night. Were a sudden natural catastrophe to occur, it would in most cases be impossible to move the aircraft to safety in time. Hailstorms also constitute a risk: in 1999 a hailstorm in Sydney damaged about 100 aircraft.

However, aircraft also constitute a danger to those living in conurbations. In Mexico City, the airport is in the middle of the urban area, with flights approaching from all directions. The nightmare scenario is not just a plane crash but a mid-air collision of two aircraft due to a navigational or air-traffic-control error.

Specific action recommended

– Since insurers can have only limited influence on the planning of aviation facilities, the best protection is to refrain from writing risks that are prone to accumulations and exposed due to their location.
– Limits of liability are an effective tool.

Motor, agricultural insurance

In summer, hot cities are at particular risk from severe storms and lightning – the hail losses in Munich (1984) and Sydney (1999) are well known. A hailstorm event that in a rural environment is unspectacular becomes a disaster in megacities, as we can see from the 240,000 cars damaged in Munich. The storm-prone microclimate around cities can also cause increased claims burdens for agricultural insurers.

Specific action recommended

Provided there is thorough accumulation assessment and control and rating commensurate with the risk, agricultural risks should not pose any insoluble problems for insurers. However, in the case of movable objects like cars, it is difficult to assess accumulations reliably. Insurers must ensure that they have adequate catastrophe cover (Cat XL treaties).

Liability insurance

What role does liability insurance play in megacities? Our considerations concentrate on major loss scenarios for hazardous plants, third-party motor insurance, and the question of how liability insurance helps to protect victims and enforce the principle that the perpetrator pays.

Major loss scenarios, hazardous plants

Indian legislators responded to the Bhopal disaster by making public liability insurance compulsory for hazardous industrial plants. This was because the claims for compensation by the victims of industrial accidents should be met, particularly where the victims are poorly protected by direct, "first-party" insurance. This was also the intention of the Seveso Directives on prevention, compensation and liability insurance for hazardous industrial plants. One problem with this is the limited capacity of operators and the private insurance market. The insurance capacity is often not sufficient to compensate for the losses. This applies equally, even in highly developed insurance markets, to notoriously underinsured nuclear power plants.

Mass scenarios: Third-party motor insurance as a contributor to urban development

In most megacities, road accidents are covered by optional or compulsory third-party motor insurance. This sometimes underlies obligatory motor accident insurance, as in Brazil, Chile, Colombia and several US states, mostly combined with additional obligatory third-party liability and accident insurance for public transport and the transportation of hazardous substances.

In practice, all such insurance models combined only provide basic cover of the real costs of road accidents. This is one of the main tasks of private insurers over the next few decades. It will be a laborious process, but what applies in theory in most countries must be put into practice, i.e. the cost of road traffic accidents must be borne by motorists and their liability insurers. However, the insurance density varies sharply from country to country. The sums insured are often low. Where they are higher, they are not exhausted in the event of serious bodily injury, or are used only selectively. Third-party motor insurers often hide behind the shortcomings of justice systems that prevent the law from being enforced efficiently or that are overstretched. Sometimes, there is no provision for recourse claims by state health insurance institutions, or else such claims are not enforced in practice or are inefficient or unenforceable. Hospital casualty units only accept accident victims who can prove they are covered under a state or private health insurance scheme. Another problem is that, due to intense competition and the lack of political influence, motor insurers are often unable to implement rates that are appropriate to the risk. They also often fail to play the role that could be expected of them with regard to improving road accident prevention. What often appears to be impossible to achieve nationwide should at least be implemented in the megacities.

Megacities and liability insurance

Not just in the case of hazardous plants and road transport but in general, comprehensive liability insurances covering a majority of natural persons and legal entities are by no means utopian. In megacities of the developed insurance markets, these have long been a reality. A tight network of liability insurance covers means:

- Increased protection of victims wherever first-party covers of people or property do not exist or are inadequate and the parties responsible can be held liable. This includes victims in catastrophe situations such as industrial accidents, as well as for everyday road accidents, burst pipes or damaged cables.

- Where health, workers' compensation or property insurance exists, the principle that the perpetrator pays can be applied and recourse can be taken against the liable parties. Thus in the case of the industrial accident in Toulouse on 21 September 2001, the claims burdens of the property, business interruption, workers' compensation and motor insurers were ultimately passed on to the company liable and its liability insurers. The claims burdens of health insurers arising from road traffic accidents are borne by third-party motor insurers.

Megacities and mega-urban regions have generally developed in connection with large industrial-cum-residential areas, as here in the Ruhr area in Germany.

Nevertheless, there are limits to liability insurance. Foreseeable losses due to continuous pollution of the air, water or soil are not insured worldwide in operators' policies. Although liability suits are indeed brought, as in the Japanese environmental impairment liability cases in the 1950s and 1960s or the current class actions due to river pollution in Colombia, the costs are normally borne by the general public and health insurers. Although it would be desirable for health insurers to exercise recourse against persistent polluters, this seldom happens. Ultimately, the megacities also have to accept liability themselves, through bodies such as municipal authorities and public corporations. In view of the long-term risks of normal urban operations, the city appears not only to be a victim, but also a collective perpetrator.

Bond insurance – Example of São Paulo

In São Paulo, one of the biggest cities in the world, investments in infrastructure are constantly rising. Bond insurance helps to finance these high investments. What is behind this model?

Bond insurance is a form of guarantee. Under this special contract, an insurance or bond insurance company undertakes to guarantee certain payments, debts or liabilities of an insured. This is essentially insurance of an insured's financial and/or operational integrity. Thus in the building industry, for example, a bond is normally used to guarantee that a given project will be completed by a certain date.

The city of São Paulo is a true megacity in terms of both the number of inhabitants and its commercial activity. Just under 60% of the country's 5.9 million companies are based in São Paulo Province. Due to the rapid growth of the population, the government has had to constantly increase its investments in infrastructure in recent years. The present government has proved to be a major promoter of such investments, having altered its political focus. This results in a fairer distribution of quality of life.

