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Full Length Research Paper

Urban seismic risk management: A methodology

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This research work presents a methodology for urban seismic risk reduction and illustrates the implementation to the methodology proposed to the site of Bab El Oued in Algiers (Algeria). The main goal is to reduce seismic urban risk at the site considered in Algiers. The seismic risk to which of more the urban centers are exposed became a world phenomenon. A significant element is the population. According to the last statistical data of the United Nations, the urban population is multiplied by twenty (20) times whereas the world population only by four (4) times. In the developed countries, 75% of the population lives in the cities, (concentration within the mégapoles: 20 amongst them exceeded the 10 million inhabitants). The main reasons of this attraction towards the city are misery, isolation of the rural areas and the movement towards the welfare of the city (Morand-Deville J., 2005). The beginning of the 21st century is marked by an acceleration of the major risks related to the natural hazards such as earthquakes. This constitutes the greatest challenge today for the scientists and the authorities. Lately the frequency of earthquakes occurrence, all over the world , challenge the decision makers and the scientific community towards a particular attention directed to the design, not only to the structures of the buildings but also to space planning and organization of the city with the aim of risk reduction. A co-operation on a worldwide scale is necessary for exchange of information and experience for the prevention and implementation of management plans and actions in the countries prone to this phenomenon. The seismic risk is as much crucial than it is necessary even of fundamental importance for the scientists to define which are the tools and the methods to provide for the various stakeholders in the act to conceive or to manage the city, namely the architects, the town planners, the developers, the engineers and the authorities in order to be able to insert the problems of the risk reduction in all the steps related to planning and city management. Seismic risk prevention constitutes an essential component of the operation of modern societies. The precondition to any prevention policy one needs is a clear-sighted examination and responsibility for all the actors concerned. This research work presents a new method for urban seismic risk reduction based on the application of an interdisciplinary work integrated in a dynamic and evolutionary process of the city planning when designing urban sites. This will clarify the aspect of prevention and management of the local risk, the vulnerability of the site and the use of the zoning, which is a dominating aspect in the risk reduction. This will encourage the decision makers and the local authorities as well as the civil society to have a local and permanent follow-up organization of the site (built, open spaces, lifelines, various networks etc.) and of a program for intervention such as simulations of an earthquake as a training tool of the population living in the territory at risk. The findings using this method are defining the safe shelter areas for the disaster victims and to redesign the road system for the access of relief, water and food supply, and a safe evacuation of wounded towards the health care establishments for a better risk management based on sound scientific research.

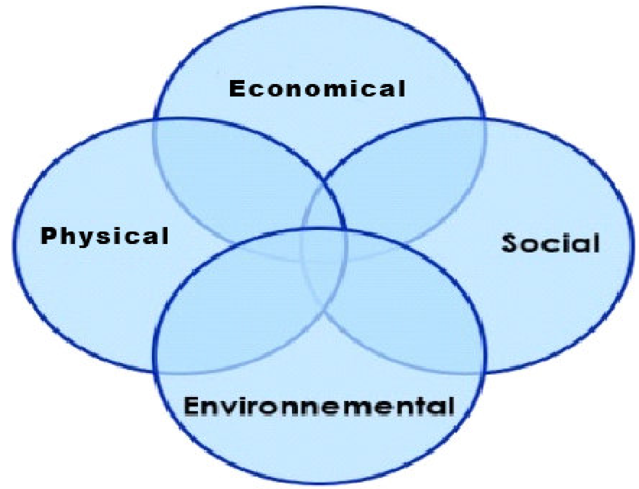
Key words: Risk, seismic, management, urban prevention planning, vulnerability.

INTRODUCTION

Earthquakes are one of the most destructive "natural" disasters compared to floods, cyclones or volcanic eruptions. Earthquakes with their unexpected occurrence, strike in a few seconds giving no chance to flee, which lead to a large destruction and many victims. We note for this reason that the most significant earthquake throughout the world occurred in large cities such as Lisbon (Portugal in 1755, 60 000 victims), San Francisco (USA in 1906, 3 000 victims), Tokyo (Japan in 1923, 141 720 victims), Agadir (Morocco in 1960, 12 000 victims), Tang Shen (China in 1976, 290 000 victims), El Asnam (Algeria, 1980) which made 3 000 victims and cost 7% of the GNP of Algeria; Mexico City (Mexico 1985) with 10 000 victims, Armenia in 1988 with 50 000 victims, Kobe in Japan in 1995 which made more than 6 000 dead and cost US$ 100 billion of damage (Revue Terra Nova, 2003), Taiwan in 1999 with 2000 victims, Turquie in 1999 with 16 000 victims, (Revue Science de la Terre et de l'environnement, 2009), Algiers (Algeria) in 2003 with 2 278 deaths, Sumatra (Indonesia) in 2004 with 250 000 victims (Revue cnrs-insu, 2004), Srinagar (Pakistan in 2005 with 83 000 victims), Sichouan (Chine in 2008 with 87 000 victims), and the last earthquake in the city of province de Qinghai (China in 2009) (Revue Sudpresse, 2009). The scope of the human life losses and the damage is thus very significant. Earthquakes cause a major handicap such as economic and social structure disorganization and destroy any development in the areas where they occur. In certain cases, a disaster can put in to question the whole process of development and wipe away years of efforts (Dossier HCCI / Croix Rouge française, 2006). It is thus important to undertake concise ideas of prevention before investing in development programs which could be reduced or altered by a catastrophe. The prevention of the seismic risk passes by the comprehension of the phenomenon itself and the inventory of the elements exposed to this risk and the capacity of each country to face or reduce the disaster effects. The seismic prevention studies lead to microzoning in order to locate the most vulnerable zones. Prevention measures prove to be non-existent for fabrics deteriorated by natural phenomena (rain, wind and earthquake) over the time, as well as the desertion, the negligence and lack of regular, adequate and effective maintenance may worsen the situation and thus increase the vulnerability. Both local authorities and civil society need a clear strategy for urban risk reduction including vulnerability evaluation, hazard assessment and risk estimation for a better risk management. Nowadays, the disaster scenario method is well used to simulate a disaster and train and prepare all the actors in charge of risk reduction as well as the population. This method allows the local authorities to implement certain preventive measures before the next disaster.

