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Mitigating Multihazard Risk for Multistoried Buildings in GIS Environment

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Abstract: Urban habitats which are generally complex and interdependent systems, are extremely vulnerable to threats from hazards both natural and manmade. Much of the research has been done in developed countries to study effects of multi hazards on urban habitats, methodology of diagnosis, mitigation strategies, and implementation issues, creating awareness, effective usage of Remote Sensing and Geographic Information System (GIS) in disaster mapping, guidelines for safer habitats, infrastructure planning and routing urban utilities.

Government of India and United Nations Development Program (2006) have suggested a Disaster Management plan dedicated to school buildings but study of vulnerability of other infrastructure under multiple hazards, their mitigation strategies and a contingency plan for implementation of protocols in the event of such disasters has not been done till date.

This paper examines how development of new technologies in GIS and interdisciplinary research using sensors, controls and data acquisition, can be utilized to monitor the hazard levels and their effective mitigation strategies; Development plans and implementation strategies to prevent huge losses to life and property of various countries have been studied. It also examines what types of guidelines should be prepared for citizens and city planners. Meticulous planning early and ahead of construction leads to optimum solutions rather than rebuilding entire cities after the destruction, especially when buildings are competing to be taller and demands on public utilities become more crucial for the economy of the regions.

Keywords: multihazard[1], mitigation[2], urban infrastructure[3]

Background

The latest National Sample Survey Organization (NSSO) report 2007 - 2008, 'Migration in India', has indicated that Gujarat has the highest rate of urbanization in the country. Looking to the increase in numbers of disasters striking the globe there is a need to give a thought to hazards in conceptual stage of the project so that the impact can be minimized. The maximum loss to life and property in Asian region due to disasters dictates the need for safer habitats.

Urban habitats are generally exposed to hazards of Earthquake, Fire, Wind, High intensity Rain, Floods, Festival related disaster and Terrorist attack/explosions. The most likely area to be affected include densely populated areas of old city, Important Buildings such as schools, hospitals, government offices, secretariats, lifelines like flyovers, bridges, buried utilities of water supply, sewerage, telephone lines, gas lines, electricity and heritage buildings. When these infrastructures are not safeguarded against hazards, the impact turns into a disaster. With a large part of Asian region communities belonging to low income strata, with people driven construction processes, appropriate technology transfer initiatives shall be in force for creating awareness, using better technologies and cost effective building technologies.

Further so far as the scenario of developing countries like India is concerned, evacuation procedures and routes required in case of a hazard for Public Buildings have not been made public. Quality of life and urban runoff mitigation is not taken into consideration for development of infrastructure and shall be given thought during the planning stage. Drainage problems with short duration high intensity rainfall which generally the major cities are facing are also area of concern for the developing countries. Also the role of corporate sectors has to be decided for risk posed by various hazards as corporate people, resourceful technically and financially, have capacity to cope up every risk due to hazard. The strategy to create safer habitats as people's movement would need massive community participation and use of media, governmental and technology back up delivery support.

Scenario In Developed Countries

Europe

A dedicated project of Applied Risk Mapping of Natural Disasters Impact Assessment "ARMONIA" has been conducted in Europe which is focused to develop a new approach to produce integrated multi risk maps to achieve more effective spatial planning procedures in areas prone to natural disasters by Decision

Support System. The project is conceived to harmonize the methodologies for various hazard and risk assessment, processes of risk mapping to standardized data collection, data analysis, monitoring, outputs and terminology in form useful to end users leading to a new guideline for regional and local sites. It also helps to synchronize various stake holders such as the city planners, municipality, public, local fire brigade etc and political units on the European Unoin. ARMONIA comprises of the following steps: Analysis of state of art for spatial planning and mapping of risk from natural hazards, development of a methodology for integrated maps, development of knowledge base of terminology, integration of risk maps with spatial planning decision processes in the form of a decision support framework and implementation, integration and analysis of a case study simulation.