The main infrastructure projects include road-building, public transport, power (e.g. electricity) and sewage treatment plants, aviation and telecommunications. Some projects are partly funded by private investors and other major projects exclusively from state funds. The Brazilian development bank, BNDES, is actively involved in financing infrastructure. It supports projects both exclusively and as a partner in public-private initiatives (see Figure 17).

The extension of the City of São Paulo's metro, the "Line 4 Project", was the largest infrastructure project in Brazil in 2003. The network extends for 12.8 km and also involves the construction of 11 underground stations and a maintenance facility. 900,000 passengers will be carried each day, 46,000 passengers an hour at peak times. After its planned completion in 2007, the underground line will pass through an area in which 2.4 million people live. The total cost of the project as a whole is estimated at US$ 497m and the sum guaranteed amounts to US$ 164m.

Bonds play an important role in financing projects, as they give investors the security of knowing that individual stages of the project will be completed successfully. Various types of bonds are arranged:

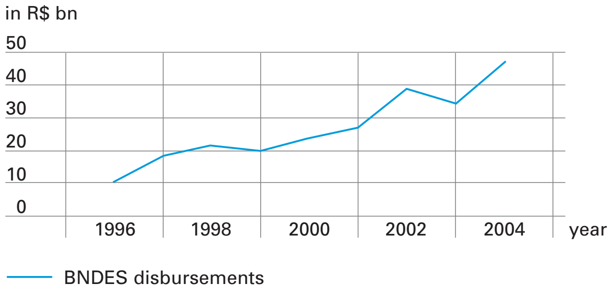
- Invitations to tender for projects are secured by bid bonds.
- Performance bonds are agreed for the actual construction.
- Following the construction stage, maintenance bonds are used to ensure the longer-term quality assurance of a project. In some cases the firm is also protected by a concessionaire using an operator's bond.

Public and private investors obtain the necessary bonds from specialist bond insurers and composite insurers. Munich Re provides a considerable proportion of the necessary reinsurance cover on a treaty basis; for highly-structured projects, however, it is only possible to offer facultative cover. In Brazil, complex projects are reinsured by the country's monopoly insurer, IRB, which then retrocedes them on a facultative basis.

The (re)insurance industry plays its part in supporting the infrastructure in this megacity. This approach to solving problems is sustainable if insurers and reinsurers are familiar with and exhaust the possibilities and practices of this business model. Our clients are familiar with the local statutory and supervisory requirements, are able to assess the solvency of the risk and estimate what period of risk is to be set. However, due to the nature of megacities, ongoing accumulation assessments on an individual risk basis are required from construction companies and engineering consultants.

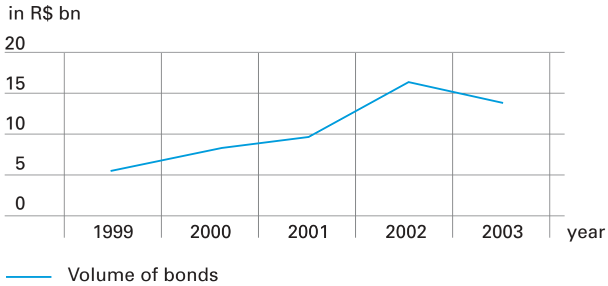
More than three million companies or just under 60% of all Brazilian enterprises are located in the province of São Paulo.

Figure 17 Public investments in Brazil



Source: BNDES, 2004

Figure 18 Volume of bonds in Brazil



Source: Ministério do planejamento, orcamento e gestao, 2003

Public investments as well as the volume of bonds in Brazil have risen significantly over the past few years.

–12% In the first ten days after the terrorist attack of 11 September 2001, share prices fell worldwide by around 12%. In the following ten days losses were almost completely recouped.

Financial markets – Sensitive seismographs

There is no question about it: catastrophes in megacities can lead to severe turbulence on the financial markets, a prime example being 11 September 2001. However, the consequences of major loss events on stock exchanges and fixed-income markets are highly complex. A distinction has to be made between long-term and short-term consequences. And there are also direct as well as indirect impacts on the economy. Asset-liability management is decisive in terms of efficiently managing insurers' investments.

Effects of disasters in megacities on capital markets

Major loss occurrences generally mean big claims payments for the insurance industry. Where, on top of that, a disaster in a megacity affects economic growth and the financial markets, insurers are hit twice. The interrelationships are complex, however, and short-term effects can be different than long-term effects.

A disaster that strikes a megacity not only costs lives, but also destroys, mostly directly, considerable economic assets – primarily real estate, production facilities and machinery, but also agricultural produce, energy supplies and much more. The owners of these goods and those who have to pay for the loss or damage are directly affected. On the capital market, this is primarily reflected in the share prices of the companies concerned. Insurance companies are impacted more than all other sectors because they often have to pay for most of the damage. Property companies and utilities can also be hit by an accumulation risk when assets are destroyed. Besides these direct consequences, there are also a series of indirect effects on the economy, the scale of which can far exceed the value of the assets destroyed.

Slowdown in growth and loss of confidence

Among the most important indirect losses are business interruptions and loss of suppliers or customers. With the exception of the insurance sector, it is difficult to identify a particular risk in the case of certain companies or sectors of the capital market. Overall, restricted economic activity is likely to have a negative impact on the economic growth of the national economy in question. In turn, a weakened economy has a negative effect on the future profits of exposed companies, and thus on their share prices. The bond market, on the other hand, would tend to benefit from this scenario initially, since lower prospects for growth mean falling interest rates and thus an increase in value for an existing bond portfolio.

The impact on consumer confidence is crucial, since in most economies consumption is the key driving force of economic activity. Where, because of a disaster, consumers lose confidence in future growth, they generally hold back on consumption. This would probably be the most significant negative outcome of a disaster in a megacity. However, consumers do not react to every disaster in the same way. The decisive point is whether the disaster is a repeat or a one-off event, the latter having much less impact on confidence. In this case, there may even be a “we’ll show them” backlash, with positive consequences for the economy. A man-made catastrophe is thus likely to have a much more negative effect than a natural disaster. Falling consumer confidence and the associated fall in consumption generally weakens almost all sectors of the stock market.

