A DISASTER RESILIENCE MODEL FOR URBAN SETTLEMENTS WITH A BENEFIT OF GEOGRAPHICAL INFORMATION TECHNOLOGY

Ebru ALARSLAN[1]

ABSTRACT

This paper outlines a disaster resilience model for urban settlements with the benefit of geographical information technology. After examining different disaster characteristics of both developing and developed countries, respectively, some common features and local differences in disaster mitigation can be identified. Such common features and local differences provide an opportunity to design a model for disaster resilient urban settlements. The model is envisaged to develop guidelines for disaster mitigation, including standards, criteria, and building codes for disaster-prone settlements. On the basis of such guidelines, proposals are formulated for short-, medium-, and long-term strategies and policies. The disaster resilience model is structured with a view to correlations between disaster mitigation stages and the procedure of spatial planning at various scales. The model is designed as a checklist of actions rather than as a detailed and comprehensive guidebook to lead to a physical resilience. Though based on a standard checklist, the model presents different approaches for developing and developed countries, respectively. The variables used in the model and the checklist can conveniently be updated in response to changing conditions of urban settlements over time. Various tools of geographical information technology are very helpful to apply the model on a certain urban settlement from macro policies to implementation details. Those tools can be applied conveniently by using spatial data infrastructure (SDI) of a selected urban settlement.

[1] **Dr.Ing. Ebru ALARSLAN,** Urban Risk Expert & Project Coordinator, ebrua@csb.gov.tr
General Directorate of Infrastructure & Urban Transformation Services, Ministry of Environment and Urbanization, *www.kentseldonusum.gov.tr/en/index.html*
Phone: +90 533 743 6054 Fax:+90312 474 0393
Address: Sogutozu Mah. 2179 Sk. No:5 06510 Cankaya/ANKARA TURKEY

UDC: 004.6:528.4]:504.11

Keywords: Disaster Resilience, Urban Settlement in Developing & Developed Countries, Physical Vulnerability, Elements of Risk, Physical Resilience Model

INTRODUCTION

Recently, natural disasters with devastating effects on human settlements have proliferated. In light of this fact, this paper will present a disaster resilience model for urban settlements. Since urban settlements are densely populated and constructed habitats of men, they a priori represent high natural disaster risks. Unless the new planning strategies integrated with disaster mitigation approaches are applied to the urbanization process, natural disaster risks remain unacceptably high in urban settlements. In the model main principles, policies, strategies, and standards are set out to guide disaster prone urban settlements in disaster mitigation process.

DISASTER RISKS IN URBAN SETTLEMENTS WITH RESPECT TO THE DIFFERENCES BETWEEN DEVELOPED AND DEVELOPING COUNTRIES

By the year 2000, half the world's population lived in urban areas, crowded into 3% of the earth's surface **(**Domeisen & Palm, 1996**).** While urban settlements exploit natural resources and cause environmental pollution due to their dense population and construction, they are the core area of economic and cultural activities as well as significant cross-roads of transportation routes, technologies, and other modern networks. According to the United Nations' figures(see fig. 1), the share of the world's population in urban settlements has risen to 50% from 30% since the 1950s and this share is expected to increase to 60% in 2030 (Munich Re Group; 2004). While the global trends of increasing population in urban and rural settlements are summarily shown in the graphic on the left side, the graph on the right side distinguishes between developing and developed countries, respectively.