Columbia County, Oregon

A research done for Colombia County, Oregon covers each of the major natural and human hazards like floods, winter storms, landslides, wild land/urban fires, earthquakes, volcanic hazards, dam safety, disruption of utility and transport systems, hazmat incidents and terrorism that pose risks to County. The objective of mitigation is to reduce negative impacts of disasters on community, to save lives, minimize damage to buildings, and infrastructure, and minimize economic losses. The mitigation is a planning document, not a regulatory document. This mitigation plan meets FEMA's planning requirements by addressing hazards, vulnerability and risk. The research work includes relative ranking of hazards as priorities for mitigation in Columbia County. Emphasis is also laid on community profile, community involvement and public process in development of mitigation plan.

The Netherlands

Research focuses on disaster prevention policy in The Netherlands, implementation issues and gaps and failure of local and national authorities' preventative policies. It has been noted that safety can easily lose out when economic interests are at stake. Comparisons are also made with the implementation of Strategic Environmental Assessment. The research lays emphasis on understanding the disasters better and giving more attention to risk oriented planning which ensures an acceptable level of risk. The parameters which shall be given prime importance are: hospitals, medical facilities and emergency treatment areas, structures containing toxic/explosive substances, public buildings, institutional buildings and jails. It also highlights failure of command and control of disaster prevention and inadequate enforcing component. For a densely populated country like The Netherlands, where there are many claims on the available space, an acquiescent approach, focusing on preparedness of disasters and a rational prevention policy seems to be more realistic.

Costa Rica

A case study has been made on Costa Rica for formulating a digitized map for the city and its surrounding and based on historical information. A GIS database is generated which is used for mapping natural multi hazards like flood, earthquake and landslide. The work was made using an orthophoto as basis on which all tall buildings, land and roads within the city and its direct surroundings were digitized, resulting in a digital map, for which a number of hazard and vulnerability were collected in the field. Based on the historical information GIS database is generated for flood depth maps with different return periods. For determining seismic hazard, a modified version of the Radius approach was used and landslide hazard was determined based on the historical landslide inventory and a number of factor maps, using a statistical approach. The cost of the building component at risk is also arrived upon and finally cost maps were combined with vulnerability maps and hazard maps per hazard type for different return periods. The outcome is in the form of probability graph versus potential damage. This data base serves as a tool for local authorities to find suitable areas for further expansion, and to relocate the people living in hazard prone zones and also determine the effect of mitigation measures by Benefit Cost Analysis (BCA). This type of analysis heavily relies on historical information, expert judgment and relationship between magnitude and return period of different events, number of assumptions and simplifications which may vary from individual to individual.

Japan & China

Research has also been conducted in Japan in joint venture with Chinese partner and it focuses to develop a methodology of diagnosis for urban disaster risk management, to provide necessary information based on spatial GIS. It also aims to form research partnership network with Chinese partners as well as development of methodologies for evaluation of urban disaster risk and effective utilization of spatial GIS. This research is focused on earthquake and takes into consideration concept of performance evaluation, economic evaluation, water resource planning and management. Niche overlap indices in the field of ecology are applied to spatial

segregation problems of elderly people and young people. Further Topographical Index (TI) is used to evaluate concentration and dispensation property of urban road networks with their redundancy. Long term and short term effects of mitigation upon regional economy are distinguished by the difference in possibility of change in the locations of firms and households. In the short run, individuals and firms cannot change their location. But in the long run, they change their locations. This can be the base for mitigation strategies. Water resource planning has also been touched upon in this research in which a hierarchical water circulation model is proposed to deal with as to how to mitigate the risks of the earthquake disaster and for water management in urban areas. GIS has been divided into three categories by the authors for the effective use and providing solutions to various agencies.