Rebuilding provides impetus

On the other hand, positive economic effects are also possible, since the authorities usually set up reconstruction programmes following a disaster. Substantial additional government spending is often provided – with considerable impetus for growth. Such measures often go hand in hand with an expansionary monetary policy, i.e. lower interest rates, from which the bond market benefits. The impact on the stock market depends on where the funding actually goes, i.e. which sectors, apart from the construction industry, receive the additional money. Naturally, usually those sectors worst hit by the disaster are on the receiving end.

Disruption of the capital markets

Megacities in particular are usually also important financial centres. This means that other indirect consequences are possible: for example, the operation of the capital markets could be jeopardised if a key financial centre were destroyed. The fundamental question is therefore: could just a few lost days of operation result in prolonged disruption? It must be said, however, that this risk is confined to just a few cities and extreme disasters since, in the age of globally networked markets, there is hardly any financial centre that cannot be replaced. Thus each of the three most important centres – New York, London and Tokyo – is able to maintain an operational market for the most important capital market products. Furthermore, most of the major players, predominantly international investment banks, are represented in all the most important financial centres worldwide. This means that they can substitute.

Moreover, the supervisory authorities require fairly comprehensive contingency plans that enable business to be resumed elsewhere within a few hours.

Whilst bottlenecks are possible with specific products that are only traded to any extent in one financial market, sustained disruption of the global markets is not very likely these days. Only if many important players were to be out of action at the same time would it lead to lasting complications. The only imaginable scenario for this would be if Manhattan were to be put entirely out of action.

Example: New York City, 11 September 2001

The graphics on page 69 show that both shares and bonds fluctuated wildly in the short term following the attack of 11 September. They also demonstrate, however, that the medium- and long-term effects on stock markets were less serious than is often assumed. Whereas the stock markets had lost between 10% and 15% in the six months prior (!) to the terrorist attacks, six months later both the local and global indices were approximately 7% higher than they had been on the evening before the disaster. Even the index of insurance company shares was higher than on 10 September. However, index levels alone do not adequately express the consequences for investors. Thus, for example, the uncertainty of players on the stock markets rose appreciably following 11 September, as the increased volatility – a measure of price fluctuations on the stock market – clearly shows.

Share prices are influenced by numerous, interrelated factors. The effects of a single event could therefore never be separated out beyond reasonable doubt based on historical data. The theory that 11 September caused the massive fall in share prices in the following year is therefore not tenable either. By then, the disaster already lay more than six months in the past, and its economic effects were largely measurable. It must therefore be assumed that, by this time, share prices had already made due allowance for the disaster. The interim conclusion was therefore that, contrary to popular opinion, the effects of the World Trade Center (WTC) disaster on stock markets were quite short term and moderate.

The situation in the fixed-income markets was different, however. Here, lasting effects were to be seen. Thus, even six months after the disaster, the respective interest rates in the USA and Europe were still 1.5 and one percentage points below what they had been on 10 September. While it is true that both economies were in a prolonged cycle of falling interest rates at the time, there is nevertheless every reason to believe that the event of 11 September intensified this trend. The expansionary monetary policy in particular accelerated the trend whereby yields continued to fall.

Cantor Fitzgerald

Cantor Fitzgerald was probably the company worst affected by the attack of 11 September 2001. The financial services provider had its headquarters between the 101st and 105th floors of the North Tower and on that day lost 658 of its 1,000-plus staff in New York City. Almost a quarter of the WTC victims were Cantor Fitzgerald employees. The company played a leading role in the US financial system as a fixed-income broker. The disaster therefore jeopardised not only the company's existence but also the operational capability of part of the financial system.

The important electronic trading platform "eSpeed" was operational again as early as 13 September. That was thanks, first and foremost, to the London office and the colleagues who survived. Furthermore, Cantor Fitzgerald's IT systems and data were protected by excellent back-up systems. Fears that the financial system might be adversely affected proved unfounded in this case, despite the massive and tragic events.

Even the Cantor Fitzgerald company itself survived. From a financial point of view, it has come out of the disaster even stronger – though this was associated with the complete reorganisation of its business model.

Naturally, Cantor Fitzgerald's story does not prove that disasters in megacities cannot harm the financial system – or even individual companies. It does show, however, that the highly connected and globalised international financial system is very robust.

Figure 19 Short-term impact on the capital markets of the 11 September attack
20 days after the attack, 10 September 2001 = 100

