

A Case Study of the *Bam* Earthquake to Establish a Pattern for Earthquake Management in Iran

Keramatollah Ziari^{a*}, Reza Ziari^b, Somayeh Ziari^c

^a Professor of Town and Regional Planning, Faculty of Geography, Department of Geography and Town Planning, University of Tehran, Tehran, Iran

^b M.A of Architecture, Kish International Campus, University of Tehran, Tehran, Iran

^c Ph.D Student of Geography and Urban Planning, Alborz International Campus, University of Tehran, Tehran, Iran

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Abstract

The field of crisis management knowledge and expertise is associated with a wide range of fields. Knowledge-based crisis management is a combination of science, art and practice. Iran is an earthquake-prone country. Through years several earthquakes have happened in the country resulting in many human and financial losses. According to scientific standards, the first 24 hours following an earthquake is the most valuable time for saving victims. Yet in the case of Bam only 5% of the victims were rescued within the first 48 hours. The success of disaster management is evaluated in terms of programming, raising public participation, organizing and hiring manpower, and supervising the management process. In this study disaster management is divided into three stages in which different actions are required. The stages and actions are explained in detail. Moreover, features, effects, and losses of the earthquake are described.

Keywords: Earthquake, Management Pattern, Disaster, Infrastructure, City of Bam, Iran

1. Introduction

Disaster as defined by the European Environment Agency is “a serious disruption of the functioning of society, causing widespread human, material or environmental losses, which exceed the ability of affected society to cope using only its own resource” (Thywissen, 2006).

There has been an increase in the incidence of natural disasters worldwide with increasing loss of life and damage to property. The risk of disasters can also be expected to rise in the future, particularly for developing countries populations. There are two reasons for this trend:

- 1-An increase in extreme natural events, primarily due to climatic change
- 2-Increased vulnerability of populations to these natural events (Working concept, 2002)

Studies by the Center for Research on the Epidemiology of Disasters (CRED), a center situated in Belgium, show an increase in the number of natural disasters and people affected by them in recent years (Fig. 1).

From January to October 2005, an estimated 97490 people were killed in disasters globally and 88117 of them in natural disasters (The WHO website).

Nowadays crisis management relates as a science of beyond course to widespread case of sciences and experts and with respect to strategy, is a complex of science, art and action witch before, during and after crisis in order to reduction of affects of these events and decreasing of vulnerability is carried out. If the crisis management can be affective and opportunity of development of multi-dimension provides for the distraction, basement of planning before crisis will be ready and subjective. (Mobaraki & Kashaniasl, 2014)

The greatest natural disasters that can happen in a country like Iran are earthquakes and floods. Thus, in this study we are concerned with earthquakes and what should be considered before and after an earthquake hits an area, with a closer look at the Bam earthquake.

Earthquakes can have profound impacts on people’s lives. On December 26th, 2003 at 5:26 AM local time (+ 3:30 GMT) an earthquake measuring 6.5 on the Richter Scale hit Bam which is one of Iran’s ancient cities located in the southeast of Kerman province.

*Corresponding Author Email: zayyari@ut.ac.ir

During the earthquake almost the entire infrastructure of the city was damaged. Power lines were cut off, telephone communication was interrupted and only %30 of it was brought back to service two weeks after the disaster. Although the city is situated in a flat area and no long-span bridges are there, transportation was also disrupted as roads and sidewalks were covered with the wreckage making the rescue efforts much more difficult (Mehrabian

and Hadler, 2005).

When a disaster occurs in a region, all the major structures should resist damages as much as possible. Some buildings such as hospitals, large sport and school complexes are expected to withstand the earthquake no matter how powerful it is.