FACTORS AND CHARACTERISTICS

The First factor is the risk (PNUD, 2004). It is identified as a phenomenon which occurs and likely to make various damage and losses in human lives and which can be avoided or reduced if human activities like the arbitrary urbanization and the environmental pollution are avoided. It is characterized by the magnitude, intensity, frequency

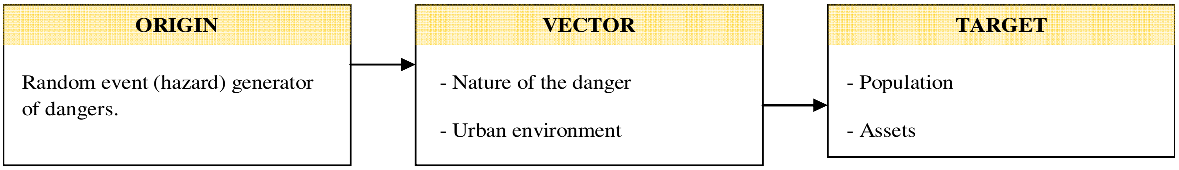


Flow chart 1. Various vulnerabilities, International Strategy for Disaster Reduction (UN-ISDR), Geneva, Switzerland, 2003.

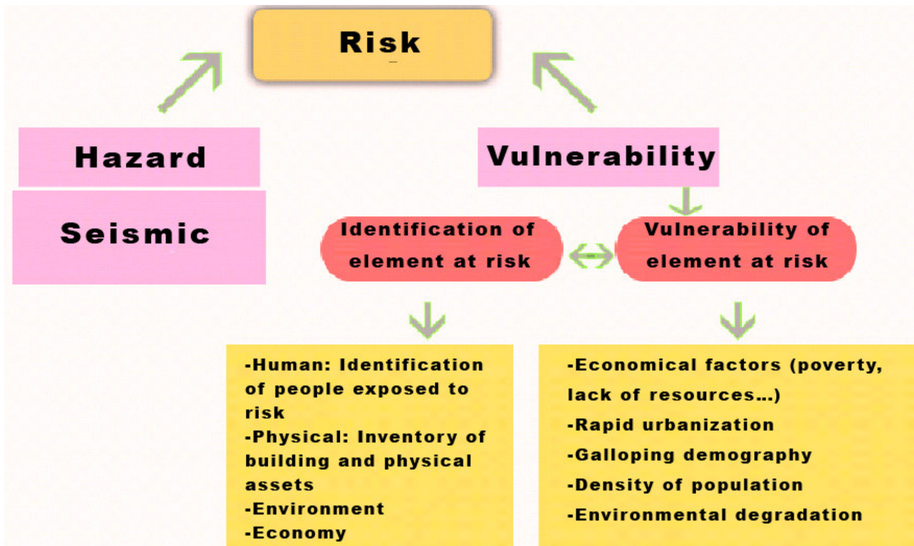
and return period. The risk is a neutral and natural phenomenon, neither good nor bad. However, in the presence of vulnerable stakes, it constitutes a threat. The upstream study of risk, in an area currently not built remains interesting in order to direct the future urbanization of potentially dangerous area. In fact, the same risk intensity at two different places does not cause the same effects. Researchers concluded that other factors were responsible for such situations like the methods of construction and preparedness of the population. The second factor is vulnerability (ISDR, 2002). It is identified like the whole of conditions or of process resulting from material, social, economic and environmental factors, which accentuate the sensitivity of the community to the impact of the risks. It is characterized by the following four types of vulnerability:

(1) Physical vulnerability; (2) Social vulnerability; (3) Environmental vulnerability and; (4) Economic vulnerability (Flow chart 1).

The vulnerability has three stages of progression (PNUD-DHU-UNDRO, 1992): first, subjacent causes (Group of factors, deeply rooted in society, which together produces and perpetuates the vulnerability). Secondly, acting forces (Process of drift which channels the effects of a negative cause in management of a dangerous situation, this process can be related to the lack of the fundamental services or due to a series of macro forces). Thirdly of perilous situations (vulnerable environment) in which the people and the assets are exposed to the risks of disasters. Yet a fragile physical environment is a vulnerable element and other factors such as an unstable economy and weak incomes and fifth components which are (Cannon, 2003), the well being, livelihoods and resilience, self-protection, social protection, the implication of civil society and institutions. The interest in this context is



Flow chart 2. Risk criteria.



Flow chart 3. Risk conception.

this context is related to the urban vulnerability, to understand the aspect of the vulnerability in urban environment. There are six contexts (SAVARIA M., 2005): Concentration, density and centralization (Population, authority, wealth, etc.); Complexity and the inter connectivity of many systems (Transport, water distribution, etc.); the informal settlements (economy, habitat etc.); Environmental degradation (air and water pollution, etc.); a built environment which must be periodically renovated (infrastructures, residences, etc.); Political and institutional vulnerability (corruption, bureaucracy, organized crime, etc.).

The vulnerability is a fundamental element for the determination of the effects of a catastrophe. It generally constitutes a certain degree of risk. It is present even in our daily life. The impact of a risk is to reveal it. For its evaluation, it requires a multidisciplinary research with the collaboration of engineers, architects, geologists, geographers, sociologists and the knowledge of the nature and the characteristics of the seismic risk.

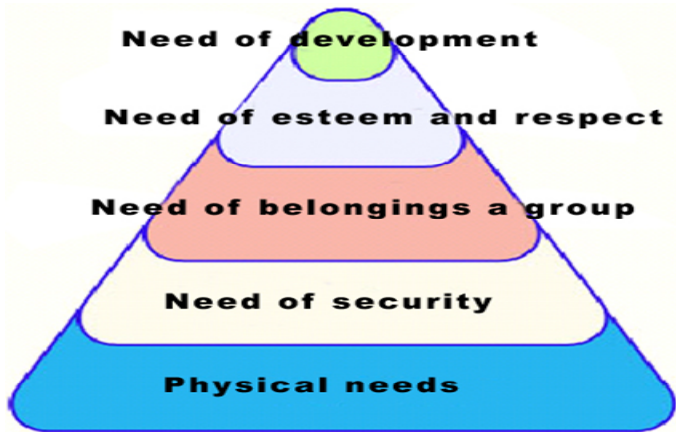
The evaluation of the social vulnerability is an international indicator (Rapport mondial, 2004), defined on the basis of Index of Risk Catastrophe (IRC), which led to the evaluation of the vulnerability as follows:

$$\text{Vulnérability} = \frac{\text{Number of deaths}}{\text{Number of exposed persons}}$$

The evaluation of the vulnerability requires the knowledge of well defined means to be used in a given situation and the know-how. Thus the mastering of this risk aspect seems to be essential for us in the future. We know that the "natural" catastrophes are a threat for our existence and because of their uncertainty, their prediction is often difficult. We can however take concrete measures to reduce it. Other factors concerned are, the stakes (Luttof, 2005) the people, the assets, the equipment, the inhe-ritance, environment, etc., suitable to be affected by a natural risk and to suffer prejudices or damage, and risks criteria, which are defined (Bourrelier et al., 2000) as the effects of a risk on vulnerable assets or people. Finally, one can say, the danger is a state, the risk its measure and its parameters are given (Flow chart 2).