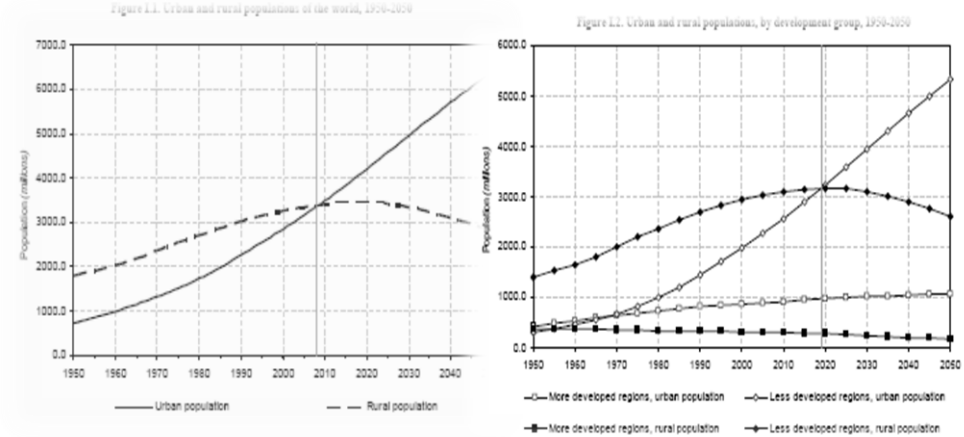


Figure 1: Urban vs rural population growth trends in developing & developed countries, respectively

Source:*ISDR,http://www.unisdr.org/eng/about_isdr/isdr-mission-objectives-eng.htm*

Different approaches are proposed to lessen the hazardous effects of natural disasters on urban settlements in developing and developed countries, respectively. A need of such different approaches in disaster mitigation has recently been advocated by many researchers and academics as, for instance, a 1999 study called "A New Approach to Disaster Mitigation and Planning in Megacities" (Velasquez et al., 1999).

From the perspective of a city planner, it is possible to distinguish between urbanization processes and urban settlements in developing countries and/or population increasing countries on the one hand and developed countries with stagnating populations on the other hand. In 1950, more than half of the population of developing countries lived in urban areas whereas the proportion was around 18% in developing countries (Munich Re Group, 2004). Since then, the rate of urbanization increased more in developing countries than that in developed countries due to the rapid population increase in the former (see fig. 1). The growth of urban population has different implications for to the urban space in developing and developed countries, respectively. While urban settlements tend to grow in a decentralized form in developed countries, agglomerations around urban settlements become the trend of urban growth in developing countries. In many developing countries, central and local authorities face myriad difficulties in providing adequate infrastructure and urban services to citizens (Domeisen & Palm, 1996).

According to a study of the Office of the United Nations Disaster Relief Coordinator(=UNDRO), urban settlements in developing countries tend to be more vulnerable to natural disasters than those in developed countries (UNDRO, 1979). The conclusions of the World Conference on Natural Disaster Reduction in Yokohama and the Hyogo Framework for Action 2005-2015 also supported this finding. According to another international study, while sustainability comprises economic features as well as social and environmental features of a country, economic conditions mainly determine the priorities of the disaster mitigation (Burby, 1998).

Another scientific study on disaster risks suggests that saving lives is the prime focus of disaster mitigation activities in developing countries and slum settlements in all countries (Wisner, 2004). On the other hand, disaster mitigation plans and programs in the United States concentrate primarily on saving assets and establishments of settlements (Godschalk, 1999). This distinction reflects different priorities driving the disaster mitigation process for different urban settlements. While saving urban assets is the primary concern in developed countries, developing countries' primary concern is preventing causalities. This fact can also be seen in the figures that among the top ten countries with highest economic losses are the six developed countries (see fig. 2). The top 50 countries of the world are ranked by International Strategy of Disaster Reduction on the basis of their financial losses suffered in the last decade due to natural disasters. Many developed countries suffer significant financial losses from natural disasters.

Another difference between developing and developed countries derives from the relative dominance of urban settlements. Urban settlements play a much more dominant role in developing countries and/or population increasing countries than in developed ones. Due to such dominant role in developing countries, the vulnerability of settlements translates into vulnerability of the country at large. Natural disasters hitting key urban settlements in developing countries tend to require time and investments into rebuilding the active daily life of the entire country (Management of Natural Disasters in the Eastern Mediterranean Region, 1998).

Consequently, although all urban settlements are prone to disaster risks, vulnerabilities vary in developing and developed countries, respectively. Thus, different approaches to risk mitigation are warranted to respond to the differences in vulnerabilities of developing and developed countries, respectively.