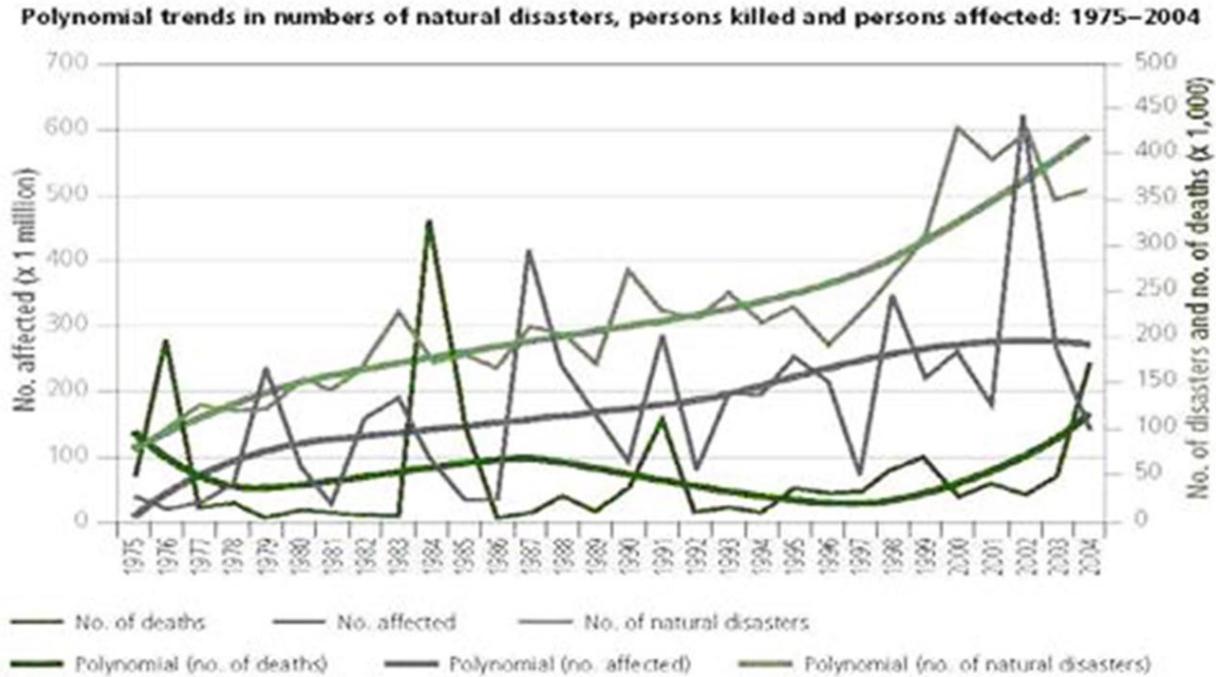


Fig. 1. Polynomial trends in numbers of disasters, persons killed and persons affected: 1975 - 2004

If such buildings withstand earthquake damages, they will allow rescue groups to provide safety, shelter, and medical services to the victims. Unfortunately in the case of Bam most of these structures did not resist the earthquake trembles, and the underground gravity-flow irrigation system of the city was badly damaged (Mehrabian and Hadler, 2005) and thus caused the lack of first hand water supply for the sufferers. It is necessary to point out that the main source of drinking and agricultural water supply in Bam is from the underground gravity-flow irrigation systems known as ‘Qanats’ (Amini Hosseini *et al.*, 2004).

By studying the buildings in the area one can reach to the conclusion that because most of the buildings were made of adobe, the number of casualties increased. Steel and reinforced concrete structures also did not perform as expected, mostly because of the low quality of design and poor materials that were used (Mehrabian and Hadler, 2005).

In order to have an effective disaster management as mentioned in Yokohama Strategy and Plan of Action for a Safer World (Yokohama, 1994), a full continuum, from relief through rehabilitation, reconstruction and development to prevention, must be the concept guiding

actions towards the reduction of human and physical losses which is the ultimate objective. Thus, to have a better performance in dealing with such situations, some actions are needed to be done before and after a disaster occurs. In the present study, we suggest that these actions should be divided into three categories as follows:

- A-Disaster management before the earthquake
- B-Disaster management in the first week after the earthquake
- C-Disaster management following the first two weeks after the earthquake

Nowadays, crisis management knowledge and expertise is associated with a wide range of fields. Knowledge-based crisis management is a combination of science, art and practice.

Crisis management can be fruitful and provide multi-dimensional development opportunity for the region to create an accurate plan before the crisis. The earthquake is one of the most common natural hazards that threaten urban spaces. In other words, the more the investment for developing and improving the foundation of a society, the less negative consequence and accidents would be.

One of the most common dangers of natural disaster is

earthquakes which threaten the urban areas. (Mobaraki & Kashaniasl, 2014)

2. Disaster Management before the Earthquake

In modern days, it is essential to be prepared to face challenges eventually leading to crisis. The idea is that effective precautions will avert future disasters or at least mitigate them (Working concept, 2002). According to Yokohama Strategy and Plan of Action for a Safer World, "Disaster prevention, mitigation and preparedness are better than disaster response in achieving the goals and objectives of the Decade. Disaster response alone is not sufficient, as it yields only temporary results at a very high cost" (Yokohama, 1994). For earthquake-prone countries it is necessary to have the ability to face earthquakes. Unfortunately until now there is no efficient way to predict where and when an earthquake may occur well in advance; therefore, people, local states, and central or federal states should work closely on having the right material and knowledge to face any disaster.