The criteria enable us to appreciate the degree of the results expectation of the objectives. These are the reference marks that one selected which will be useful as a basis to our judgments. They specify until one waits on which aspect our judgment will be carried out (Revue CRES, 2004) (Flow chart 3).

The description of the concepts of risk and vulnerability makes it possible to expose the fact that the risk constitutes the result of the interaction of these two elements: Hazard and Vulnerability. That resulted in defining the risk as the combination of the probability of occurrence of a



Flow chart 4. Human needs -Pyramid of Maslow, C. Paulus; (Pyramide de Maslow , doc. Quesoco, France, 2007).

hazard and consequences being able to result from it on the elements vulnerable from a given environment (Revue Sécurité Publique, 2009).

By risk one understands generally a dubious or unforeseeable event being able to destabilize the well being of a community by the loss of human lives and damage to property.

The Risk is the result of a convolution of hazard and vulnerability as mentioned as follows:

Risk = Hazard * Vulnerability

THE SEISMIC RISK

The seismic risk is defined as: "the probability of an event which occurs and could cause damage", and is due to the phenomenon of a rapid break (Commissariat général du plan, 1997) of the earth's crust, which yields suddenly, after having accumulated significant constraints accumulating for centuries, even of the millennia.

There are three types of earthquakes according to their depth, (Distribution globale des séismes, 2006): *Superficial earthquakes with less than 60 km;* Intermediate earthquakes from 60 to 300 km;* Deep earthquakes from 300 - 700 km, (there is not more beyond). It should be noted that 95% of the earthquakes in the world take place with a depth lower than 60 km and only 5% have a depth higher than 60 km. (PNUD, 1991).

The energy released at the time of an earthquake may reach, to even exceed for the catastrophic events, a power of ten million times stronger than the bomb thrown on Hiroshima in 1945 (Revue Prim Net, 2006).

Risk management

The need for safety belongs to the fundamental needs of human being, and the satisfaction of this need ensures us a blooming and social equilibrium. In the pyramid of MASLOW Abraham (1908 - 1970), American psychologist established a hierarchical representation of human being needs. One notices that the need for safety succeeds immediately the physiological needs (Flow chart 4).

The risk identification constitutes a fundamental phase in its management; it generally depends on the availability of the information which influences considerably the way in which the people, the communities, administrations, and the organizations perceive the risk (awareness, knowledge, prevention, understanding, preparedness, response, etc.). It is commonly widespread that the populations are more vulnerable when they are not conscious of the dangers and that they did not prepare to face them.

To protect a city against the seismic phenomenon; one tries initially to understand and know the situation which may occur after the occurrence of an earthquake (disaster scenario), which brings us to raise the following questions (Belazougui M. et al., 2003):

1 - What will be the aspect of the city after a destructive earthquake?
2 - How to face the catastrophe?
3 - How to organize the helps?
4 - Can one limit the losses?
5 - What should one do?

The disaster scenario will allow the local authorities and the civil society to perceive with a certain degree of reliability the risk they are facing and thus should prepare the human and material resources to confront the next disaster. Figure 1 illustrates perfectly what should be done before, during and after the event (Table 1).

Flow chart 5 shows the space analysis and the set up of communication systems for the evaluation of the vulnerability of territories and cities confronted to natural risks. It also illustrates an integrated disaster management organization to cope with disaster risk reduction in a territory. It summarizes all the activities to be conducted before, during and after the event. The participants in management are:

*The State; *Local authority; *Civil protection; *Health service; *the urban police; *Insurances; *Population; *the Army.

THE URBANIZATION POLICY AND NORMS FOR THE SEISMIC RISK REDUCTION

The urbanization does necessarily not lead to an increase in the risk of catastrophe if it is managed correctly and will contribute to its reduction. The evaluation of the vulnerability could be achieved by making scenarios with probable earthquake which could strike for example a city and its surroundings. The authorities of the