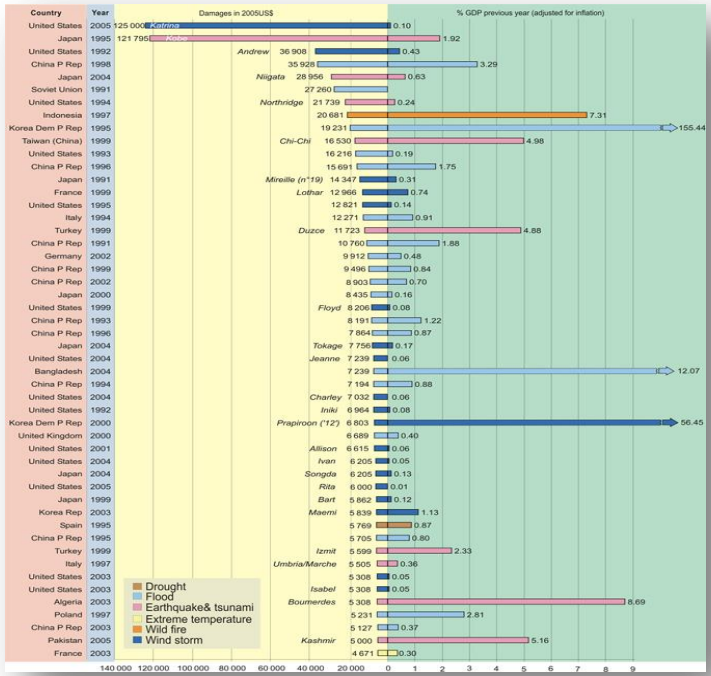


Figure 2: Economic Damages: Amount reported by natural disaster & country in the period of 1991-2005
Source: *ISDR,http://www.unisdr.org/eng/about_isdr/isdr-mission-objectives-eng.htm*

SCOPE OF THE MODEL

This model is aimed at maintaining physical resilience of urban settlements rather than strengthening social, political, administrative, etc. structures. However, since an urban settlement is a space in which multi-dimensional functions interact, other relevant issues such as political, administrative, economic, and social are also taken into consideration to support the physical resilience of urban settlements. The disaster resilience model is structured with a view to correlations between disaster mitigation stages and the procedure of spatial planning in various scales. The model has two main parts, namely risk factors of an urban settlement and elements of resilience (see fig. 3). As "Figure 3" shows, the parts of the model interact with a view to adapting to both the dynamic features of the urban settlement concerned and those of the natural disaster threatened the urban settlement.

The model is designed as a checklist of actions rather than as a detailed and comprehensive guidebook. This checklist of actions and recommendations can be easily modified to urban settlements of both developing and developed countries in light of specific priorities. The model is designed in a hierarchical structure from macro policies to implementation details through the headings set out below:

1. Risk Factors (of a Settlement)

a. Potential Impacts

For a certain urban settlement, the characteristics, magnitude, and range of the natural disasters as well as the type, frequency, occurrence time, and duration of disasters should be determined in light of recorded historical data. Although the proposed model aims at maintaining the physical resilience for urban settlements prone to natural disasters, this study concentrates on earthquakes. In the case of earthquakes, ground shaking, surface faulting, liquefaction, landslides, tectonic deformation are all features of natural hazards (Melching & Pilon, Eds.2006). In addition to these hazards, the potential impact of earthquakes cover environmental, technological, social, political, and infrastructure risks as well as economic risks (Munich Re Group, 2004). Thus, a multi-risk assessment study for an urban settlement should be prepared by considering each feature of "Potential Impact" and be enriched by long-, medium-, and short-term impact analyses.