There are several definitions by international organizations of disaster management before its occurrence. To define a package for earthquake mitigation, several measures should be taken. In this regard, the packages are classified as:

- 1- Building Construction
- 2- Physical Planning
- 3- Economic Planning
- 4- Energy Planning

3. Building Construction

There are two types of buildings in cities: The first type includes residential and commercial building that should resist hazard, and the other type comprises buildings like shelters (large schools and sport complexes) and hospitals which should not only be earthquake resistant but also have the ability to function because of their primary role in an earthquake aftermath.

Strengthening structures for confronting earthquakes is one of the most crucial issues that should be emphasized as a top priority in disaster management planning. It is a priority to establish stricter safety measurements and to implement these measurements in health care structures and shelters. These structures should be able to withstand and resist earthquakes and they should be fully operational within minutes after an earthquake hits a region. Health care facilities are of special importance because of:

1-The people in the centre including:

- . Medical team: Doctors, nurses
- . Technical team: Technical staff
- . Others: Patients, elderly, children, visitors

2-Medical equipment: Heart scan, MRI, other equipment

3-Emergency services: Search, rescue, relief, recovery (Nateghi and Isadkhan, 2004).

Pre-build and equipped shelters should also be available. Shelters can and should provide dormitories, food, clothes and other necessary services to the victims.

As Nateghi (2000) states, "Building codes are the critical frontline defense for achieving more strongly engineered structures, in large private buildings, public sector buildings, infrastructure, transportation networks and industrial facilities".

Disaster-resistant building codes are, however, unlikely to result in resistant buildings unless the engineers who have to implement the code accept its importance, endorse its use, and understand the code and the design criteria required. A code should fit into an environment and there has to be the establishment of an effective administration to check code compliance in practice (Nateghi, 2000).

Obviously an earthquake can destroy the main infrastructure of a city. As a result it is important to use appropriate materials and conduct dynamic structural analysis in designing them. But since no one can predict what exact magnitude and seismology an earthquake will have, it is important to take account of some other aspects.

Considering this issue in this study, the building structures in Bam can be categorized into:

- 1-Adobe building structures
- 2-Unreinforced masonry buildings
- 3-Steel structures
- 4-Reinforced concrete structures (Mehrabian and Haldar, 2005)

Unfortunately most of the adobe and unreinforced masonry building structures did not withstand the earthquake. Lots of steel structure and reinforced concrete buildings also did not resist the earthquake because of lack of attention during design and construction (Mehrabian and Haldar, 2005). In fact, preliminary investigations by the Iranian officials indicated that around 70 to 80 percent of buildings and cities infrastructure in Bam and its surroundings were destroyed (EERI, 2004).

The findings of the above studies show that some drastic measures should be taken in Iran in order to minimize the cost and loss of earthquakes. In the first place, new building codes should be defined in the regional scale based on seismology studies. Then as implementing the new building codes is vital, new methods of auditing buildings under construction should be provided.

Meanwhile, educating ordinary people about the necessity of implementing building codes can raise demands for well-built buildings. This indicates the importance of using incentive methods to build new houses all over the country.

4. Physical Planning

With regard to physical planning, a crucial issue is that main infrastructures as well as hospitals and shelters should be located in hazard free zones. This emphasizes the importance of land use. Although Iran is situated on the earthquake belt, there are areas on the regional and city scale where the impact of earthquake is less. Thus, a very thorough study on land use will allow a physical planning in which major buildings will be build in less hazardous areas.

Other issues related to physical planning are careful location planning of roads, water pumps, water resources, electricity sub-stations, and telephone line exchanges. Reviewing the studies about Bam indicates the significance of this issue. Unfortunately after the earthquake the city was completely disconnected from the world and thus the government was not aware of the disaster until 3 hours after it occurred. Power lines, cell phones, waterline, fire stations, and medical centers were mostly out of order. The lack of safe roads also made the rescue teams struggle because the earthquake caused some geological phenomena such as widespread sinkholes (Mehrabian and Haldar, 2005).

An important consideration in physical planning is that any infrastructure in an area is not only used for the city but also for rural areas around it (Ziari, 2002). Bam which was supposed to be able to provide facilities for its rural areas was itself in trouble and barely functional. In physical planning it is necessary to consider all possible ways to access medical centers or shelters from the regions depending on the main city. Any abnormality in the main city will have a very negative effect on rescuing people in neighboring regions. Main roads should be built in a way that they would not be filled with wrecks of collapsed buildings. In the case of Bam earthquake the access to medical centers were barred because of ignoring this important issue.