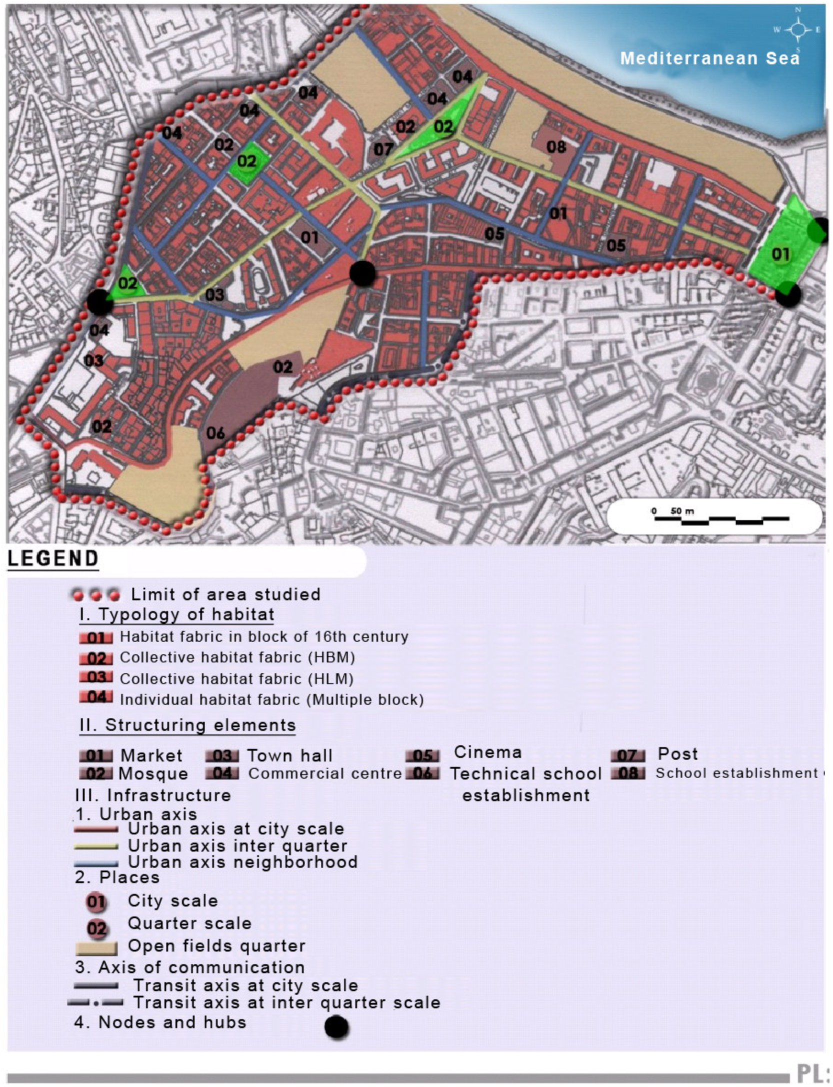


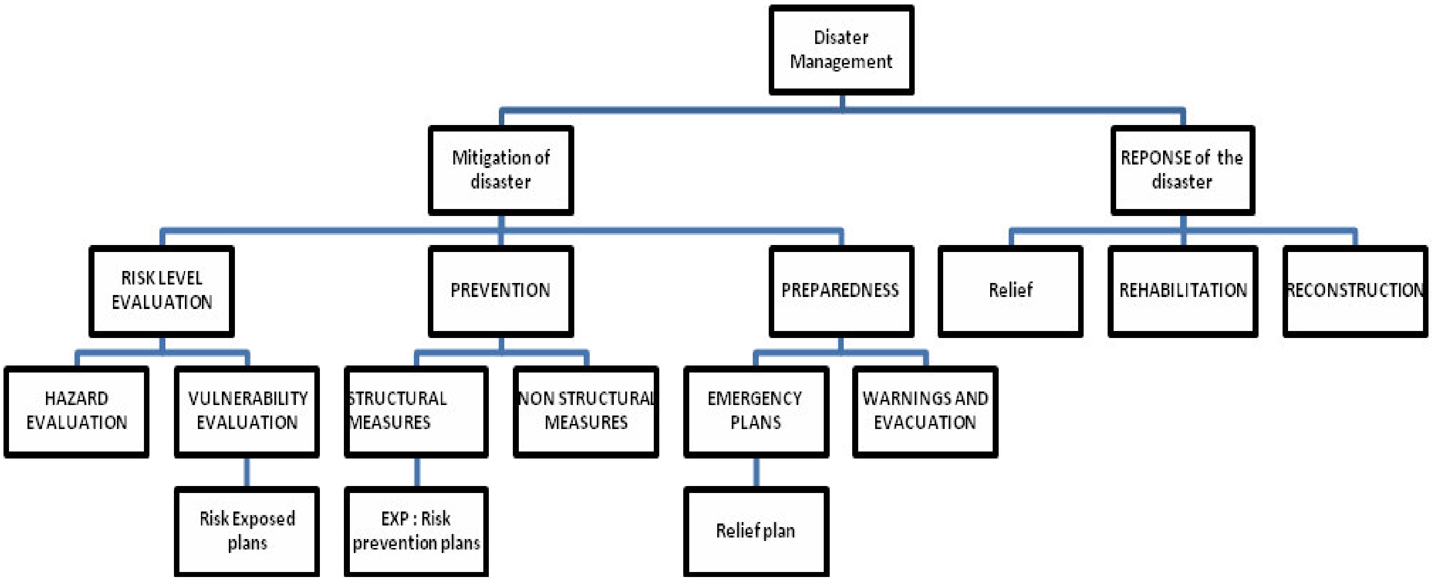
Figure 1. Illustration of an example of a functional analysis of the site.

Table 1. Various stages concerning the risk management: Program United Nations for development (UNDP), 2004.

Before	Prevention by generalizing the vulnerability evaluation and the implementation of preventive actions of seismic risk reduction; The resources.
During	The launch of emergency plan with all the concerned local authorities (ORSEC)
After	The displacement of the disaster victims (population) in provisional adequate places; The clearing of the places of the disaster; The rehabilitation and reconstruction.

city will thus have elements which will enable them to know and to estimate the losses in advance, with an acceptable margin of error, and to take the necessary measures. According to the Deputy Secretary-General of the World Meteorological Organization, "a dollar invested in prevention saves from 10 - 100 dollars in cost of rehabilitation after a " the natural "catastrophe (Dossier HCCI HCCI/ Croix Rouge française, 2006). The urban growth and the fast urbanization increase the seismic vulnerability. For an acceptable seismic risk reduction solution it is essential to integrate parameters like solidarity, the constraints, the resources, the acceptable sacrifices on behalf of the common interest (LGIT, 2006). The various influential factors, aspects and characteristics on the seismic risk are:

-Geophysics and the topography of the territory;
-Characteristics of the population (demographic structure);



Flow chart 5. Hierarchy actions MANCHE Yannick (Université J-F. Grenoble I, Oct. 2000).

- The urban structure (structure and morphology);
- Characteristics of the technical infrastructure;
- Principles and normative bases of planned space;
- The architecture and construction parameters control;
- Mode of organization of the urban process;
- Planning and installation;
- The microzoning;
-Density of the population; the structure of the population;
- The constraints (general rules of town planning related to the public and private domains);
- Technical infrastructures (essential networks);
- Architectural forms.

The main specialists for a better control of this natural phenomenon (earthquake) are those of town planning, architecture, civil engineering, seismology, geography, economy, health (Psychology, traumatism, etc.), various road systems and networks, as well as other essential elements such as the civil protection, which works in close cooperation with the quoted experts.

URBAN PLANNING AND RISK REDUCTION

The specific role of the urbanization in space planned is the action developed in the area of contact between the expertise and the operational level on the process of urban seismic risk management. The urban measures of the local level (urban) are directed towards the long term in the political field of the seismic risk management. They cover the measures of prevention before the occurrence of the earthquake and help the operational actions after the earthquake by the following aspects:

The reduction of the seismic risk passes by the introduction and a minimum compliance with the rules concerning the density, the heights of constructions and the distance between the buildings.
-To ensure the access to all the parties of the urban structure to immediately intervene after the disaster.
-To ensure the organization of space to shelter the affect-ted population temporarily and to carry a medical help urgently.

One meets two types of urban situation:

- The construction of new urban structure;
- The restoration of existing urban structure.

