On the Role of Quality Management in Earthquake Disaster Risk Reduction

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ABSTRACT

Considering the "Risk" as the product of "Hazard" and "Vulnerability", it is obvious that "Risk Reduction" requires the reduction of either hazard or vulnerability. Both of these reductions need qualified management in order to be successful, particularly vulnerability reduction, which deals with issues such as - in the case of "Building Industry" - the quality of architectural and structural design, the quality of construction materials and workmanship, the quality of technical inspections, and so on. This paper tries to explain the role of "Quality Management" in various aspects of "Disaster Risk Reduction" with special emphasis on the quality management in "Disaster Education". The paper tries, at first, to explain the "Disaster Risk Reduction" requirements, and present some simple mathematical formulas for relating the contributing concepts. Secondly, it discusses the methods by which quality management can be performed in any disaster risk reduction program. Finally, the paper addresses to some extent the quality management in "disaster education" as one of the most important aspect of disaster risk reduction.

1. Introduction

Disasters are the result of extensive damage to buildings and facilities in rural or urban areas, subjected to some natural or man-made hazard, which leads to the interruption of systems' operation or services. It is obvious that the damageability or vulnerability of a system, such as a building, subjected to a hazardous event, like an earthquake, is the direct result of some weakness or deficiency in the system. Deficiency itself is the result of low quality in either phases of production and operation, including planning, design, construction (manufacturing), and maintenance. On the other hand, "Quality Management" (QM) is the method for ensuring that all the activities necessary to design, develop and implement a product or service are effective and efficient with respect to the system and its performance. On this basis, it can be evident that to what extent the QM can affect the vulnerability of man-made systems or services.

Some 75 percent of the world's population live in areas affected at least once by earthquakes, tropical cyclones, floods or droughts between 1980 and 2000. The consequences of such widespread exposure to natural hazards for human development are only now beginning to be identified. Natural disaster risk is intimately connected to processes of human development. Disasters put development at risk. At the same time, the development choices made by the individuals, communities and nations can generate new disaster risk. But, this does not always need to be the case. Human development can also contribute to a remarkable reduction in disaster risk. The fact is that while only 11 percent of the people exposed to natural hazards live in countries classified as low human development, which account for more than 53 percent of total recorded deaths. This implicitly shows the role of management in general and QM in particular in distinction between developed and under-developed countries. There are also samples, which prove that disaster risk is not inevitable, as in fact, good practice in disaster risk reduction can be built into ongoing development planning policy (UNDP 2004).

Sustainable development has been and still is the main goal of all developed and especially developing countries in the world. Development can not be sustainable if the effects of natural and man-made hazards are not taken into account. To consider these effects, it is necessary to apply the "Risk Management" programs, and this application needs a highly qualified management to be successful. In fact, hazards and their consequent disasters can erode and in some cases outweigh the development gains. Therefore, it is necessary to include the "Disaster Risk Management Programs" in every development program, particularly in developing countries. This is even more important in countries such as Iran, which is ranked among the 10 tops of the highly disaster-prone countries. In fact, Iran is the sixth-most disaster-prone countries in the world (UNDP 2004). Iran is located in one of the most seismically active areas of the world. Losses due to hydro-meteorological hazards such as drought, floods, and landslides are also severe. Three consecutive years of drought have reduced the agricultural land, rangeland, and forests, and have resulted in a shortage of drinking water in many urban and rural areas. Uncontrolled urbanization has also increased vulnerability to disasters.

As noted, one of the main reasons behind the high rate of disasters and their victims, particularly in un-developed and developing countries, is some weakness in quality due to the lack of QM. This paper tries to firstly explain that "Disaster Risk Reduction" requires the reduction of either hazard or vulnerability, and secondly to discuss the fact that both of these reductions, particularly the vulnerability reduction, need qualified management to be successful. In the following sections of the paper, at first some basic concepts in disaster risk management are explained, followed by some simple mathematical formulas for relating the explained concepts together as well as to the management, and then the role of the QM in risk reduction and the requirements for its application and the methods by which it can be performed, are explained. Finally, QM in “disaster education” as one of the most important aspect of disaster risk reduction is discussed in detail to show, as a sample, the application of QM in disaster risk reduction.