b. Vulnerabilities

In light of the aforementioned potential impacts, a vulnerability analysis should be prepared with respect to each feature of an urban settlement, such as the site, ground survey, planning standards, population density, and economic profile of the settlement. In order to facilitate a vulnerability analysis for an urban settlement, the table of vulnerable physical elements is prepared as a checklist. The vulnerable physical elements of urban settlements are grouped at three scales in accordance with the scales in spatial planning. At the macro scale, vulnerable elements of an urban settlement are checked at the regional planning level. At the meso scale, vulnerable elements of an urban settlement are checked at the level of main urban functions such as transportation, residential area, and commerce. At the micro scale, vulnerable elements of an urban settlement are checked at the level of detailed urban features, such as architectural and design features of constructions, building codes, as well as daily habits and the life style of citizens. In this frame, the checklist provides guidance for measuring physical vulnerability of an urban settlement. At each level, useful questions are recommended to ask to the relevant authorities for assessing physical vulnerability.

c. Worst Case Scenarios

In order to be prepared for future natural disasters, the administrative body or disaster management authorities of the urban settlement concerned should prepare various alternative disaster management plans and programs based on possible scenarios of destructive natural disasters. Defining these scenarios should involve disaster experienced executives, technical experts, academics as well as members of other scientific institutions, representatives of search and rescue teams and relief organizations, NGOs, other public interest groups, as well as the media. The worst case scenarios should pave the way to answering key questions in case the scenario materializes namely, (i) what are major lessons learned? (ii) what are priority topics? (iii) what are challenges in terms of institutional, financial, organizational, administrative, and political capacities and capabilities? (iv) if possible, what are the results of a SWOT analysis in terms of local coping capacity? (v)what short-, medium-, and long-term solutions can be generated?

2. Elements of Resilience

a. Policy Level

At the policy level, urban policy-makers and governors, mayors, and relevant local administrative officers as well as agents of the central governments who are in charge of local development policies should design an effective disaster mitigation approach with a view to disaster resilience. Some main principles, policies, and strategies are proposed to guide disaster prone urban settlements on disaster resilience. The elements of the disaster resilience policies should be analyzed with a view to the question of ***"What makes the urban settlement disaster resilient?"*** The relevant policy instruments should be determined with a view to key questions, notably, **(i)** what particular features of a particular urban settlement imply risks and challenges for a disaster resilience policy? **(ii)** which elements of the coping capacity of the urban settlement are supportive of a disaster resilience policy? **(iii)** what long-, medium- and short-term approaches can be envisaged towards improving disaster resilience of the urban settlement? **(iv)** what processes and instruments are available in implementing disaster resilience policies? **(v)** what (potential) side-effects of disaster resilience policies and measures must be taken into account?

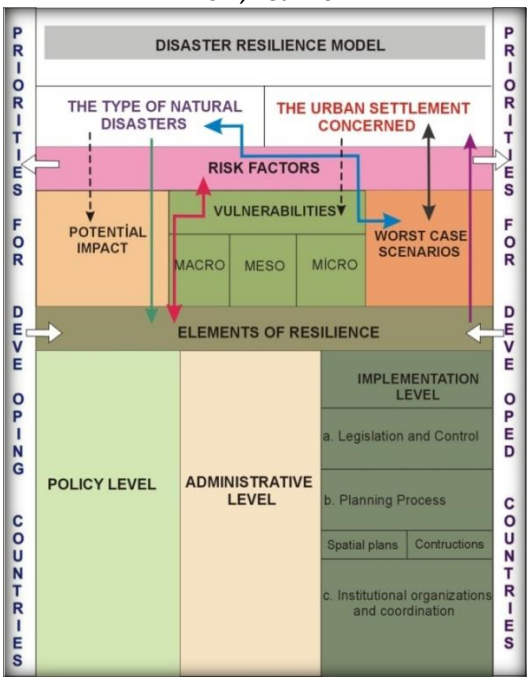


Figure 3: A disaster resilience model for an urban settlement
Source: *own source*