The problem of planning and urban research:

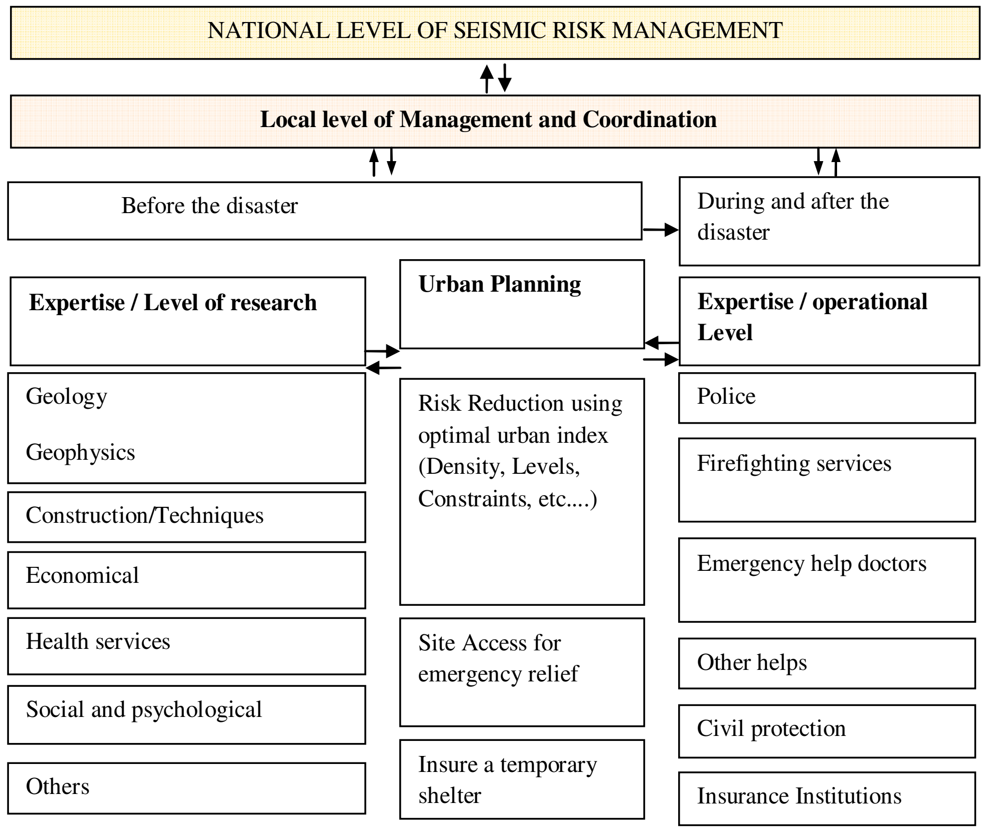
-Compulsory introduction of urban parameters recomm-endations.
- The proposal for an intervention with a view of vulnera-bility reduction of the urban structure (Flow chart 6).

METHODOLOGY

Case study of site of Bab El Oued - Algiers - Algeria

This site has undergone in the past natural disasters, such as the floods of the 10/11/2001, which made several victims and property damages. More recently the Algiers earthquake of the 21 of May 2003 caused many victims and severe damage to the built environ-ment. Before any analytical reading of an urban site, one must begin with a historical reading; where time is important and enables us to understand the process of formation and transformation of the elements having played a significant role in the structure of the site. It is also necessary to understand the urban organization system of the site of Bab El Oued, to identify its deficiencies likely to restore the balance of the system and to put forth assumptions and recommendations in order to provide for thereafter prevention and an earthquake risk management of the site.

The methodology of the work to be adopted relating to this



Flow chart 6. Specification and role of urban planning.

Table 2. National Office of the Statistics (ONS), statistical data (RGPH 98) of the site of Bab El Oued (Algiers - Algeria), Oct. 1999.

Bab El Oued site	Total area (ha)	Number of housing units	Population RGPH 98	Residence density (ha)	Inhabitant density (ha)
Total	117,25	14 026	87 557	120	747

objective is of better describe the complexity of the urban landscape of Bab El Oued. Particular interest to elements considered as invariants, applicable to any site. The perimeter of study will be analyzed under its double aspects: structural andfunctional (Table 2).

The perimeter of study is 3 km and the surface is 33 ha.

Urban site analysis

The various analyses of the perimeter are carried out as follows:

- The situation of the built environment;
- Density;
- Heights of constructions;
- Activities;
- The legal statute;
- Normative reading;
- Typology of construction;
- The current structure.

The execution of the urban analysis of the site enables us to raise the problems inherent in the space studied such as:

- Circulation (mechanical and pedestrian);
- Car parks;
- Parks and relaxations;
- Industrial activities;
- The old built environment;
- Density of the population;
- The relation between the district and the sea (littoral);
- The refitting of the littoral;
- The functional structure.
- The service roads;
- The population needs Infrastructures (commercial, cultural, sport infrastructures).

Experimental implementation (site of Bab El Oued, Algiers - Algeria)

The method suggested is a visual official report on the various areas affected by earthquakes which I visited; it is worth noting that the victim population fled the disaster space on a distance no more than 120 - 300 m to shelter in an open space. This method is based on the principle of distance, by the creation of regrouping area, which are actually areas arranged in parks of relaxation with an

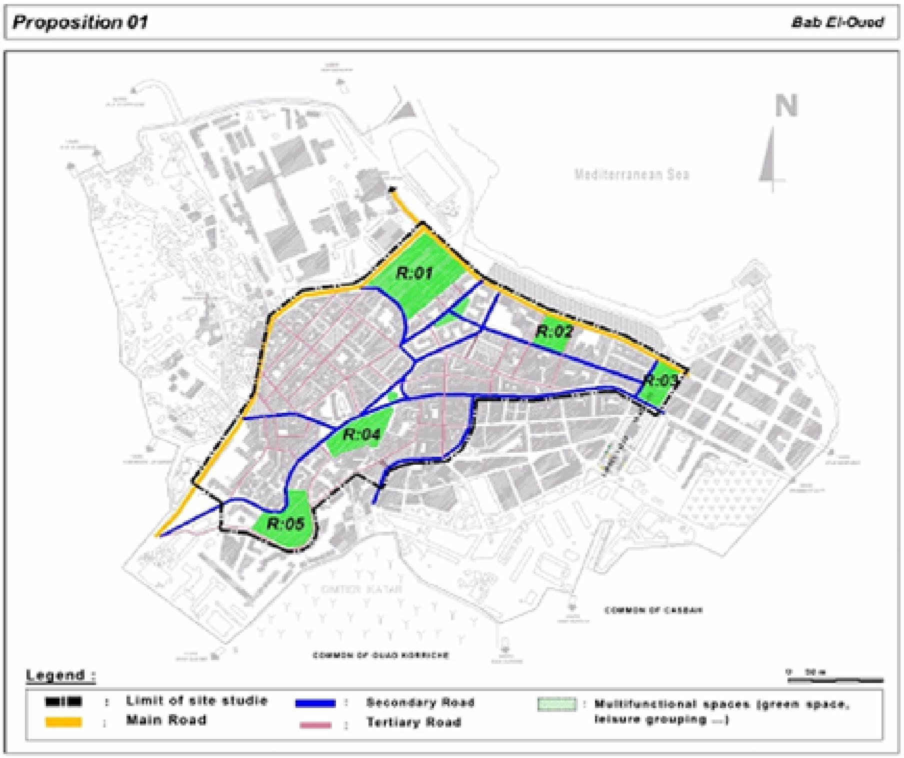


Figure 2. Site of the regrouping places.