United States

In United States, a dedicated research has been done which focuses on schools and hospitals for seismic vulnerability. Through the application of standardized questionnaires, both a structural and nonstructural vulnerability index are derived which allow a priority ranking and an identification of the most vulnerable features so that responsible authorities are able to conduct a targeted investigation using more advanced investigation methods. In contrast to other available approaches, structural and non-structural vulnerability are treated separately. While the structural vulnerability index is generated taking into account main design failures as well as the age of the building and its general state of maintenance, the non-structural vulnerability index covers all types of installations, secondary structural elements as well as their impact on the functionality of the building. Based on the outcomes of survey tools and the experiences gained during these case studies, a calibration of the questionnaires was done through the definition of reliable weighting factors for the different vulnerability-affecting aspects. However, a more substantiated calibration of the importance factors, age and actual state factors, and vulnerability indexes with thorough analytical studies of selected structures is ongoing (Verbicaro et al. 2009) and will be the purpose of future investigations.

Modification in built environment

Research has also been conducted in some countries on the investigation of built environment affected by earthquake, flood, wind and fire which further leads to definition of specific measures for each category of risk as well as measures for mitigation related to structural modification. It is summarized that multi hazard approach of design team is required for proper mitigation assessment of the impacts on the built environment. The study emphasizes on the structural modification, topographical landscape & green pedestrian areas and also takes into consideration modern human needs.

Decision support system for urban utilities

Research has also been made for buried urban utilities leading to a web-based system for supporting the selection of the most suitable routes. The aim of the proposed system is to support decisions through a collaborative semi automated environment, in which stakeholders can share information and/or study the impacts of different routing alternatives with respect to decision constraints. First, the knowledge relating to route selection for urban utilities is represented through ontology. The ontology defines the types and attributes of infrastructure products and the surrounding areas. It also defines the impacts of routing options on surrounding areas through a set of decision criteria adopted to evaluate the effectiveness of any route in terms of its potential impacts. A set of constraints are also defined to help represent the decision criteria. Secondly, a GIS-based system has been created to help visualize route data, interact with users, and support the needed discussions among stakeholders. The portal also achieves data interoperability through wrapping existing geospatial data with ontology structures. The system is capable of (1) extracting the attributes of each routing option, (2) testing the interaction/conflicts between route attributes and the constraints of the surrounding area, (3) studying the impacts of a route as stipulated in the ontology, (4) referring users to existing best practices to help enhance routes or address conflicts and, when needed, (5) develop objective measures for comparing different routes. On the micro level (street level), route options are evaluated through a "constraint-satisfaction" approach. On the macro level (city level), route options are evaluated through a fuzzy inference scoring system. The proposed system focuses on facility life cycle, sustainability, and community impacts. Construction costing, scheduling, labor, and equipment along with other management issues can either be added to the system or, better, analyzed through integrating the system with four-dimensional modeling tools.

Creating resilient cities

This paper proposes a comprehensive strategy of urban hazard mitigation aimed at the creation of resilient cities, able to withstand disasters. The paper reviews hazard mitigation practice, defines a resilient city,

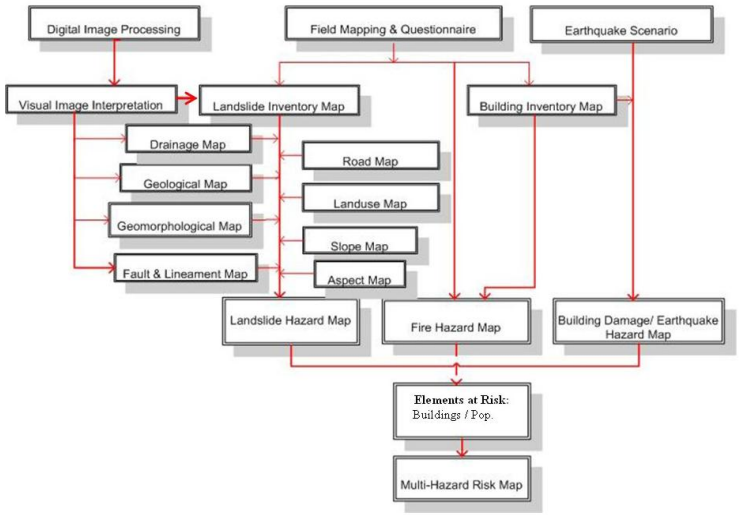
considers the relationship between resilience and terrorism, and discusses why resilience is important and how to apply its principles to physical and social elements of cities. Contending that current hazard mitigation policy, practice, and knowledge fail to deal with the unique aspects of cities under stress, the paper recommends a major resilient cities initiative, including expanded urban systems research, education and training, and increased collaboration among professional groups involved in city building and hazard mitigation