However, development trends and policies of countries may create further undesired results on and vulnerabilities of urban settlements. In this context, the vulnerability of urban settlements in developing countries should be evaluated on the basis of interactive relationships of intensity of disasters, environmental degradation, and side-effects of disaster resilience policies & activities. In developed countries, various approaches and methods are available with a view to protecting the environment such as policy instruments for sustainable urban settlements and the EU Strategic Environmental Impact Assessment Directive (SEA, 2001/42/EC; European Parliament & European Council, 2001). In general, policy designers and decision makers of the urban settlement should pay attention to adverse effects of disaster response and mitigation activities as well as general development policies and settlement strategies on urban environment and space. In this respect, the following questions will provide guidance to policy designers and decision makers of the urban settlement:

- What are the possible sources of environmental contamination and damages during the disaster response activities?
- What types of disaster response activities can give damage to the urban space in terms of disorder and distortion?

- What are the possible sources of environmental contamination and damages stemming from disaster mitigation activities?
- What types of disaster mitigation activities can give damage to the urban space in terms of disorder and distortion?
- What are the possible sources of environmental contamination and damages stemming from general development policies and strategies?
- What types of general development policies and strategies can give damage to the urban space in terms of disorder and distortion?

In the light of the above questions, the preparation of some key documents is strongly recommended to develop effective disaster resilience policies. These include a macro scale disaster mitigation map, a macro scale spatial policy document which outlines nation-wide policies and approaches towards mitigating the disasters, a local scale disaster mitigation map and spatial policy document with relevant local specifics. The aforementioned documents should be updated periodically. An effective and efficient resilient policy should be constituted with the participation and sharing knowledge of central government authorities, local authorities, NGOs and community-based organizations as well as private sector representatives, academic and research institutions, search and rescue teams, disaster assistance organizations, and media (ISDR, 2003).

b. Administrative Level

Effective disaster management requires a well-organized administrative structure as well as institutional organization and coordination. In case of problems and inefficiencies in the administrative structure, the following questions might help to find effective solutions:

- Is there any conflict or gap among the responsibilities of various institutions in terms of disaster mitigation, preparedness and response? If yes, the key criteria will provide guidance to the reorganization of tasks and responsibilities among institutions namely, historical background of an institution, field of experience, financial and technical capacity and capability, and institutional performance.
- Are responsibilities efficiently shared by relevant institutions?

c. Implementation Level

c-1. Legislation and Control

To sustain disaster resilient urban settlements, relevant spatial planning instruments should be supported by effective legislation, controlling mechanisms and processes as well as dynamics of institutional and public awareness. As regards effective legislation the following principles are recommended:

- A macro scale disaster omnibus act should exist.

- All disaster related-legislations of the country should be consistent with aforementioned omnibus act.
- Controlling mechanisms and processes should be defined and clarified in terms of implementation of the legislation.
- Controlling processes and measures towards should play integral roles in implementing a disaster resilience policy.
- Public and institutional awareness should be increased in support of disaster resilience policies.

Where existing legislation falls short of the above principles, remedial new legislation should be prepared.

c-2. Planning Process

Spatial plans provide an important basis of disaster resilient urban settlement. Multi-dimensional planning instruments and integrated processes of spatial planning towards disaster mitigation are crucial. Disaster mitigation techniques should be included in the preparation process of a spatial plan; more specifically, this process should include the preparation of i) analysis maps, ii) a synthesis map compiling data of analysis maps, and iii) a spatial plan based on the synthesis map. It is possible to incorporate disaster/earthquake mitigation techniques and approaches into the steps of spatial plan preparation process as follows:

- Preparation of a land-use map
- Preparation of various layers of analysis maps
- Preparation of vulnerability analysis maps
- Preparation of disaster/earthquakes risks maps
- Preparation of spatial plans at various scales.
- Preparation of a micro zoning map denoting e.g. safe zones, and prohibited zones.
- Preparation of a risk mitigation plan including an evacuation plan and an urban transformation action plan.