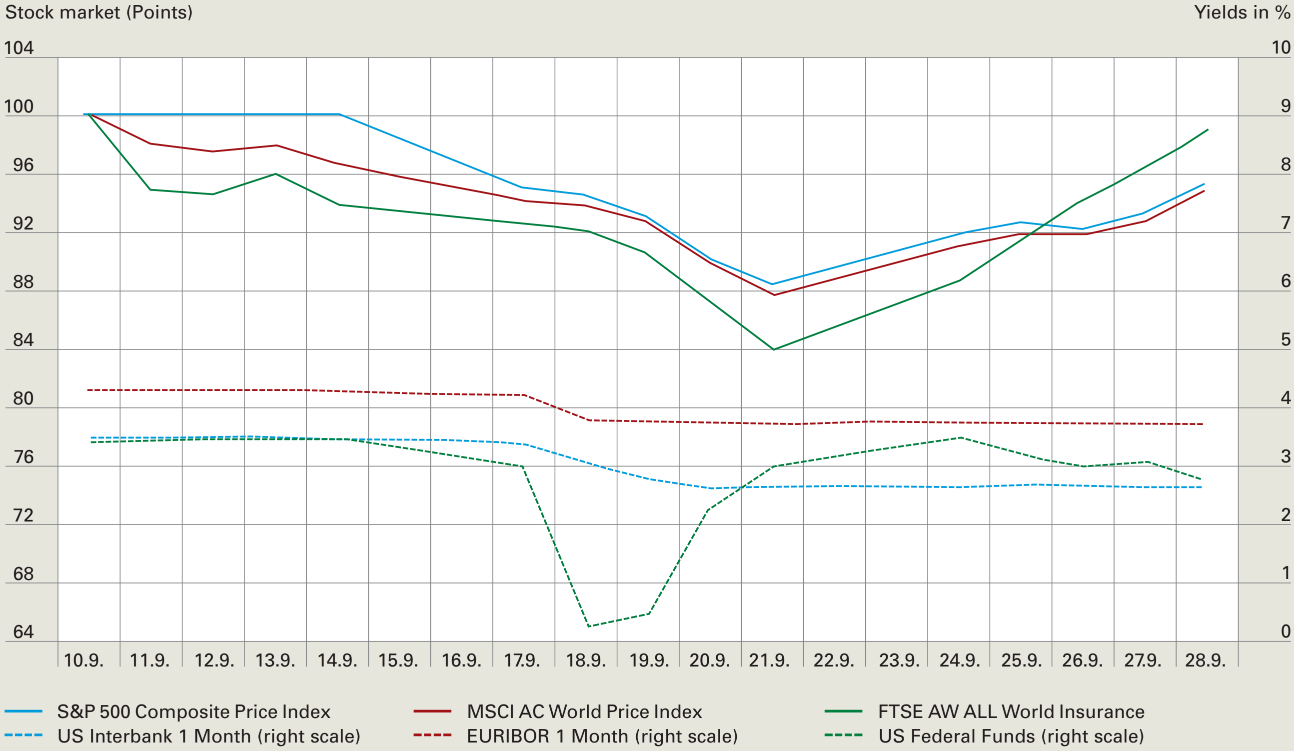
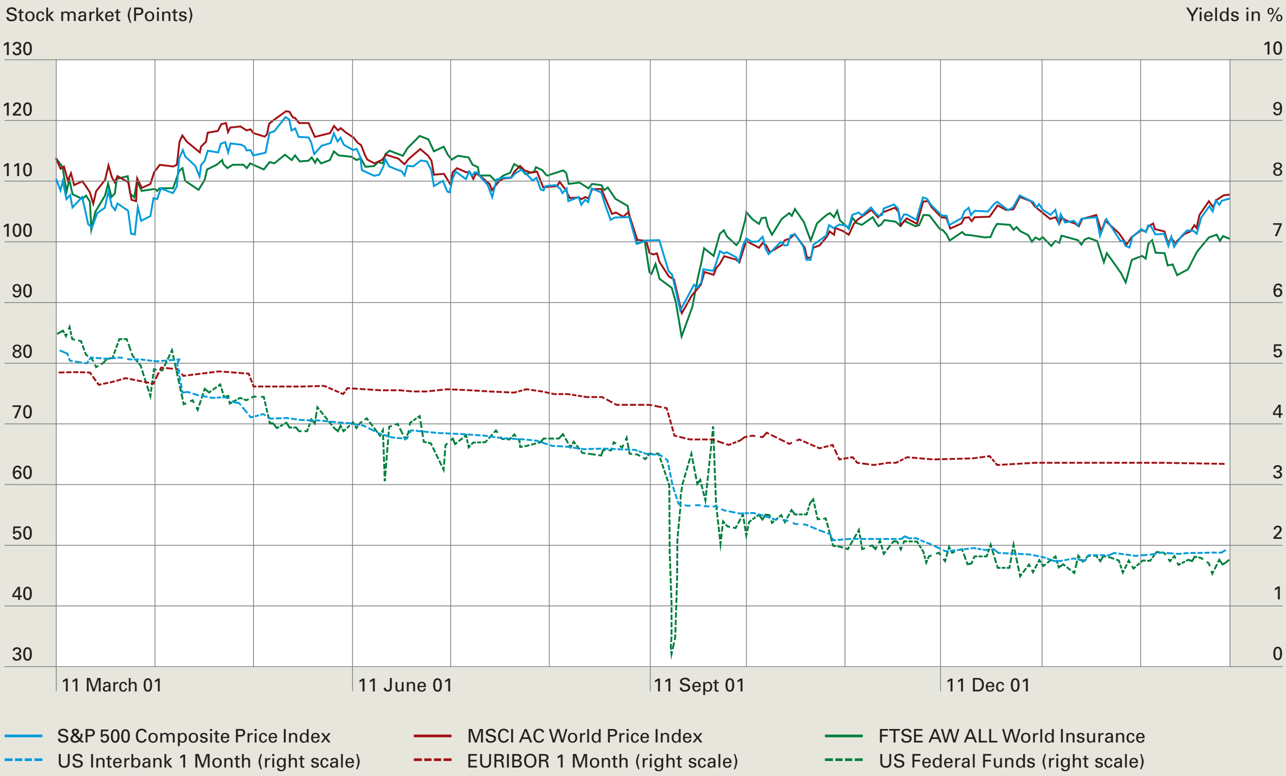


Figure 20 Long-term impact of the 11 September attack
6 months before and after the attack, 10 September 2001 = 100



The terrorist attack of 11 September 2001 had a telling effect on the capital markets in the short term. In the course of the first ten days, share prices worldwide fell by around 12%, with no big difference visible between US markets and the rest of the world. Shares in insurance companies fell only slightly more than the market as a whole. The striking thing was that the losses were almost completely made up over the next ten days.

There were strong reactions in the fixed-income markets too. Thus, within a few days of trading resuming, US interest rates fell by almost one full percentage point. European interest rates (EURIBOR) also fell by some 50 basis points. The erratic fluctuations in the interest rate set by the Federal Reserve for US Federal Funds illustrate the authorities' great uncertainty. Unlike the situation in the stock markets, the downward trend in interest rates continued.