2. Fundamental Concepts in Disaster Risk Management

There are some fundamental concepts usually used in “disaster risk management”, which can be defined by some revision, as follows (Hosseini 2004):

- **The Existing Risk Level:** is the level of risk if no risk “reduction measure” is employed in the corresponding community.
- **The Reduced Risk Level:** is the level of risk after applying the “risk reduction measures” in the corresponding community.
- **The Existing Hazard Level**: is the level of hazard in an area if no hazard “reduction measure” is employed in the corresponding area.
- **The Reduced Hazard Level**: is the level of hazard in an area after applying the “hazard reduction measures” in the corresponding area.
- **The Existing Vulnerability Level**: is the level of vulnerability of properties (buildings and infrastructures) if no vulnerability “reduction measure” is employed in the corresponding community.
- **The Reduced Vulnerability Level**: is the level of vulnerability of properties (buildings and infrastructures) after applying the “vulnerability reduction measures” in the corresponding community.
- **Reduction Measure**: is every action, practice, or service which results in reducing the level of hazard, vulnerability, or risk in a community or any part of that community provided that the “reduction potential” does exist for that purpose.
- **Reduction Potential**: is the possibility level of reducing the amount or the probability of any specific hazard or vulnerability level in an area or in a community.
- **Reduction Index**: is an index obtained as the product of the “reduction potential” and the “reduction enforcement level” which can be achieved by the implementation of “risk management” in the community.
- **Reduction Execution Level**: is the amount of implementation of the possible measures in reducing the level of hazard, vulnerability, or risk, and can be defined as the ratio of "the utilized or active capacity" to "the existing capacity".
- **Risk Index**: can be any index stating the level of risk, either existing or reduced, in the context of population, properties, Gross Domestic Production (GDP), economic growth rate and so on.

By using the above concepts, some basic relationships can be considered between them which are explained in the following section.

3. The Basic Relationships

There is a basic logical relationships between the aforementioned concepts used in the risk management field (Dowrick 1987).

$$R = H \times V \tag{1}$$

Based on Eq. (1) it is evident that in order to reduce the Risk (*R*), it is necessary to reduce either Hazard (*H*) or Vulnerability (*V*). Clearly, these reductions need management. Some scholars have considered the effect of management in risk reduction by using the following formula:

$$R = \frac{H \times V}{M} \tag{2}$$

As it can be seen in Eq. (2), the management has been contributed to the risk formula in the denominator to show the effect of management in risk reduction, i.e. better management leads to more reduction in risk, however, Eq. (2) has a mathematical shortcoming, that is in the case of no management, *M* will be 0, which mathematically means that the risk value will be infinity. In order to overcome this problem, it is suggested that Eq. (1) is used in two various states, "Existing Risk" and "Reduced Risk". In fact, in Eq. (1) *R* can represent the existing risk, R_e, which threats the community, if it does not employ any "Risk Management Program", or the reduced risk, R_r, which threats the community after the employment of the "Risk Management Program". Apparently, if "Risk Reduction Measures" are implemented in the community, the risk can be reduced to some extent, depending on how those measures are implemented. On this basis, the reduced risk, R_r, can be expressed as:

$$R_r = R_e (1 - I_{Rr}) \tag{3}$$

in which I_{Rr} is the "Risk Reduction Index", whose value can vary between 0 and 1. As described earlier, management is a key factor in order to achieve R_r. In fact, good management is a prerequisite to move from the state of $R_r=R_e$ (no risk reduction) to $R_r=0$ (perfect risk reduction). Hence, in the case of "no management" $I_{Rr}= 0$, and in the "ideal case", $I_{Rr}=1$. Similarly, the following equations can be written for relations between "The Reduced Hazard Level" and "The Existing Hazard Level", and also "The Reduced Vulnerability Level" and "The Existing Vulnerability Level":

$$H_r = H_e (1 - I_{Hr}) \tag{4}$$

$$V_r = V_e (1 - I_{Vr}) \tag{5}$$

where I_{Hr} and I_{Vr} are respectively, the "Hazard Reduction Index" and the "Vulnerability Reduction Index" obtained as the product of the "Reduction Potential" and the "Reduction Enforcement Level" or "Reduction Execution Level" in the community, namely:

$$I_{Hr} = P_{Hr} \times E_{Hr} \quad (6)$$

$$I_{Vr} = P_{Vr} \times E_{Vr} \quad (7)$$

In Eq. (6), P_{Hr} and E_{Hr} are respectively, the "Existing Hazard Reduction Potential" and the "Hazard Reduction Execution or Implementation Level", and similarly in Eq. (7), P_{Vr} and E_{Vr} are respectively, the "Vulnerability Reduction Potential" and the "Vulnerability Reduction Execution or Implementation Level" in the community. The concepts of "hazard reduction potential" and "vulnerability reduction potential", whose values are between *0* and *1*, are considered here to acknowledge the fact that in many cases, it is not possible to actually reduce the hazard or the vulnerability. For example, in case of the existence of some major seismic fault in the vicinity of a city, there is no chance for reducing the potential of seismic hazard for the city. Also, in the case of a building, located on a slope which has the potential of large and deep landslide, it will not be possible to reduce the vulnerability of the building against this landslide, since if the landslide occurs, the building can be extensively displaced and most probably be significantly tilted or even completely toppled. This means that the will be useless, even if it can remain completely intact, and it has to be demolished.

The values of "Hazard Reduction Execution or Implementation Level" and "Vulnerability Reduction Execution or Implementation Level" are also between *0* and *1*, where *0* means the case in which no reduction measure is implemented in the community at all, and *1* means where the reduction measures are fully implemented in the community. Combining Eqs. (1) to (7), excluding Eq. (2), one can obtain the relation of "risk reduction index" with "Hazard Reduction Index" and "Vulnerability Reduction Index" as shown in Eq. (8):

$$I_{Rr} = I_{Hr} + I_{Vr} - I_{Hr} \times I_{Vr} \quad (8)$$

in which the values of I_{Hr} and I_{Vr} are given by Eqs. (6) and (7) respectively. With the increase in management level, the indices values starts to move from 0 toward 1. Clearly, to have a value larger than 0 for either of I_{Hr} or I_{Hr} it is required that both elements of potential and implementation or execution do exist. If the potential mentioned in the Eqs. (6) and (7) is not used, there is actually no management implemented and therefore, there is no difference between the existing risk and the reduced risk. This concept can also be stated by using the "Management Efficiency Index" which can be defined as the ratio of "Used Capacity" (C_U) over the "Existing Capacity" (C_E), as stated by Eq. (9):

$$MEI = \frac{C_U}{C_E} \quad (9)$$

To show how this formulation can be used in "Disaster Risk Management" it is necessary to make a brief discussion on the role of management, and particularly QM and Quality Assurance, in "Risk Reduction". In the following section, a fundamental discussion on this issue is provided.

4. QM in "Risk Reduction"

As mentioned before, QM is the method for ensuring that all the activities necessary to design, develop and implement a product or service are effective and efficient with respect to the system and its performance. Quality Assurance (QA), alternatively, is the activity of providing evidence needed to establish confidence among all concerned, that quality-related activities are being performed effectively. All those planned or systematic actions are necessary to provide adequate confidence that a product or service will satisfy given requirements for quality. QA is a part and consistent pair of QM proving fact-based external confidence to customers and other stakeholders that a product meets their needs, expectations, and other requirements. QA assures the existence and effectiveness of procedures that attempt to make sure - in advance - that the expected levels of quality will be reached. It also covers all activities from design, development, production, installation, and servicing to documentation. It introduced the sayings "fit for purpose" and "do it right the first time". It includes the regulation of the quality of raw materials, assemblies, products and components; services related to production; and management, production, and inspection processes (Wikipedia 2007). It is also worth mentioning that based on these issues, combining the architectural, structural, and industrial designs has been suggested for having disaster-proof future buildings (Hosseini 2007).

On this basis, and considering the concepts used in Eqs. (6) to (9), namely "Reduction Index", "Reduction Potential" and "Reduction Execution Level", and what those equations imply, namely defining the "Reduction Index" as the product of "Reduction Potential" and "Reduction Execution Level", the role of management in "Risk Reduction" can be clearly realized. In fact, management should be applied into two following areas to achieve a successful risk reduction:

- Realizing whether the reduction potential, either in case of hazard or the vulnerability, is possible and how this potential can be increased,
- Planning to increase the reduction implementation level by considering various scientific, technological, social/cultural and economical aspects.

The following two examples help the reader to better understand the intended concepts and formulation.