As integral parts of the spatial planning process, building plans and construction processes should also support earthquake resilience. In this respect, this model provides guidance to the actors involved in developing design and construction processes on the types of strategies and instruments useful to enhance earthquake resilience. The following strategies and instruments are highlighted with a view to earthquake resilience of buildings:

- ✓ Analysis of existing building stock in terms of resilience. Such analysis should be prepared with a view to different indicators related to buildings, such as function, construction style, building materials, height, and age (Meskouris et al, 2003). The analysis should also be prepared for other types of construction elements such as storage areas, terminals, bridges.

- ✓ Feasibility analyses of various alternative programs on reducing the loss in future earthquakes (FEMA, 2004); and
- ✓ Earthquake resilience action programs in cooperation with building insurance and building permit authorities.

c-3. Institutional Organization & Coordination

Effective institutional organization and coordination is crucial to ensuring disaster resilience. All disaster mitigation plans and programs need to be prepared in the pre-disaster period, and they need to be coordinated under one single authority. In this context, the following key questions are relevant to effective coordination:

- Is there an institution in charge of coordinating all disaster mitigation activities and programs in the urban settlement?
- If yes, does this institution work effectively?
- If not, what are the shortcomings of the existing coordinating institution?
- Is the existing institution able to overcome such shortcomings?

After clarifying the position of the coordinating institution, the dynamics of the institutional structure should be determined in terms of coordination and organization. In this study, the main elements of institutional coping capacity are defined in terms of (i) risk perception, (ii) institutional awareness, and (iii) organizational administrative, technical, financial structures and equipments. These elements should be elaborated at three levels, namely urban settlement, regional, national levels. The most suitable position for each institution or organization may be determined on the basis of SWOT analyses of each element and each level.

As already mentioned, though based on a standard checklist, the model will include the different approaches for developing countries and developed countries, respectively. These different approaches are defined in terms of different priorities of developing and developed countries with respect to key topics. Developing countries might assign priority to the following issues:

- ✓ Survival of citizens
- ✓ Provision of shelter, security, and some basic goods and services
- ✓ Organizing public campaigns and well-attended public training programs on self-survival techniques
- ✓ Considering limits regarding financial resources, strengthening of super- and infrastructure starting from the provision of essential services
- ✓ Prevention of environmental degradation & protection of natural resources

For developed countries, the following issues might merit priority status:

- ✓ Strengthening super- and infrastructure

- ✓ Introducing an effective disaster/earthquake insurance system for both buildings and infrastructure
- ✓ Designing an effective program and process to provide earthquake/disaster resilience in provision of main services and utilities
- ✓ Building and developing the capacity of airway transportation modes and vehicles for disaster response
- ✓ Enhancing civil initiatives and community based organizations with a view to increasing public awareness on disasters

The above priorities feature more prominently in the part on "Element of Resilience" than in the part on "Risk Factors" due to the definition of check list in terms of potential impacts and vulnerabilities. The model is meant to propose a flexible check list that can be modified for an urban settlement with different features in terms of geographic, demographic, administrative, and social characteristics. The variables used in the model and the checklist may be open to be updated in response to changing conditions of urban settlements over time. Thus, the model is amenable to reflecting periodical monitoring as well as data of scientific research with respect to individual settlements.