Source:
Datastream, 2004

Example: Kobe, 17 January 1995

Whilst, on balance, there was no evidence of any medium- and long-term effects on world stock markets as a result of the Kobe earthquake, the Japanese stock market lost a further 10% of its value over subsequent months. However, mirroring the Japanese economy, the market was in a sustained downward trend throughout the 1990s. Any negative effect of the disaster beyond the loss of the first few days is therefore questionable.

Around 2.5 months after the earthquake, interest rates on the Japanese bond market fell by around one percentage point, whereas the international bond markets were unaffected. However, the timing of this development also fits in with a longer-term trend, giving rise to the suspicion that the disaster merely intensified the previous trend.

Seen as a whole, although the capital markets' responses to these disasters were different, the trends outlined support the theory that the effects of a disaster in a megacity tend to be relatively short-lived and moderate.

Conclusion

A disaster in a megacity always affects the two important factors of risk and return. Whereas with return both positive and negative effects are superimposed (with the net effect doubtful), the uncertainty, i.e. the risk, basically becomes greater and has a negative impact on the capital markets. The bottom line is therefore hard to predict and cannot be clearly attributed. Overall, stock markets tend to lose value. How lasting this effect is largely depends on its impact on consumer confidence and thus on the nature of the disaster. A man-made disaster is far worse than a one-off natural disaster. The bond markets tend to benefit in the event of a disaster, because interest rates fall. This is positive for an existing portfolio. In the long term, however, this development leads to lower reinvestment interest rates – something that has to be taken into account in insurance premiums.

Ultimately, past events suggest that the consequences for capital markets tend to be less serious than is generally assumed. It is nevertheless possible to imagine scenarios that would most probably have a marked effect on capital markets. This would be especially true of economies that generate a large part of their growth in a megacity. These effects would generally tend to be confined to the region in question, however.

Figure 21 Short-term impact on the capital markets of the Kobe earthquake of 17 January 1995
20 days after the earthquake, 16 January 1995 = 100

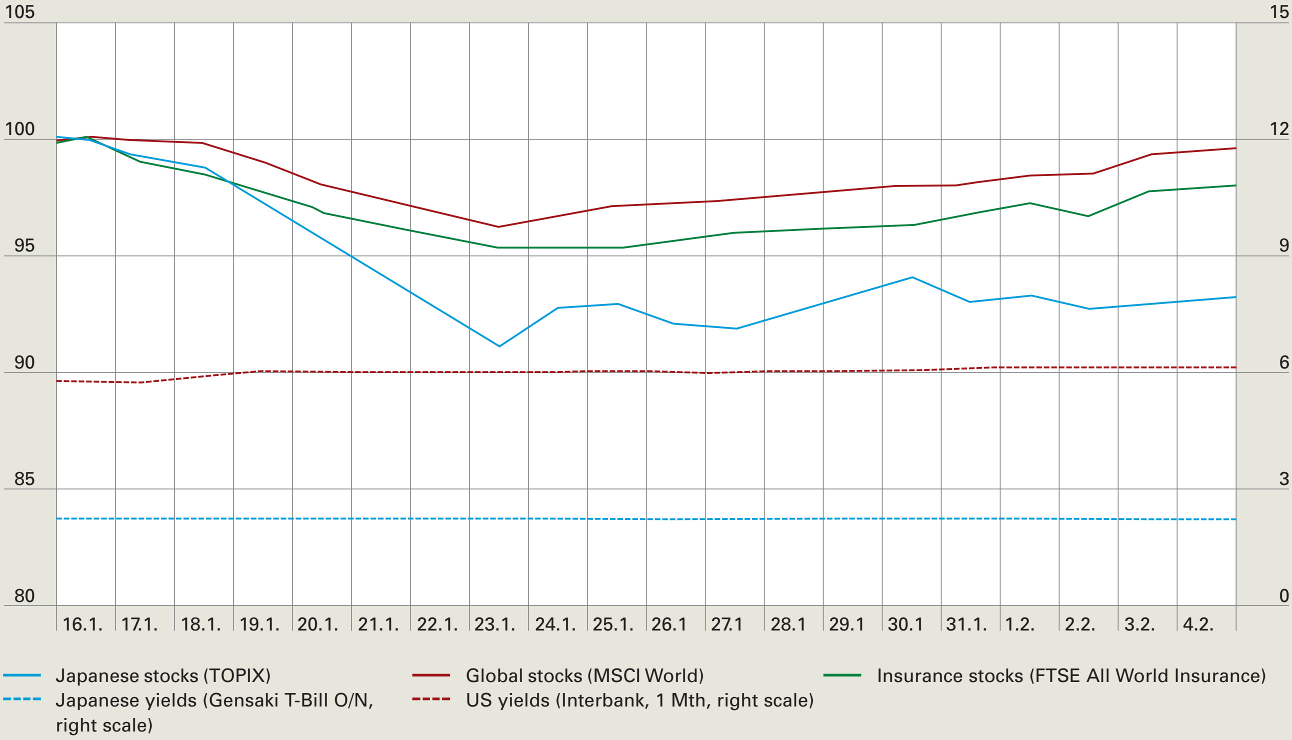
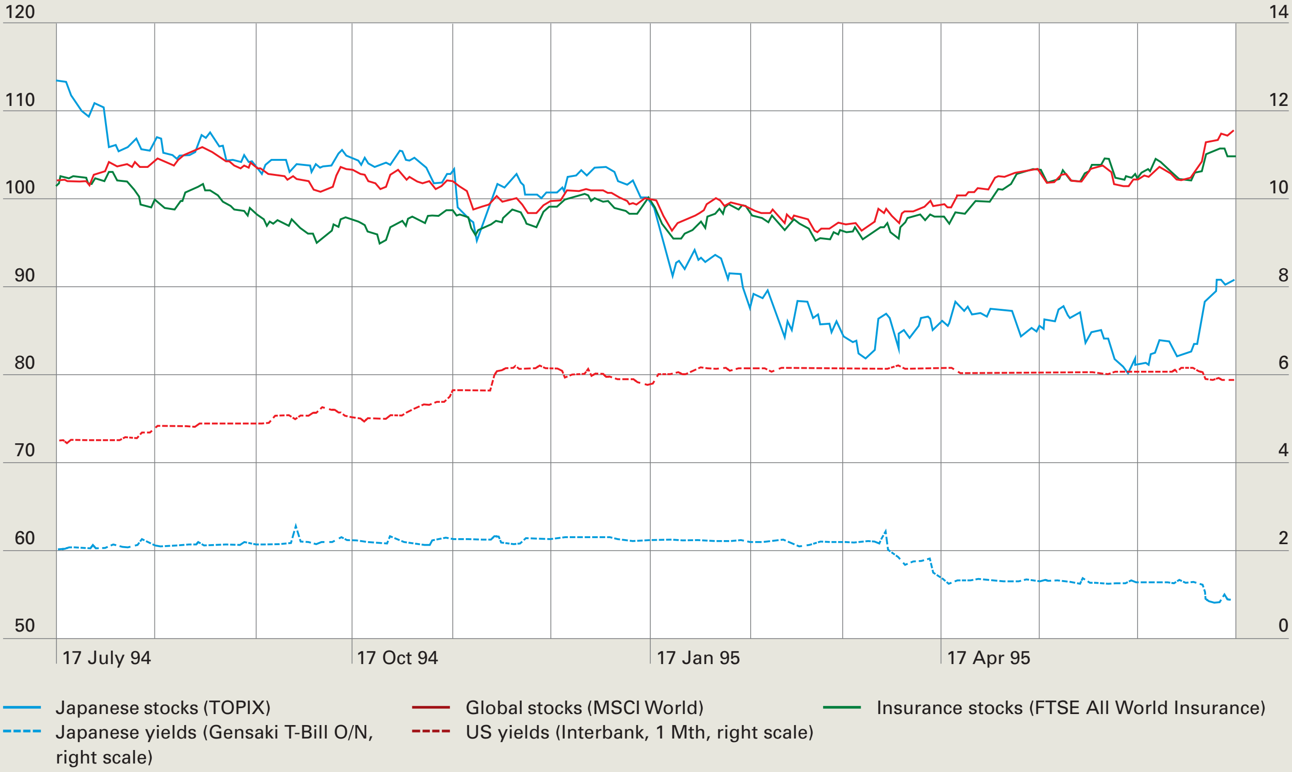