Table 3. Regrouping spaces.

Space	Surface (ha)	Perimeter (m)
R : 01	1.90	578
R : 02	0.43	263
R : 03	0.44	273
R : 04	0.74	401
R : 05	0.95	430

Table 4. Effective regrouping sites.

Distance between	two regrouping spaces (m)
R1 – R2	324
R2 – R3	251
R1 – R4	380
R4 – R5	248

adequate urban site. These spaces will have all the conveniences (tents, medical, health service, etc.) to receive the disaster victims in the event of an earthquake.

To be effective, this method requires open spaces. The old and unused buildings should be destroyed and the safety ways dimensioned so that the access system will fully play its role (examples: access of relief, drinking water and food supply). The effectiveness or the advantage of this method is that each regrouping entity is specific to an area and at the time of a destructive earthquake, it must receive the population nearest in a distance from de 120 m to 300 m in temporary shelters.

PRESENTATION OF THE FINDINGS

The findings of this research work are presented in Figures 2 - 7. Figure 2 shows the regrouping spaces reserved for the various part of the city considered. These regrouping places are determined according to the density of the population in the blocks considered.

Table 3 shows the details of areas and perimeters of the sites allowed for sheltering the victims. The determination of the area and perimeter of each shelter site is determined according the density of the population and the building stock is presented in Table 3.

Table 4 illustrates the results in terms of distances between regrouping sites.

Consequently the effective regrouping radius:

$$\Sigma(323 + 250 + 380 + 248)/4 = 300 \text{ m}.$$

Table 5 illustrates the general summary of the population and the buildings to be evacuated.

With this intention the following data was taken into account:

Table 5. Population, buildings and residences to be evacuated.

Proposition	Buildings	residences	Population (persons)
	40	480	1920

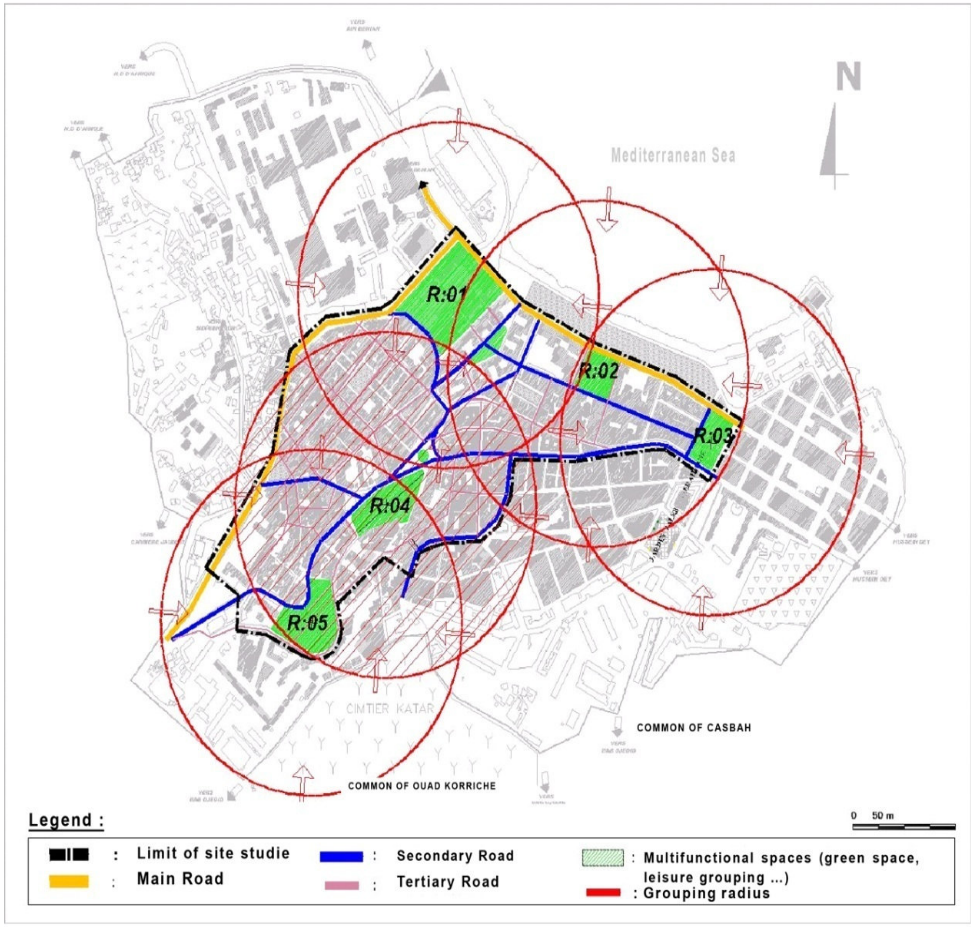


Figure 3. Illustrates the space allocated to each part of the city according to the principle of the distance R of 120 - 300 m for the establishment of regrouping sites and roadway systems.

-The average of the building levels: 06 (the buildings on the site have are of 4 - 16 levels

-The average of the inhabitants by housing: 04 (the inhabitants are

estimated from 3 - 8 people).

-The provisional surface for re-housing a family (4 people) in the regrouping places of is 15 m^2 (tents of 3 ×5 m).

- Creation of regrouping place of an existing parks or the site of the buildings to be destroyed according to the plan of the municipality. (Figures 3 and 4).

- Proposal for principal, tertiary and primary access roads (re-dimensioning of the roadway system).

Figures 5, 6 and 7 illustrate the proposal for principal, tertiary and primary access roads (re-dimensioning of the roadway system for the city of Bab El Oued.

CONCLUSIONS AND RECOMMENDATIONS

Decision-makers need adequate integrated information on the likely (probabilities) intensity of the disaster the city will face if they are to reduce disaster vulnerability. This research shows the need of an integrated disaster risk management in mega cities.

