Risk and Disaster Management in Mega Cities utilizing Earth Observation Data

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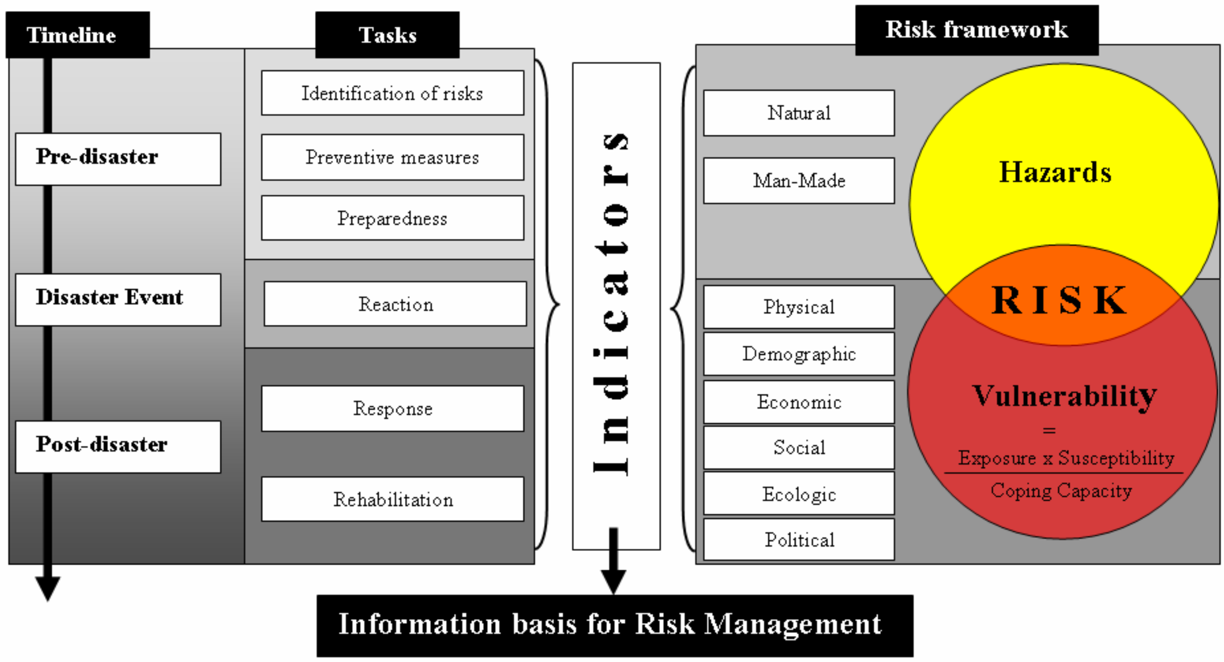
INTRODUCTION

Mega cities are defined as megalopolis with more than 10 million inhabitants. The number of so-called mega cities increased in the period from 1975 until today from 4 to 22, mostly in less developed regions of the world (Münchner Rück, 2005). Qualitatively mega cities are characterized by high and dense population concentration, a high density of industries as well as social, technical and transportation infrastructure. Especially in developing countries they show extreme, uncontrolled urban sprawl, high traffic pressure, ecologic overload, concentration of assets and power, high spatiotemporal dynamics and the coexistence of socioeconomic disparities (Kraas, 2003) - all indicators showing high vulnerability to external and internal hazards. Many mega cities are furthermore located in areas exposed to natural disasters. Examples are the earthquake prone mega cities of Istanbul, Los Angeles, Mexico City or Tokio, landslide hazards in Caracas, Hong Kong, Rio de Janeiro, Manila, floods in Mumbai, Dhaka, Kolkata, Seoul, Bangkok, tropical storms for Shanghai or Taipeh, tsunamis for Jarkarta, Mumbai or Tokio or volcanic eruptions for Mexico City. The concurrence of high exposure to (natural) hazards and high vulnerability make mega cities victims and producers of risks at the same time. To a large extent successful strategies in disaster and risk management depend on the availability of accurate information presented in an appropriate and timely manner. In recent years satellite systems and image analysis techniques have developed to an extend where civil and commercial earth observation instruments can contribute significantly in supporting the management of major technical and natural disasters as well as humanitarian crisis situations (Voigt et al., 2007; Taubenböck et al., 2008). There are at present several optical systems (e. g. Quickbird, Ikonos, Spot, Landsat) and Synthetic Apertur Radar (SAR) sensors (e. g. TerraSAR-X, ERS-2, RadarSAT) in space providing a broad and global observation of the planet at different temporal and geometric resolutions. Utilizing multi-source remotely sensed data up-to-date and area-wide geospatial information, maps and thematic analysis can be produced in various scales supporting risk and disaster management before, during and after an event.