Figure 22 Long-term impact on the capital markets of the Kobe earthquake of 17 January 1995
6 months before and after the earthquake, 16 January 1995 = 100



Share price trends following the Kobe earthquake show only partial similarities with the trends following the attack on the WTC. In the first week after the disaster, the Japanese share index lost up to 9% of its value. Global stock markets recorded losses too. At only about 4%, however, these were within the normal variation range for stock markets.

The shares of insurance companies were also affected only slightly more than the market as a whole. Unlike following the attack of 11 September, there were no short-term reactions on the fixed-income markets following the Kobe earthquake. Unlike New York, Kobe was not a financial centre, and there were no fears of severe market liquidity problems.

Source:
Datastream, 2004

Proactive measures to safeguard investments

Disasters in megacities tend to have a more or less negative impact on insurance companies' investments. The weakening effects can be reduced by means of rigorous asset management and the efficient structuring of investments, but even in a perfectly structured portfolio a disaster will generally leave its mark.

The key role in efficient investment management falls to asset-liability management. In other words, investments must be made in such a way that there is the highest possible correlation with liabilities. As future liabilities increase sharply whenever a disaster occurs, suitable investments are ones that go up in value in such a case. Such investments are not generally to be found, however. Realistically, the thing to do is therefore to concentrate on minimising negative effects by putting money into investments that will lose the least value in the event of a disaster.

Diversification of share investments

Insurance company shares are the ones most directly affected by disasters in megacities. It therefore makes no sense for companies within the insurance industry to invest in the shares of other insurance companies. Generally speaking, equity investments in the economy in question will suffer the most. Share investments used to back underwriting risks should therefore be widely diversified across the globe wherever possible. Where necessary, currency risks can be hedged on the capital market. The principle of diversification applies especially to economies that are largely concentrated in megacities. If an insurance company having its headquarters in a megacity and writing few international risks only invests in the domestic stock market, it is especially at risk: in the event of a disaster, the assets of that megacity are affected; at the same time, there is an explosion in liabilities, while investments implode. The result would most probably be a crisis threatening the insurance company's very existence. The problem: the national regulatory authorities often impose rules that get in the way of international diversification and are not always comprehensible.

There are in fact shares that can benefit from a disaster – those in companies in the construction industry which are given a boost by the reconstruction work, and those in companies specialising in safety and security systems, which see increased demand for their products following terrorist attacks. All the same, it is not opportune to gear investments to scenarios of this kind. Firstly, the nature of the disaster (natural disaster, man-made disaster), and thus the sector that will benefit most, is almost impossible to predict. Secondly, it would be necessary to have a high concentration of investments in the sectors in question in order to offset the consequences of a disaster. In normal times, however, this would lead to an undesirable risk accumulation and have a strongly adverse effect on the results.

Safe-haven bonds

Interest rates usually fall following a disaster, causing the net cash value of existing liabilities to rise. In addition, the value of an existing bond portfolio will increase. Matching liabilities as closely as possible in terms of periods and currencies can largely neutralise the net effect. This is not a new discovery and applies to every interest rate movement. It does not, however, offset any new liabilities arising as a result of the disaster.

Hedging with derivatives

Insurers can also protect themselves against possible disasters with derivatives. Thus in recent years, ever more complex structures have been developed, including catastrophe bonds, or "cat bonds" for short. With these bonds, repayment or the amount repaid is linked to whether or not a specific event, such as a disaster, occurs. Where an insurance company issues this kind of bond to investors, it is at least partially protected against catastrophe risks. Cat bonds are not primary capital market products, however. Rather underwriting risks are transferred to investors. Alternatively, the insurer could choose not to write the corresponding risks or could retrocede them.