In a country which, regrettably, is a disaster-prone as Algeria or in other country, it is of crucial importance, at all the levels, for the country to have a well established and well regulated disaster management plan. This will enable the government at all levels to avoid undue crisis management when future emergencies occur. It is also of crucial importance, again at the all levels, to integrate disaster management in all its facets with government's

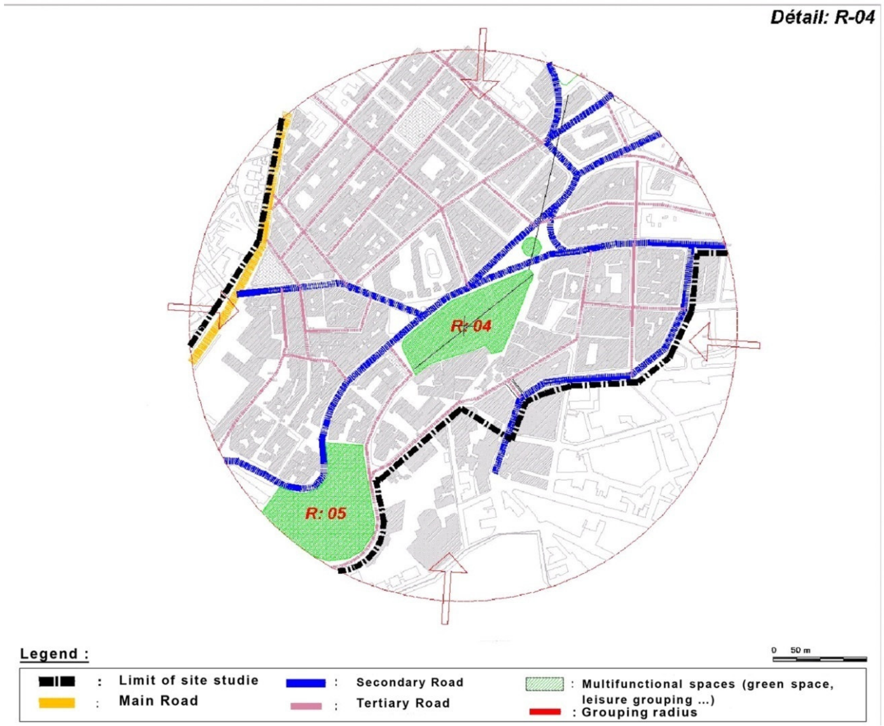


Figure 4. Shows the details of the influence of the occupation for a distance of radius R between 120 and 300 m.

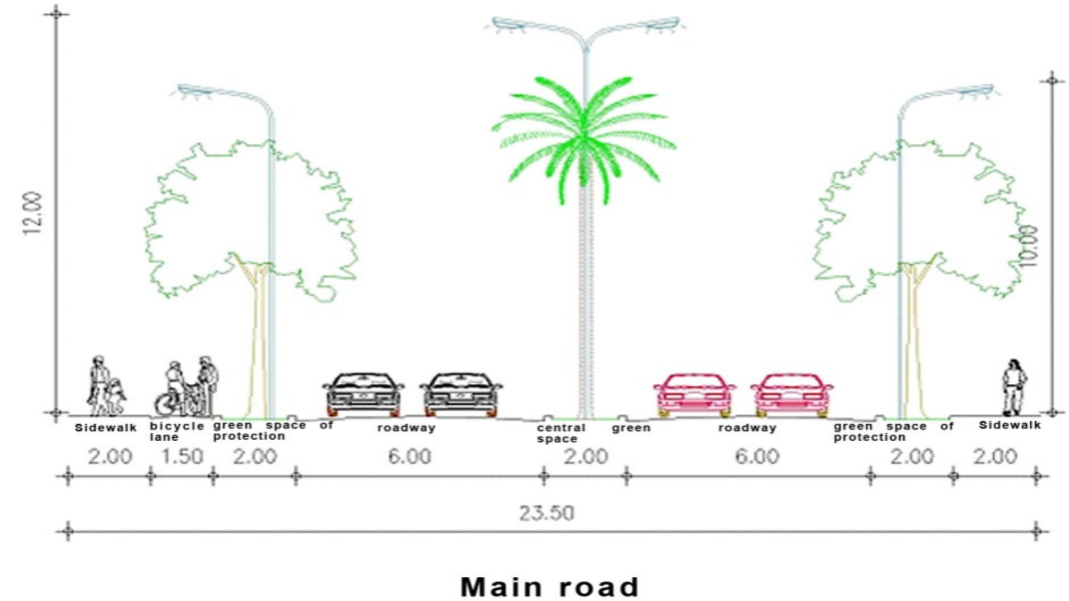


Figure 5. Illustrates the proposal for main road.

mainstream policies and plans for local, regional and national development.

To fulfill these goals, the proposal of the establishment of a local commission for disaster management has two objectives (1) to prepare the local disaster management plan and; (2) to create a sustainable cadre of disaster