THE ROLE OF GEOGRAPHICAL INFORMATION TECHNOLOGY IN THE APPLICATION OF THE MODEL

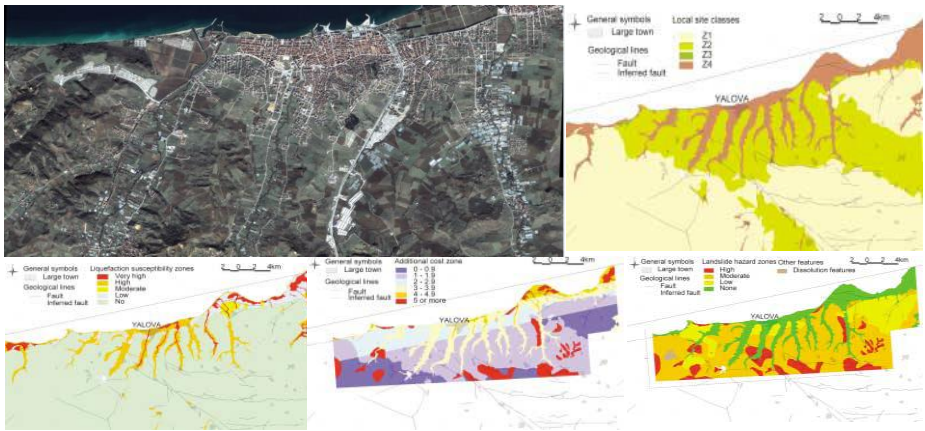
Geographical information (GI) technology encompasses the geographical information system (GIS) as well as remote sensing methods and tools of space technology. It provides opportunities to collect, analyze, store, manage, and integrate spatial and non-spatial data. Especially since the last decade of 20th century, GI technology has been used for disaster risk mitigation activities in urban settlements. It is also used in spatial planning and urban management projects as well as disaster mitigation activities. Some tools of GI technology facilitate data collection via existing land use maps, aerial photos and satellite images as well as data processing, preparation of statistical analyses and thematic maps. Such tools are especially useful for the development of spatial plans (Nieminen, 1996). Other GI technology tools are used for periodically monitoring and auditing planning standards and building codes in urban settlements. In addition to spatial planning, GI technology tools also play an important role in performing disaster risk mitigation activities such as preparing mitigation plans and contingency plans as well as developing of possible disaster scenarios (see fig.4).

Various tools of GI technology can be instrumental to the application of the aforementioned resilience model. In the frame of risk factors, some GIS tools can be crucial to performing hazard assessments by the means of

mapping the historical records of natural disaster damages. Disaster modeling tools of GIS are especially helpful in the process of disaster mitigation as well as in designing worst case scenarios.

More generally, various tools and methods of GI technology can facilitate data collection, spatial analysis, risk mitigation planning, and 3D imaging. The functional particularities of GIS such as data acquisition and integration, data accessibility, liability, and interoperability can create opportunities for improving risk assessments, disaster preparedness evaluations, and response activities. As regards the elements of resilience, recent developments of the GI technology can support smart decision-making in the disaster management process. In particular, the 3D image of an urban settlement can be drawn by means of DSM (Digital Surface Model), and DTM (Digital Terrain Model). This facilitates efforts in defining risky areas, micro-zoning, auditing compliance with building codes and planning standards. DTM and DSM can also play a pivotal role in assessing damages due to disasters (Greene, 2002).

After the 1999 Earthquakes in Yalova/TURKEY, the disaster risk maps were prepared by the application of GIS techniques on the sattelite images.



Source: *BECT, 2000*

The efficient use of GI technology requires spatial data infrastructure (SDI). SDI can be described as infrastructure enabling the interoperability among various stakeholders as well as to provide the easy and quick access to data and services for the users. Interoperability requires communication

and interaction among various systems having different hardware and software installations. Stakeholders can be grouped into data suppliers and users. Services of SDI are main procedures for process, analysis, and provision of spatial data (Ianucci et al., 2011). In this respect, central and local authorities will be responsible for generating and updating their own relevant data and services to apply the proposed disaster resilience model. The development of SDI can help upgrading performance in applying the model, especially for the parts of worst case scenarios and policy development.

The different approaches are recommended in the model to determine the main policies, strategies, and standards towards disaster resilience for developing countries on the one side and developed countries on the other. Moreover, SDI must be tailored to the particular features and dynamics of the urban settlement concerned (Salvemini, 2004). For that purpose, data, services, and stakeholders (users & producers) in the urban settlement concerned should be analyzed with respect to spatial dynamics, disaster risk profile, and existing information technology. In short, recourse to GIS and SDI can significantly enhance disaster resilience of urban settlements.