Conclusion

There are problems associated with gearing the investment structure specifically to a disaster in a megacity. Firstly, the scale of the consequences cannot be predicted accurately enough. Secondly, there are few suitable investment products to offset losses in the event of a disaster. Moreover, a reasonable risk-return profile must also be ensured in the absence of any disasters. Adequate recommendations on action are therefore confined to implementing the principles of asset-liability management efficiently: a portfolio should therefore be geared to the liabilities and be as widely diversified as possible. This is especially true of insurance companies writing predominantly domestic risks that are concentrated in a megacity. Here the global diversification is especially important and should exceed the usual proportion.

Risk financing and insurance solutions using ART concepts

Where reinsurance capacities for highly-exposed areas like megacities become tight, alternative concepts are required. The capital markets can fill the gap: their volume is many times larger than that of the insurance markets; they have adequate liquidity; and both their innovativeness and the need to diversify mean that new classes of risk are being created all the time.

Alternative risk transfer – "ART" for short – has now become an integral part of (re)insurance and capital market concepts. At Munich Re, finite risk (re)insurance and capital markets products complement traditional reinsurance as part of comprehensive risk, balance sheet and liquidity management. What lies behind these concepts and how are they designed?

Finite risk (re)insurance

Finite risk (re)insurance or financial reinsurance involves a reinsurance contract with limited risk transfer. Any potential loss here is mainly financed by either a specially accumulated fund or by deferred payment. Finite risk (re)insurance offers clients the option of leaving more risk in the retention, whilst at the same time smoothing out the results over time by using riskfinancing methods instead of pure risk-transfer models. The aims of finite risk (re)insurance are:

– Optimising retentions and (re)insurance structures
– Equalising results over time and liquidity support
– Optimising investment strategies
– Supporting corporate planning and risk management
– Protecting key ratios and ratings

Typical features of self-reinsurance are substantial pre- and post-funding of losses by the protected company over a multi-year contract period. In addition, structured risk elements provide for a significant transfer of insurance risks to the insurer or reinsurer in accordance with the relevant accounting guidelines. It is precisely where there are high exposures – accumulation risk in megacities – that finite risk (re)insurance concepts offer customised solutions. These concepts complement and optimise the traditional reinsurance needs of insurance companies and – through the use of captives or primary insurers – of companies directly.

Capital markets products – Insurance securitisation and insurance derivatives

Since the mid-1990s, capital markets instruments as sources of capacity and finance have been gaining in importance as a complement to traditional reinsurance. Two products – insurance securitisation and insurance derivatives – are at the forefront: In the case of insurance securitisation, the capital for a potential loss is securitised and issued as a bond. Investors in the capital markets assume insurance risks by buying these bonds. The bond serves as a guarantee fund for liabilities under the (re)insurance contract; in the event of a loss, it becomes worthless. Munich Re issued such bonds – "PRIME capital catastrophe bonds" – in 2000 to cover the risk of earthquake in California (San Francisco Bay Area and Greater Los Angeles), hurricane damage in the New York and Miami metropolitan areas and windstorm damage in conurbations like London, Holland's Randstad, Paris, and the Ruhr area of Germany. Earthquake and typhoon risks in the Tokyo-Yokohama conurbation, hail damage in the Greater Zurich area, earthquake risks for football stadiums in Korea and Japan, or potential terrorist attacks on stadiums in the 2006 FIFA World Cup in Germany have been and are being insured via the capital markets, and are thus contributing to efficient financial relief for megacity risks.

Weather derivatives for hedging against weather risks

In recent years, it is precisely in conurbations that increasing numbers of companies have insured themselves against weather risks. The demand for weather derivatives comes mainly from utility and energy companies and their customers, as well as from manufacturing industry and the leisure industry as a whole. As part of an integrated risk management strategy, such instruments can both stabilise the results and protect the balance sheet.

To hedge against weather risks, the organisers of big sports or cultural events may take advantage of such financial products as weather derivatives.

The market for weather risks is very dynamic, and a good database and strong demand ensure that cover is being improved all the time, particularly in respect of risks in conurbations.

The Munich Re Group has had years of experience with these innovative tools, working closely with specialist traders and underwriting funds. Currently, the emphasis is on developing individual, customised solutions. These are either written as derivatives through Munich American Capital Markets (MACM), our financial products subsidiary, or posted to the accounts in the form of an insurance policy with the parent company, Munich Re, or the US subsidiary, American Re. Experts in the Enterprise Risks and Capital Markets Department of the Special and Financial Risks Division work very closely here with Munich Re's meteorologists, so as to be able to offer clients the best solution in each case.