5. Economic Planning

It is not possible to neglect the significance of a strong economy for preemptive measurements. A strong economy can afford the cost of building more earthquake resistant buildings. It is a sign of having the ability to recover from any disturbance. A single-crop or a single-industry region might not be able to withstand the economic shocks of an earthquake or other sources of disturbance aftermath. Greenspan (2007, p. 7) believes that the greatest strength of U.S. economy is its resilience

and ability to absorb disruption and continue its path. No matter what the cause of disorder is, the ability to recover from shocks and disturbances plays an essential role in bringing back life to a devastated city.

Bam is a single-crop city. Its main agricultural production was and is date. In February 1998 it was declared to be a free industry zone. It was then that a private consortium began to build and develop leisure facilities in the region (www.argejadid.ir). The Bam airport was also built by these investors. Moreover, the so-called "Arg e Jadid" was constructed by them to improve the quality of life in the region and attract much more needed investment in the region.

Now it is noticeable if it was not because of the facilities made by the investors, the effects of the earthquake would have been much worse and the number of casualties much more. For instance, while the car production company suffered from the death of its employees, it was able to bring hope to the city and help with rebuilding a city which might have never withstood such a life-size disaster.

To further examine the importance of economic planning in the case of Bam earthquake, let's compare it with *Jirooft*. If *Jirooft*, a city which is about 100 Km away from Bam, was hit by such a strong earthquake, it could not bear any of the outcomes due to the lack of investment in the city and its surrounding region. This is partly due to the fact that *Jirooft* is a single agricultural-based economy only accessible by road and the closest operational airport to it is the one situated in Bam.

6. Energy Planning

The authors strongly believe in the importance of energy planning for crisis prevention. Energy has a vital role in our life. We totally depend on energy for living and it is impossible to name any aspect of life that is not related to it. Energy planning relates to crisis management in several ways. The effectiveness of rescue missions highly depends on the availability of energy. Transportation also depends on energy. The functionality of water supplies like water pump station depends on energy. Telecommunication structures are energy-dependent too.

When an earthquake occurs, hospitals and shelters should be able to function properly no matter how badly the city's infrastructure (roads, bridges) is damaged. These constructions are highly dependent on water supply and electricity because all their equipment for fulfilling the needs of victims is highly dependent on these two factors. Clearly, a hospital without electricity is dysfunctional and a shelter without the energy supply cannot fulfill the basic needs of sufferers like hot water and food.

All the above examples help us to understand the importance of energy in disaster management policies. To

further address the issue, it is important to realize what could go wrong in supplying energy after an earthquake. In Iran electricity and gas are the main sources of energy in use. There is a huge electricity and gas network that even reaches out to rural areas. Unfortunately these networks are vulnerable to earthquake. The gas lines especially can be very dangerous in time of hazard as they might explode. To address this issue, the role of small suppliers of energy needs to be considered. In this regard, an important principle is that the deconcentration of elements at risk-services provided by one central facility are always more at risk than those provided by several smaller facilities (Nateghi, 2000).

As a result, in this paper we emphasize the importance of decentralization, especially in electricity supply systems. A decentralized electricity grid or decentralized energy production will reduce the vulnerability to disasters. Disaster managers should persuade local and national governments to use distributed generation (DG) systems. Although in Iran hospitals are equipped with emergency electricity units, unfortunately they are mostly dependent on the gas network which is itself vulnerable to any disaster.

Another advantage of distributed generation systems is the combined heat and power (CHP) production. This will increase the efficiency of the system and in turn will minimize energy consumption (Borbely and Kreider, 2001, p. 292). It is important to notice that after a crisis the consumption of energy increases while the availability of energy decreases.

Now, a relevant argument that may arise here is about the ways we can convince officials to pursue this goal. Everyone knows the importance of the issue but since producing energy from renewable sources and distributed generation systems are still more costly than the conventional forms, it is essential to consider a method to increase their competitiveness. To do so, a virtual connection between different forms of electricity production can be fruitful since the virtual connection will build a decentralized energy system called a "Virtual Power Plant" (VPP) (Assadian, 2005).