CONCEPTUALIZATION OF DISASTER AND RISK MANAGEMENT

Disaster and risk management are rather abstract terms for the complex task of well situated decisions for successful mitigation, preparedness, response and recovery strategies. A conceptualization aims to resolve the abstract terms down to clear, quantifiable and comparable indicators with respect to the timeline of risk and disasters. In the pre-disaster phase substantial, up-to-date and area-wide information is the foundation to identify risks and its spatial pattern. The first step is assessing the weaknesses of a system (vulnerability) in order to systematically implement preventive measures. The multidimensionality of vulnerability is defined as the condition determined by physical, economic, social, environmental factors or processes, which increase the susceptibility of a community to the impact of hazards (UN, 2004). In the disaster phase required information aim to support the decision maker in assessing the situation by estimating the location, dimension and spatial pattern of the impact to organize mitigation and response measures. In the post-disaster phase the knowledge on impact enables to organize the reaction and rehabilitation

Table 1: Risk framework in dependency of timeline of potential disasters



processes. Table 1 shows a framework of risk and disaster management tasks in dependency of the timeline specifying in indicators determining the hazard and the vulnerability perspective of risks.

Contributions of Earth Observation Data to Disaster and Risk Management

The capabilities of remote sensing to support risk and disaster management are manifold: In the pre-disaster phase products from multi-source remote sensing data like urbanization rates over time, the analysis of the urban structure including parameters like number of houses, building height, built-up density, land-use, location and dimension of open spaces or the street network enable to assess the spatial distribution of aspects of vulnerability. In addition the calculation of tsunami prone areas or the spatial distribution of landslide hazards derived from a digital elevation model support the area-wide assessment of the hazard perspective of the risk conceptualization. Figure 1 presents results derived from high resolution Ikonos data to assess vulnerability in the forefront of an expected earthquake impact in the mega city Istanbul, Turkey. The land-cover classification provides up-to-date and area-wide data on “what” is “where” in the urban landscape. This is the basis for further products, like location and dimension of safe areas or inner-city highways to assess accessibilities or carrying capacities. In addition an interdisciplinary approach with civil engineering enables to calculate expected damage grades for various building types for the actual scenario (Münich et al., 2006). Furthermore, the structural characteristics of the houses—building heights, building density and function (e. g. residential or commercial usage)—allow an indirect assessment of the population distribution within the urban landscape in the course of a day (Taubenböck et al., 2007). In the disaster phase, the substantial information basis generated before an expected disastrous event enables ad-hoc coordination during the disaster. To it, accurate and spatially precise information on the damage caused is of vital importance for rescue and relief operations and to mobilize resources for repair and recovery. Fast acquisition of satellite data from the struck area enables a measurement of damage caused by the impact in reality. Manifold examples of rapid mapping products based on multi-source satellite data pertain tsunami impact, forest fire mapping, earthquake damage assessment or landslide mapping. Thus, a first assessment of affected structures and affected people enables localization of focus areas and the diagnosis of the dimension of the impact. Utilizing this information basis the coordination of a fast reaction in the post disaster phase can be supported and accomplished and is elementary information for coordinated relief and rehabilitation measures.