1) As the first case, consider a road which is subjected to landslide hazard. In case that the sliding area is not very wide, it is usually possible to build a retaining wall in the foot of the hill in order to prevent the slippage. This means that the potential for reducing the hazard does exist (P_{hr}=1). Additionally, if the retaining wall is constructed with enough strength and resistance against the soil slippage, then reduction measure has been completely executed (E_{hr}=1). Therefore, by using Eq. (6) I_{Hr} is equal to 1, and this in turn results in a value of 1 for I_{Rr} by using Eq. (8), and finally, the value of R_r will be equal to 0 by using Eq. (3). This means that in this case the ideal or perfect risk reduction has happened.
2) As the second example, think of a community that 80% of its school children have been well trained and educated for sheltering acts in the time of disasters, and those children have fully transferred their sheltering knowledge to their families. This

means that 80% of community are aware of sheltering acts. If it is assumed that all the buildings structures in this community are earthquake resistant (only non-structural hazard does exist), and that correct sheltering can reduce the number of casualties up to 90%, the potential of reducing the casualties number is 0.8 x 0.9 = 0.72, Now, if just 70% of the trained people really do the sheltering acts correctly, which means that the execution level is 0.7 or 70%, then the “Risk Reduction Index” for life-loss in this community will be 0.72 x 0.7 = 0.504 or 50.4%. Of course, by better management of disaster education and public awareness the percent of trained people and the level of implementation of sheltering acts are increased the “Risk Reduction Index” will be increased as well.

Obviously, it is not possible to reduce the level of natural hazard in the large scale in any region. For example, the level of seismicity in a region depends on the activities of existing seismic faults in that region, and as long as the level of seismicity of those active faults is high, the level of seismic hazard does not change, and there is no way to reduce it. However, as the new cities are built or developed and the buildings and facilities in the existing cities are renewed, it is always possible to avoid the hazardous areas, at least for essential building and facilities. In fact, by having appropriate site selection for new facilities, it is possible to reduce the level of exposure to seismic hazards, such as ground shaking, faulting, landslide, liquefaction, rock fall, large settlements, tsunami occurrence, and so on. This is what it may be called the “Hazard-Avoidance-Oriented Development and Renovation”.

Furthermore, if a distinction is considered between "hazard" and "hazard exposure" concepts, the function of the building can contribute to the hazard exposure and consequently the "hazard avoidance". For example, consider a critical facility such as a public center in which a great number of people work in, and which is located in the high seismic zone. The level of exposure can be decreased in this building, by changing it from a public center into a residential building, since in the latter one, the number of people who are exposed to the hazard will be less. In the case of existing buildings and facilities with no change of function, the reduction potential for hazard or hazard exposure level is zero, however in case of future buildings, the potential can be more than zero, and even 1.0, if a good development design is followed based on a highly qualified management.

With regard to the second area of management application (vulnerability reduction), it is a necessity to upgrade the knowledge level of various groups of people in the community. For example, to realize the role of management in "vulnerability reduction", it is just enough to mention that vulnerability reduction deals with issues such as the quality of architectural and structural design, the quality of construction materials, the quality of workmanship, the quality of technical inspections, and so on.

In the case of vulnerability reduction for all existing buildings and facilities, retrofitting is one of the main preventive actions that can take place. In this regard, the quality of retrofit design and construction is of great importance from both reliability and economy aspects. It should be noted that in all the aforementioned aspects of disaster reduction, the term "hazard" implicitly refers to a great source of information. In fact, seismic hazard maps which can be prepared in various scales with different levels of accuracy are referred as macrozonation and microzonation maps depending on their scale and accuracy. QM can also play an important role in the process of preparing these maps, particularly the microzonation maps, which are the base for retrofit design of essential buildings and facilities as well as developing "earthquake scenarios", which are required for crisis or emergency management action plans.

As mentioned before, disasters put development at risk. Bringing "disaster risk reduction" and "development concerns" closer together, requires three steps (UNDP 2004) such as:

- Collection of basic data on disaster risk and the development of planning tools to track the relationship between development policy and disaster risk
- Collection and dissemination of best practice in development planning and policy which reduce the disaster risk
- Galvanizing the political will to reorient both the development and disaster management sectors.