CONCLUSION

This article outlines a model for enhancing physical resilience of urban settlements with a focus on their particular vulnerability for natural disasters. The model seeks to provide guidance to developing concrete policies and action programs for urban settlements in light of their particular features and dynamics. For that purpose, key questions and recommendations are set out in a checklist format. These are inspired by the fifteen years of experience and observations of urban settlements prone to natural disasters. Special consideration is given to relevant fundamental differences between developed and developing countries, respectively. To reach effective results in the application of the resilience model GI technology plays a crucial role. While the model requires collecting, analyzing, storing, managing, integrating, and updating various data for a given urban settlement, the use of GI technology will facilitate the application of the model. Spatial data infrastructure will provide a significant support to the implementation of GI technology. To increase the performance of the model, the tailor made SDI is especially recommended.

REFERENCES

1. "*Management of Natural Disasters in the Eastern Mediterranean Region*", The Sis-Med II International Seminar,12-14 October 1998, Istanbul, the Turkish Ministry of Public Works & Settlement's Publications.
2. Burby, R. J., (ed.). *Cooperating with Nature-Confronting Natural Hazards with Land-Use Planning for Sustainable Communities*; Joseph Henry Press: Washington D.C., pp. 82-118, 167-198, 1998.
3. Domeisen, N & Palm, E.; *Rapid, Uncontrolled Urban Growth=More People in Hazardous Areas + More Disaster Risks*. Stop Disaster, 28, 1996.
4. FEMA, www.fema.gov/plan/prevent/earthquake/publications
5. Godschalk, D. R. et al., *Natural Hazard Mitigation-Recasting Disaster Policy and Planning*; Island Press, Washington D.C., pp. 36-37, 373-390, 1999.
6. Greene, R.W., (ed). *Confronting Catastrophe: A GIS Handbook*, ESRI Press: California, pp.2-26, 83-104, 2002.
7. *Hyogo Framework for Action 2005-2015*, www.unisdr.org
8. Ianucci, C., Salvemini, M., Vico, F., (eds). *Plan4all Project-Interoperability for Spatial Planning*, Plan4all Consortium, 2011, ISBN 9788890518324.
9. ISDR, *Disaster Reduction and Sustainable Development*, World Summit on Sustainable Development in 26 August-4 September 2002, Johannesburg, 2003.
10. ISDR,http://www.unisdr.org/eng/about_isdr/isdr-mission-objectives-eng.htm
11. Melching, C., Pilon, P. (eds). *Comprehensive Risk Assessment for Natural Hazards*, The World Meteorological Organization Press, 2006.
12. Meskouris, K., Kuhlmann, W., Mistler, M., *Seismic Vulnerability Assessment of Buildings by the EQ-FAST Software Module*, The Conference of Concrete Structures in Seismic Regions, Athens, 2003.
13. Munich Re Group, *Megacities-Megarisks: Trends and Challenges for Insurance and Risk Management*, Munich, 4-24, 2004.
14. Nieminen, J., VISP-*A New Methodology in Urban Planning*. Stop Disaster, 28, 1996.
15. Salvemini, M.,From *the GIS to the SDI: a design path*, in Proceedings of the 7th AGILE Conference, Heraklion, Greece, April 29 - May 1, 2004, pp. 41-42.
16. The British Earthquake Consortium for Turkey (BECT); *Yalova Province- Confidential Report*, Ankara, 2000.

17. UNDRO, *Disaster Prevention and Mitigation* (Vol:7), New York, 1979.
18. Velasquez, J., Uitto, J.I., Wisner, B., & Takahasi, S., *A New Approach to Disaster Mitigation and Planning in Megacities: The Pivotal Role of Social Vulnerability in Disaster Risk Management*, United Nations University Press, Tokyo, 161-184, 1999.
19. Wisner, B. et al., *At Risk*, Routhledge- 2nd edition, London, 2004.
20. *Yokohama Strategy and Plan of Action for a Safer World*, http://www.unisdr.org/eng/about_isdr/bd-yokohama-strat-eng.htm