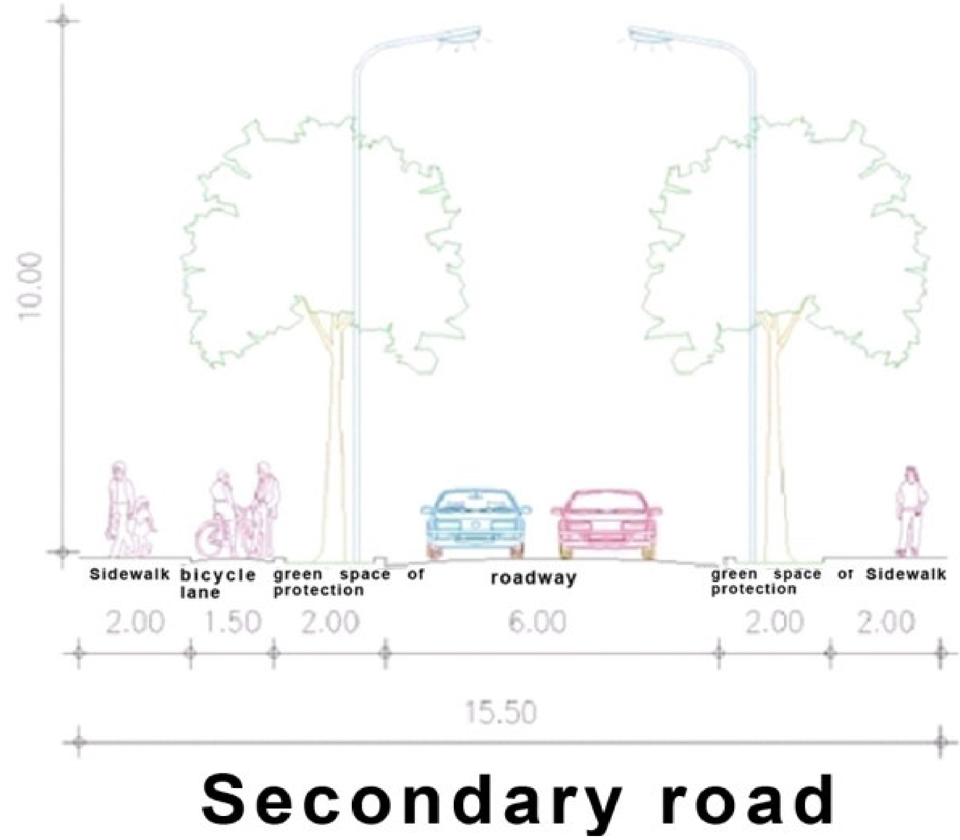


Figure 6. Illustrates proposal for secondary road.

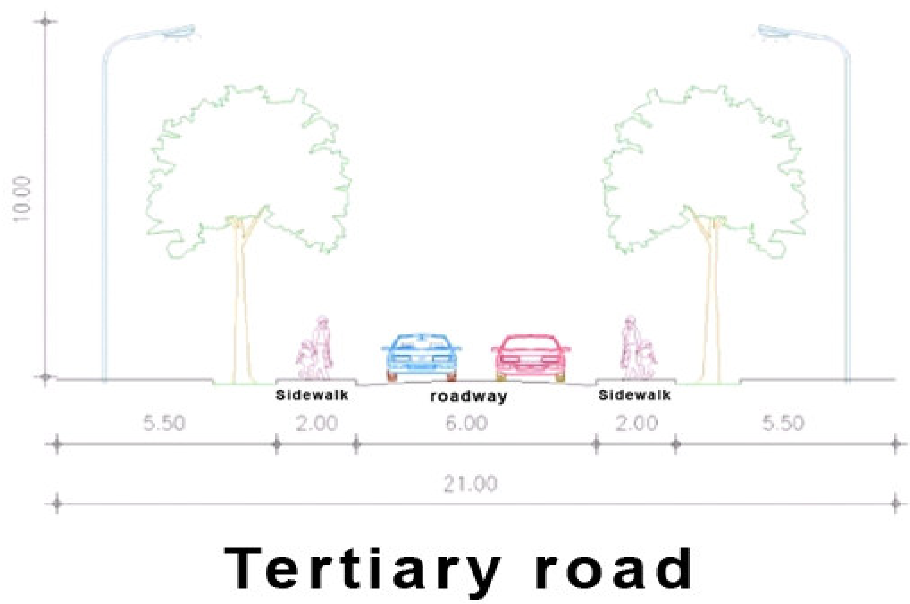
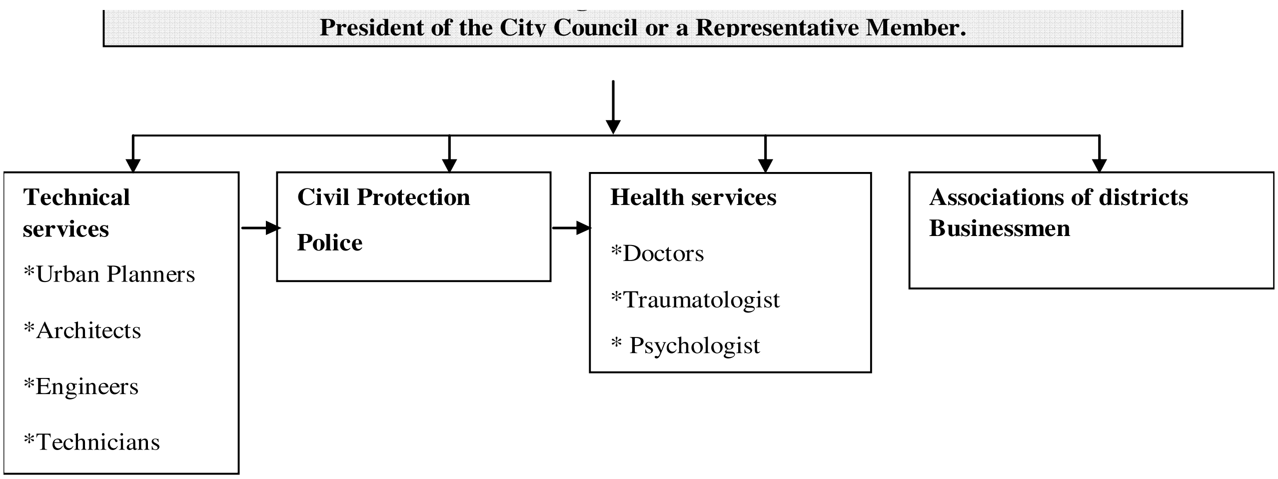


Figure 7. Illustrates proposal for tertiary road.

management staff at the local level, and to promote public awareness of disasters, their effects and likely relief activities. The need of permanently established local, as well as national, disaster management organization



Flow chart 7. Proposal of commission in charge of the prevention and seismic risk management.

zation is a must today. The organization chart describes the structure, the chain of control and reporting, and the main working relationships (Chart 7). It allows having a permanently established and functioning integrated data collection system to gather information relevant to disaster management in all its aspects. The structure of the commission will then incorporate existing government, non-government and community information/data sources in order to provide an overall picture of potential danger zones, multi- sectoral early warning indicators and available resources. This enables particular attention to be paid to problem geographic sectors or problem functions, and the consequent mobilization and allocation of resources in advance of disasters. A proposed permanent commission for disaster risk reduction management integrated in the local authority structure is presented in Chart 7. This commission has the role of evaluating, proposing, according to an established annual program, all the elements of the urban structure of the site (states of the built environment, inheritance, technical infrastructures, etc). It has also the role to prepare and carry out at least one simulation of a catastrophe scenario per year with the participation of all the stakeholders of the municipal-lity. The decisions adopted by the commission must be imperatively consigned in the register of prevention and of seismic risk management and a written report must be transmitted for information and coordination with the hierarchy. At each end of day, for one given period a meeting of all the actors to estimate, to evaluate, and to coordinate various aspects of the situation of the disaster on the municipality level.

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