The VPP can enhance the competitiveness of individual and distributed energy production systems and thus increases the use of DGs (Borbely and Kreider, 2001, p. 199). Another advantage of using the VPP is minimizing the risk of network cut offs. For instance, if the main power line to a town is cut off because of an earthquake, the presence of a VPP in the town will allow the management of power distribution in a way that minimizes the shortage of electricity for the residents (Assadian, 2005).

All in all, in the preceding part we discussed some strategies and policies that should be taken into account for pre-disaster management. In the following parts, we

present the actions required to be taken in the first week after the earthquake and later.

7. Disaster Management in the First Week after the Earthquake

When an earthquake happens, both the victims and the authorities are in a disastrous situation. Response and relief efforts should start immediately. If governmental and local authorities have no clear strategic plan to manage the situation, there will be delays (Atmanand, 2003).

The victims will be in pain. Depending on the magnitude of the earthquake the damage can be different. An immediate response is necessary to rescue people hit by the earthquake. Different actions including finding the injured people, preparing medical centers, and sending medical and rescue teams to the area must be done. The emergency creates medical and surgical needs at the site of impact while new health-related needs may arise in the areas to which the stricken population has moved for safety (Gunn, 1995).

In order to make sure that the rescuers have what they need some basic infrastructures should run without any problem. The availability of city's geographical and infrastructural maps with required information is a necessity. These maps will allow the rescuers who mostly do not know the area well to become familiar with the area they are working at. The full details allow them to imagine and stimulate and thus predict what the damages are and where survivors may be found. This preparedness highlights the importance of having clear search and rescue plans and role-players' understanding and knowledge of the roles (Atmanand, 2003).

Another thing that should be considered in the rescue operation is to make sure that no harm is done to any living thing under the debris. Unfortunately there were reports from Bam that some victims became handicap and lost the ability to walk due to the lack of professional rescuers with the volunteers in the site. The government has a vital role in making sure that in such situations any volunteer group of people is well organized by professionals.

In addition to the rescue operation, four other issues should be dealt with in the first week. These issues are gathering information and assessing them, ordering and ranking of the organizations involved, budget planning, as well as evaluation and control. Accomplishing these tasks will have a great effect on the success of the rescue operation. These tasks are quite familiar to the people concerned with management issues as they are necessary for the success of any planning. In what follows there is a closer look at these issues, especially their requirements in a post-earthquake situation.

8. Gathering and Assessing Information

It is required to gather information on the damages made by the earthquake and assess them with a preplanned program. As a matter of fact, physical, social (security), health, economical, and environmental effects should be determined. Physical assessment concerns damages to the buildings and infrastructure in the area, social assessment evaluates the security of the site in order to prevent any looting, economical assessment evaluates all the issues regarding damages to the regional economy, and environmental assessment deals with damages to the environment. The quality and quantity of needs should be fully investigated in order to understand all the necessary issues in the area. It is the first step in planning but it is vital to realize that it should not stop the immediate rescue operation. Afterwards it should be clear from where and when the helps will be available.

9. Ordering and Ranking of the Organizations Involved

Each organization in the crisis area should take a specific responsibility managed by one top committee. The coordination between different organizations will have a great effect on the effectiveness of the mission. Another important thing that should be understood is the gap between disaster researchers and emergency rescuers. This influences the responses and probably the efficiency and effectiveness of the operation.

10. Budget Planning, Defining and Executing

With no doubt budget has the most important role in any crisis. Any planned relief operation should be controlled and if any discrepancies were observed based on the indicators, required changes should be done. This will lead to a more effective use of money and resources available.

11. Evaluation and Control

Evaluation and control is a priority in order to find new and better ways of managing the crisis and helping the people. This control is limited to monetary spending and is used for engineering and medical assessment. As mentioned by some paralyzed victims of the Bam earthquake, the lack of experienced rescuers in the field made a vast number of inexperienced people try to help but they not only were not helpful in most of the cases but also were responsible for their injuries (Series of Article about Bam, 2004). If a well-established evaluation system was available, it could recognize the problem immediately and at least could take some measures to make people aware of the potential threat.

12. Disaster Management following the First Two Weeks after the Earthquake

Two weeks after the earthquake, a strategy should be developed upon two bases. One is the process for the rehabilitation of victims. The other is a sustainable reconstruction plan.

The victims cannot be forgotten once the immediate disaster has passed. Probably this is the most difficult period of time for the sufferers (Atmanand, 2003). A quick start of reconstruction will be beneficial to both the victims and the government. The central government should use all its power to help the regional and local government in the reconstruction process. But the most vital role that it has is planning a sustainable reconstruction and development program.