On the other, hand governance for disaster risk reduction has economic, political and administrative elements. Economic governance includes the decision-making process that affects the country's economic activities and its relationships with other economies. Political governance is the process of decision making to formulate policies including national disaster reduction policy and planning, and the administrative governance is the system of policy implementation which requires the existence of well functioning organizations at the central and local levels. In the case of disaster risk reduction, it requires the functioning enforcement of building codes, land-use planning, environmental risk and human vulnerability monitoring as well as safety standards. In this regard, the following emerging agendas can be considered (UNDP 2004):

1) Appropriate governance
2) Factoring risk into disaster recovery and reconstruction
3) Managing the multifaceted nature of risk
4) Compensatory risk management
5) Addressing gaps in knowledge for disaster risk assessment.

Development needs to be regulated in terms of its impact on disaster risk. Perhaps the greatest challenges for mainstreaming disaster risk into development planning are the political will and geographical equity. Development appraisal and decision making tools, and monitoring programs that incorporate disaster risk management are also needed to mainstream prospective disaster risk management. The argument made for mainstreaming disaster risk management is doubly important during reconstruction following disaster events.

Regarding all these matters it can be realized that how effective the QM can be in disaster risk reduction. There is no need to explain that "Disaster Risk Reduciotn" as the final goal of every "Disaster Risk Management Program" needs an interdisciplinary management framework itself in which the quality of management in all various phases of mitigation, namely prevention, preparedness and protection, response and recovery, and reconstruction is very important. However, among these categories, "Disaster Education" issue is believed to be the foundation of all risk reduction programs, in the next section the role of QM in "disaster education" is discussed to some extent. This discussion not only helps the reader to get a better picture of the role of QM in disaster risk reduction, it also helps to realize which parts of disaster education need more attention for modification or enhancement.

5. QM in Disaster Education

In order to reduce the vulnerability in disasters, there are three prerequisites as follow:

1) Retrofitting the existing buildings and facilities;
2) Disaster-proof design and construction of the future structures;
3) Obtaining and maintaining the preparedness for performing proper disaster response and recovery actions, and reconstruction works..

Clearly, proper education and training of all the people involved in the above activities (specialized training and education), and more important, proper education of the whole community (public awareness) as the main end-users and those who benefit from all these endeavors are prerequisites for the success of the mentioned endeavors (Davis et al 2004).

It is obvious that the quality of education is the most important aspect in any education program. Unfortunately, in developing countries, educating all levels of the society is not easily possible due to the lack of enough expertise and existing educational materials. Therefore, one of the best ways of publicizing awareness programs can be the integration of the awareness initiatives into children's programs in both preschool and school levels (Izadkhah and Hosseini 2005). There are some other ways for improving the quality of education, of which training the authorities for emergency response (Hosseini and Izadkhah 2006), training people for disasters in residential complexes (Hosseini and Izadkhah 2006), and training classified target groups of the community (Izadkhah and Hosseini 2007) are some good samples

Another important factor in improvement of training quality is assessment. Regular assessment of the effectiveness of all awareness programs is a necessity. This can be achieved through systematic planning by the involved organisations and related ministries for each of the various disaster awareness programs that are implemented. When appropriately accomplished, the results of the assessments lead to improved implementation of new and updated initiatives. A key "implementation challenge", to be addressed is the perceived gap between the enormous volume of education to children through schools and the achieved "transfer" of disaster knowledge to families, which does not as yet seem to reach satisfactory levels. It has been demonstrated that during the recent Firooz-Abad-e-Kojoor earthquake in Iran in May 2004, many people in Tehran ran out of their buildings, contrary to recommendations.

There are some challenges in reaching a quality control of these educational initiatives, of which the most important ones are:

1. How to ensure that the advice being offered concerning recommendations for safety measures and behavior is technically accurate;
2. How to switch the emphasis from the rather passively named 'public awareness' to the much more active description, 'public learning';
3. How to test the effectiveness of these programs, namely to determine what changes in behaviour have resulted from the education and what are the levels of adaptation by families to the threat, to enhance their resilience to disaster;
4. How to shift the focus of education from 'individual learning' to 'community learning and adaptation';
5. How to make certain that the approaches to public learning are socially acceptable and culturally appropriate**;** and
6. How to ensure that the typical awareness programs rely on information dissemination process and getting the messages across.

For designing the future initiatives and activities, there is a need to develop a systematic and regular community-focused evaluation and monitoring which is mainly focused on process rather than the outcome, also to collect the information based on the needs assessments for the expansion of a communication strategy. Using the principles that fits correctly into the culture of target group and examining the methodology carefully before its application is important. To assess the process by skilled and trained personnel, developing and designing activities according to the reliable sources with the aim of changing people's behavior and paying attention to issues such as timing, location, delivery and appropriate medium and channels and clarity of the messages is highly crucial (Izadkhah 2006).