Appendix

Table 1 Statistics and natural hazard risk for 50 selected megacities

Megacity	Country	Population (mill.) (1)		Area (km^2) (2)	City GDP in % of country's GDP (3)	Natural hazards (4)								Risk index (5)
		As at 2003	Forecast for 2015			Earthquake	Volcanic eruption	Tropical storm	Winter storm	Thunderstorm/ hailstorm/tornado	Flood	Tsunami	Storm surge	
Tokyo	Japan	35.0	36.2	13,100	40	High	Low	Medium	Low	Medium	Low	Low	Medium	710.0
New York	USA	21.2	22.8	10,768	<10	Low	None	Medium	Medium	Medium	Low	Low	Medium	42.0
Seoul, Inchon	South Korea	20.3	24.7	4,400	50	Low	None	Medium	Low	Low	Medium	None	None	15.0
Mexico City	Mexico	18.7	20.6	4,600	40	High	High	None	None	Medium	Low	None	None	19.0
São Paulo	Brazil	17.9	20.0	4,800	25	None	None	None	None	Medium	Low	None	None	2.5
Mumbai	India	17.4	22.6	4,350	15	Medium	None	Low	None	Low	Medium	Low	Medium	5.1
Los Angeles	USA	16.4	17.6	14,000	<10	High	None	None	Low	Medium	Medium	None	None	100.0
Delhi	India	14.1	20.9	1,500	<5	Medium	None	None	None	Medium	Medium	None	None	1.5
Manila, Quezon	Philippines	13.9	16.8	2,200	30	High	Medium	High	None	Medium	Medium	Medium	Low	31.0
Calcutta	India	13.8	16.8	1,400	<10	Medium	None	High	None	Medium	High	None	Medium	4.2
Buenos Aires	Argentinia	13.0	14.6	3,900	45	Low	None	None	Low	Medium	Medium	None	Medium	4.2
Osaka, Kobe, Kyoto	Japan	13.0	13.2	2,850	20	High	None	Medium	None	Medium	Medium	Low	Medium	92.0
Shanghai	China	12.8	12.7	1,600	<10	Low	None	Medium	None	Low	Medium	None	High	13.0
Jakarta	Indonesia	12.3	17.5	1,600	30	Medium	Medium	None	None	Low	Medium	Medium	Low	3.6
Dhaka	Bangladesh	11.6	17.9	1,500	60	High	None	High	None	Medium	High	None	Low	7.3
Rio de Janeiro	Brazil	11.2	12.4	2,400	15	None	None	None	None	Medium	Medium	None	None	1.8
Karachi	Pakistan	11.1	16.2	1,200	20	High	None	Low	None	Low	Medium	Low	Medium	3.1
Ruhr area	Germany	11.1	11.1	9,800	15	Low	None	None	Medium	Medium	Medium	None	None	14.0
Cairo	Egypt	10.8	13.1	1,400	50	Medium	None	None	None	Low	Medium	None	None	1.8
Beijing	China	10.8	11.1	1,400	<5	Medium	None	None	None	Medium	None	None	None	15.0
Lagos	Nigeria	10.7	17.0	1,100	30	None	None	None	None	Medium	Low	None	None	0.7
Moscow	Russian Fed.	10.5	10.9	1,100	20	None	None	None	None	Medium	Low	None	None	11.0
Paris	France	9.8	10.0	2,600	30	None	None	None	High	Medium	Medium	None	None	25.0
Istanbul	Turkey	9.4	11.3	2,650	25	High	None	None	None	Medium	Medium	Low	Low	4.8
Chicago	USA	9.2	10.0	8,000	<5	Low	None	None	Medium	Medium	Low	None	Low	20.0
Lima	Peru	7.9	9.4	550	50	High	None	None	None	Low	Low	High	None	3.7
Washington, Baltimore	USA	7.6	8.6	9,000	<5	None	None	Low	Medium	Medium	Low	None	Low	16.0
London	UK	7.6	7.6	1,600	15	None	None	None	High	Medium	Medium	None	Medium	30.0
Bogotá	Colombia	7.3	8.9	500	20	High	None	None	None	Low	Low	None	None	8.8
Teheran	Iran	7.2	8.5	500	40	High	None	None	None	Medium	Low	None	None	4.7

None Low Medium High

Megacity	Country	Population (mill.) (1)		Area (km²) (2)	City GDP in % of country's GDP (3)	Natural hazards (4)								Risk index (5)
		As at 2003	Forecast for 2015			Earthquake	Volcanic eruption	Tropical storm	Winter storm	Thunderstorm/ hailstorm/tornado	Flood	Tsunami	Storm surge	
Jo'burg, East Rand	South Africa	7.1	8.5	17,000	30	Low	None	None	None	Medium	Low	None	None	3.9
San Francisco Bay	USA	7.0	7.7	8,000	<5	High	None	None	Low	Low	Low	None	None	167.0
Randstad	Netherlands	7.0	8.0	4,000	50	None	None	None	High	Medium	Medium	None	Medium	12.0
Hong Kong	China	7.0	7.9	1,100	10	Medium	None	High	None	Medium	Medium	Low	Medium	41.0
Bangkok	Thailand	6.5	7.5	500	35	Low	None	Low	None	Medium	Medium	None	None	5.0
Bangalore	India	6.1	8.4	300	Unknown	Low	None	None	None	Low	Low	None	None	4.5
Bagdad	Iraq	5.6	7.4	500	Unknown	Medium	None	None	None	Medium	Medium	None	None	1.3
Santiago de Chile	Chile	5.5	6.3	950	15	Medium	None	None	Low	Low	Low	None	None	4.9
St. Petersburg	Russian Fed.	5.3	5.2	600	<5	None	None	None	Medium	Low	Medium	None	Medium	0.7
Madrid	Spain	5.1	5.3	950	20	None	None	None	None	Medium	Low	None	None	1.5
Singapore	Singapore	4.3	4.7	300	100	Low	None	None	None	Medium	Low	Low	Low	3.5
Sydney	Australia	4.3	4.8	2,100	30	Low	None	None	Low	Medium	Low	None	Low	6.0
Milan	Italy	4.1	4.0	1,900	15	Low	None	None	Low	Medium	Low	None	None	8.9
Miami	USA	3.9	4.5	2,900	<5	None	None	High	None	Medium	Low	None	High	45.0
Alexandria	Egypt	3.7	4.5	100	Unknown	Medium	None	None	None	Low	Low	Medium	Low	1.4
Abidjan	Ivory Coast	3.3	4.4.	500	50	None	None	None	None	Low	Low	None	None	0.3
Berlin	Germany	3.3	3.3	900	<5	None	None	None	Medium	Medium	Low	None	None	1.8
Athens	Greece	3.2	3.3	450	30	Medium	None	None	None	Medium	Low	None	Low	3.7
Medellín	Colombia	3.1	3.8	250	Unknown	Medium	None	None	None	Medium	Low	None	None	4.8
Frankfurt area	Germany	2.7	2.7	2,900	<10	Low	None	None	Medium	Medium	Medium	None	None	9.5

None Low Medium High

A selection of 50 of the world's megacities: Population, area, size in economic terms, and natural hazards risk (listings based on population figures for 2003).

Sources:
(1) UN 2004, Statistical authorities
(2) Bronger 2004, Statistical authorities, ESRI 2003, various websites
(3) Statistical authorities, various websites
(4) Munich Re, 2004
(5) Munich Re, Topics 2002

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