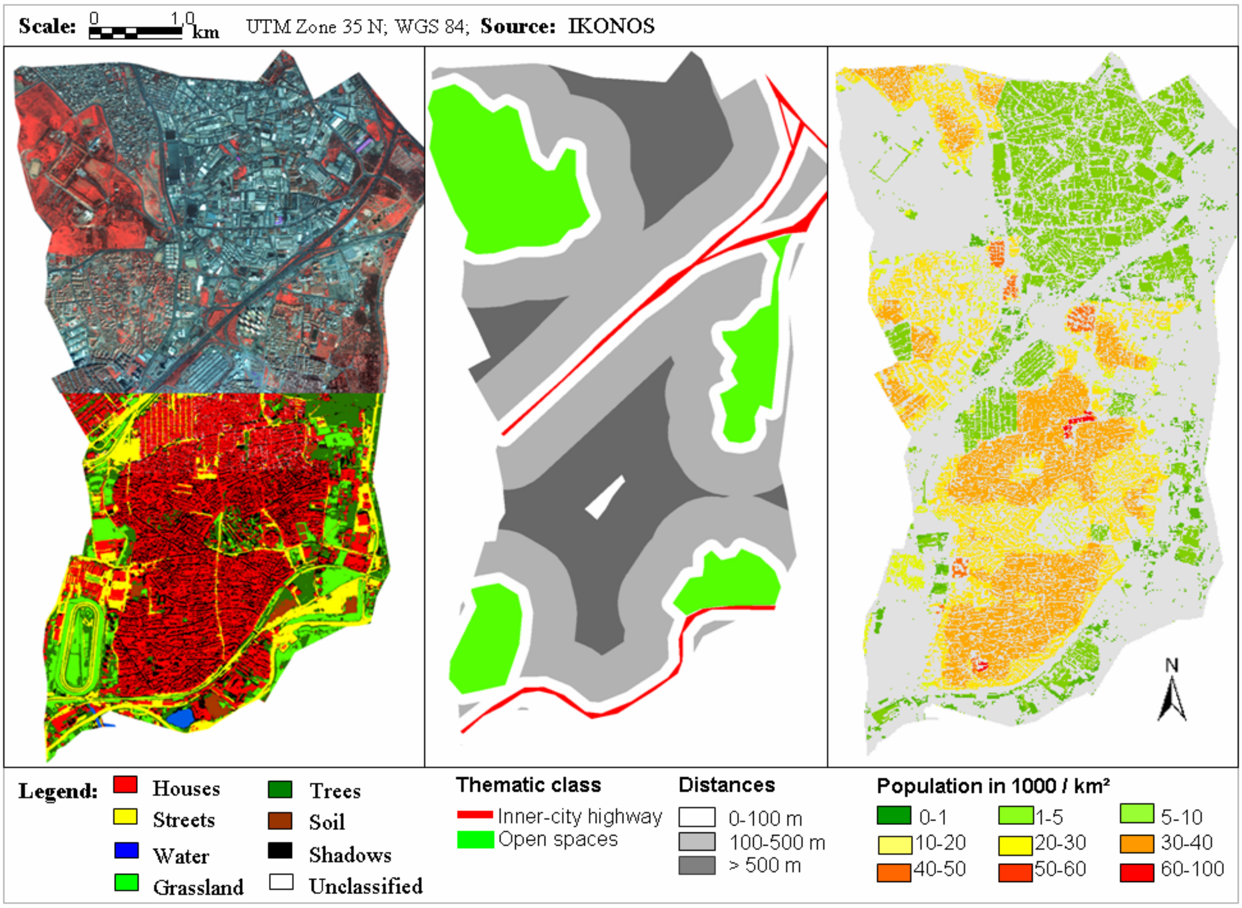


Fig: 1: Products to support risk management derived from high resolution satellite data

CONCLUSIONS

Along the outline of this study – the conceptualization of risk management - various indicators derived from multi-source remote sensing data contribute to risk and disaster management before, during and after an event. Especially in the explosively growing mega cities in developing countries remote sensing proves to be an independent, up-to-date and area-wide data source to provide substantial spatial data on risk assessment and disaster management.

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