Planning a sustainable strategy for development is not a one-day task. The local and regional authorities should be prepared for a reconstruction plan in advance. In this plan the main task is to involve victims in the reconstruction process since it will help them mentally.

If the planner regards helpless victims as active participants, the process of planning and implementation will change. This speeds up the reconstruction process and helps victims to take back the required self-confidence (A series of Article about Bam, 2004). In other words, in this active participation, the victims themselves will have a key role in planning and policy making and thus eventually regain their self-confidence.

As mentioned above, developing a sustainable reconstruction plan is another important process which is to be dealt with following the first two weeks after the crisis. In this regard, new standards should be defined and implemented so that future crises can be prevented. To do so, it is obligatory to examine the previous standards and inspect the buildings in which the standards were implemented. In the inspection the assessment indicates how well the standards were defined and what necessary changes are required. The results will allow engineers to define new standards that should be used in the reconstruction process.

Here a guideline involving four steps is introduced which is similar to the guideline provided in the previous section of the paper:

Gathering and Assessing Information

It is necessary to continue gathering information two weeks after the earthquake. Some information might be similar to the information gathered during the first week but also some other information for the rebuilding process should be collected. The context of the data in this process is different from that of the first week. Here the purpose

of gathering data is to define new standards by thorough but fast analysis. The analyzed data then would be fed into the reconstruction planning.

Ordering and Ranking of the Organizations Involved

Here again the order and the rank of the organizations involved should be vivid. Each organization should know what its mission is and should fully collaborate with other participants. Localized planning will allow organizations to have a better understanding of what they have achieved and thus understand the problems they have. In the case of Bam, “Islamic Revolution Habitat foundation” is responsible for the reconstruction process.

Budget Planning, Defining and Executing

An important issue in any crisis management is the ability to attract new capital, money, and other resources as much as possible. The resources can be of any type. They can be funds, money or materials needed for reconstruction. Some of the resources are from abroad and some others are local—collected across the country. Like the investment in a market, it is very important to be able to absorb as many appropriate resources needed for construction as possible.

After an earthquake occurs several countries and international organizations donate money to the relief operations and the reconstruction process. Besides, people or firms in the country donate money and materials too. To absorb enough internal resources, the government can promote the name of companies that have helped in the process. The government might also give some tax incentives to any company that donates money or materials needed for reconstruction. The country hit by the disaster needs and should be able to develop the rebuilding planning as soon as possible and find ways to collect the donated money. There are several issues that may slow down the reconstruction process, with one delay in the payment by the countries that are committed. Since this may be because of the lack of trust between nations, it is necessary to have a well-organized plan for reconstruction in which foreign countries can be informed about the ways their money is used without any concerns.

Furthermore, it is important to involve domestic firms in the process of construction and observation. This helps to build the needed trust between people and the government. If this trust is not built, it will affect the process of help negatively in future crises. Planning and executing plans, accepting the mistakes made in them, and informing people of the mistakes and measures taken to minimize them will help to build the required trust.

Evaluation and Control

As discussed in the previous part, trust is needed to be built between governments and also people and their

government for future cooperation. Evaluating all the mentioned processes will help to understand mistakes, assess the process, and modify it for future operation.

In the control process, we should assess all resources, the effectiveness and efficiency of the organizations involved, and planning, and then make any required restructuring. In this regard, involving the nation in the process and giving feedback to them is crucial.

13. Conclusion

In any crisis especially the ones caused by earthquake, pre- and post-management issues are very significant. As discussed before, management before crisis is the most important issue that should be considered. In the pre-earthquake management phase, four topics including building construction, physical planning, economic planning and energy planning are important. The issue of building construction relates to the fact that buildings should be constructed in a way that they can withstand earthquakes. This will minimize injuries and damages. Physical planning discusses issues of how a city should be build and expand. It aims to minimize the construction of infrastructures in earthquake-prone regions. Economic planning will enable a region to have the necessity flexibility to withstand damages. This can be done by widening the economic infrastructure (Greenspan, 2007). The most important issue is the availability of energy thus energy planning is a way to reduce the effects of earthquake on energy supplies. Using distributed generation systems and virtual power plants will increase the flexibility of energy supply systems.

To discuss the management of earthquakes aftermath, we have considered two time periods. In the first week after an earthquake, there are several tasks to perform that are different from the tasks needed to be done in two weeks after the earthquake. In the first week, the priority is to help victims and find as many survivors as possible. Then the rebuilding process in which the victims themselves should be engaged should start two weeks after the crisis in order to minimize the social cost of disasters.

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