Assessment should cover the followings:

- **The Contents of the Materials –** compatibility with trainees' requirements. The materials should be designed in a way to meet the trainees' needs. It is important that training materials be designed by reliable sources and knowledgeable expertise.
- **Training Tools and Media –** There should be compatibility with trainees' capabilities in using specific media and tools. Different training tools and media should be presented in a way that can be used by various special groups of people mentioned earlier.
- **Qualifications of Trainees –** The Trainees should be qualified enough and have the required background knowledge in order to understand the materials presented to them.
- **Qualifications of Trainers –** The idea of assigning an disaster expert seems appropriate. Also there is a need to select volunteers from various groups of the representatives of people and to train them about disasters to act in turn as the next level of trainers.
- **Training Times –** The time of the training can be set differently for various groups of trainees in the society.

The assessment procedure itself should be of high quality. This mean that the assessors should have enough knowledge and experience to use most effective ways and employ the most appropriate tools in each case for their assessment, and present their assessment results in the most effective modes to be used by training planners.

6. Conclusions

Based on the above discussions, it can be concluded that there are several links between the "Disaster Risk Reduction" and "Quality Management". Among all, the role of QM can be more important and sometimes deterministic in the following issues:

- Preparation of hazard maps, particularly microzonation maps;
- Constructing the fragility curves of the structural components subjected the various levels of hazard;
- Developing the design codes and guidelines;
- Evaluating the existing technical and economical capacity of the community;
- Identifying the existing and developing the new ways to increase the potentials for reduction of either hazard or vulnerability;
- Planning specialized training and education as well as public awareness programs; and finally
- Regular assessment of disaster education materials, either for public or for training the technical staff.

Further comprehensive studies are required for some of the above issues, which need the cooperation of various experts, including hazard analysts, earthquake engineering specialists, economists, sociologists, educational experts, and so on.

7. References

Davis, I., Hosseini, M., and Izadkhah, Y. O. (2004) "Public Awareness and the Development of a Safety Culture: Key Elements in Disaster Risk Reduction", Proceedings of the SEE-4 Conference, IIEES, Tehran, Iran.

Dowrick, D. J. (1987) *Earthquake Resistant Design for Engineers and Architects*, 2nd Ed., John Wiley and Sons.

Hosseini, M. (2004) "The Relations between Disaster Risk Management And Quality Management", Proceedings of the 2nd Int'l Conference on Quality Management, Iran Group of Surveyors (IGS), Tehran, December.

Hosseini, M. (2007) "Combining Architectural-, Structural-, and Industrial Design: A Necessity for Having Disaster-Proof Future Buildings, Proceedings of the 1st International Conference on Engineering and Product and Design Education, Northumbria University, Newcastle Upon Tyne, UK, 13-14 September.

Hosseini, M., and Izadkhah, Y. O. (2006) "Training Authorities for Earthquake Emergency Response: Challenges and Opportunities", Proceedings of the 1st INDM Conference, Tehran, Iran.

Hosseini, M., and Izadkhah, Y. O. (2006) "Training People for Disasters in Residential Complexes- From Risk to Opportunity", Proceedings of the 1st ECEES Conference, Geneva, Switzerland.

Izadkhah, Y. O. (2004) "Bridging the Generations: A Critical Assessment of Disaster Education in the Development of a Seismic Safety Culture in Iran", PhD Dissertation, Cranfield University, 683 pages.

Izadkhah, Y. O. (2006) "Mine Risk Awareness Initiatives for Children: A Continuous Challenge", ISDR, Davos, Switzerland.

Izadkhah, Y. O. and Hosseini, M., (2005) *Towards Resilient Communities In Developing Countries Through Education Of Children For Disaster Preparedness,* International Journal of Emergency Management, pp138-148.

Izadkhah, Y. O. and Hosseini, M. (2007) "Disaster Preparedness Strategy through Earthquake Education and Training of Classified Target Groups", Proceedings of the 2nd INDM Conference, Tehran, Iran.

UNDP (2004) Reducing Disaster Risk: A Challenge for Development, United Nations Development Program, Bureau for Crisis Prevention and Recovery.

www.wikipedia.org [accessed in June 2007]