Quality of life as development factor

As sustainable development becomes a more important objective in civil infrastructure planning and policymaking, quality of life is an increasingly important measure to understand, characterize, and apply effectively in the development of appropriate infrastructure solutions for sustainability. It provides an overview and critique of approaches in defining quality of life and explains its significance in infrastructure decision making for sustainable development. Examples are used to demonstrate how infrastructure can be strategically developed or redeveloped to improve regional quality of life and economic competitiveness while preserving or enhancing the natural environment. Based on the theoretical review and examination of infrastructure development examples, the authors suggest that a new paradigm that views infrastructure development as part of a socio technical system be considered. Such a paradigm would encourage strategic infrastructure designs and policies that expand choice and achieve multiple objectives for sustainable development.

Indian Scenario

Very little research has been done in India on the combined effects of multi hazards. A study of Kohima town, Nagaland is an example of multi hazard risk assessment, carried out for a rapidly developing city with very limited availability of existing data. Building footprints were generated from remote sensing and characteristics of various elements at risk such as building structure, materials, condition of building, socio-economic aspect based on which further population at risk is calculated through field surveys and questionnaires. Field mapping, historical data and individual hazards were analyzed in GIS using vector operations and all the individual hazard maps were integrated to prepare a multi hazard map. Surveys have been done to derive the population at risk for individual hazard and based on these results, buildings with both single and multi hazard are identified and population at risk is calculated. The study develops a methodology which can be adopted for other towns having similar problems (Landslides, Earthquakes and Fire) but generally it is focused on Kohima City of Nagaland. The analysis has been made in three wards of Kohima city but since the area is politically instable access to topographical data and aerial photographs for this region is restricted. This study heavily relies upon the historical data and judgment of individuals. Generalized flowchart of the method followed for multi hazard risk assessment in the city of Kohima is mentioned as under:



Source: *Petevilie Khatshu & Cees J. Van Westen*

A different study made by *V. Suresh*, depicts the scenario of developing countries, which are increasingly exposed to the risks due to rapidly growing population. With large part of population belonging to low income strata, people driven construction processes and appropriate grass root level technology transfer initiatives should be put in place for creating awareness, appreciation and application models for using disaster resistant and cost effective building technologies. Emphasis is laid on need for evolution of safer habitat which

can respond and resist the loads, forces and effects due to natural disasters. The work is focused on earthquake only but it discusses the implementation issues and gaps in our system which act as a barrier for safer building construction. Technology know-how are always available through codes, manuals, standards, brochures and folders but most important is its grass root level application which is a major drawback in developing countries like India. The cost effective technologies are also discussed so that the people of low income strata can be benefitted.

Conclusion

For a developing country like India where 85% of country's land is vulnerable to various disasters and where growing population is another major issue, it is imperative to address the risks and give due importance to multi hazard assessment and its mitigation strategies. Further Government of India and National Disaster Management Authority has formulated several guidelines related to schools but there too implementation is a major issue. In most of the developed and developing countries research is focused on effects of multi hazards for planning of urban habitats. In India, research has been based on a particular hazard in isolation but generally a hazard is coupled with several other features which need to be included in mitigation strategies so that normalcy can be reinstated at a faster pace. In Bhuj earthquake (2001), infrastructural collapse was coupled with disruption of utilities like power failure, communication failure etc. In this phase of rapid urbanization, with the limits of cities expanding, generally characterized by construction of new high rise buildings after destruction of old ones, the need for well planned and dedicated research is need of the hour. Thus detailed mitigation plans for fast paced cities on the growth path, are required to be in place with due consideration for multiple hazards.

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