Chapter 2

The Earthquake Disaster Risk in Japan and Iran and the Necessity of Dynamic Learning from Large Earthquake Disasters over Time

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Additional information is available at the end of the chapter

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Abstract

This book chapter targets how learning from large earthquakes disasters occurred and developed in Japan and Iran in the last 100 years. As research case studies, large earthquake disasters in Japan and Iran were investigated and analyzed. Normal distribution was found to be a good estimate of the magnitude distribution for earthquakes, in both the countries. In Japan, there is almost a linear correlation between magnitude of earthquakes and number of dead people. However, such correlation is not present for Iran. This lack of correlation in Iran and existence of linear correlation in Japan highlights that the magnitude of earthquakes directly affects the number of fatalities and extent of destruction in Japan, while in Iran, there is an increased complexity with regard to the factors affecting earthquake consequences. A correlation is suggested between earthquake culture and learning from large earthquake disasters in both Japan and Iran. Learning from large earthquake disasters is impacted by a multitude of factors, but the rhythm of learning in Japan is much higher if compared with Iran. For both Japan and Iran, a reactive learning approach based on past earthquake disasters needs to be constantly backed up by a proactive approach and dynamic learning.

Keywords: earthquake, earthquake disasters, Japan, Iran, learning, earthquake culture, earthquake risk, earthquake disaster risk, earthquake disaster risk management

1. Introduction

Earthquakes disasters build over time and an earthquake is a dramatic context that takes tiny units of time to bring huge human loss, injuries and massive destruction and damages [1–6].

Almost 12% of all fatal earthquakes in the world occurred along the margins of eastern side of Pacific and Japan is part of it. However, 85% of the most fatal earthquakes in the world occurred along the Alpine-Himalayan mountains belt and Iran is part of this seismic area. It was identified that both Japan and Iran belong to a particular cluster of countries that host the highest number of earthquakes and the world most fatal earthquakes [7].

The research objective of the present study targets to unveil how learning from large earthquakes disasters occurred and developed in Japan and Iran. The need for systematic learning from earthquake disasters is a challenge, which deserve particular attention.

The following section provide theoretical insights about learning from disasters. Further on, five case studies of earthquakes and large earthquake disasters occurred in Japan, were investigated and analyzed. For Iran, the case studies of 15 earthquakes and large earthquake disasters that took place over almost the same period of time, were considered. The timescale for both the countries covers more than a century-time period. As a research methodology, a historical longitudinal study with focus on earthquakes, earthquake disasters and learning from earthquake disasters was performed. A systematic comparison approach among the case studies in Japan and Iran was further implemented. Earthquake field reports, earthquake catalogs, archival documents, narratives of survivors and witnesses to earthquake disasters, cartographic materials, various academic studies and materials were consulted.

2. Learning from disasters

Disasters and crises can trigger learning and generate knowledge for communities and societies [8] and learning from disasters represents a facet of resilience, more precisely, the adaptive capacity [9, 10]. Cutter et al. [10] advised that learning from disasters occurs when disaster mitigation and preparedness are significantly improved and the resilience of communities is enhanced. Furthermore, social learning from disasters needs to be seen as result of various adaptations, actions, measures, and implementation of different policies and improvements, in order to mitigate and reduce the disaster risk. Moreover, Djalante et al. [11] emphasized that long-term planning, technical, logistical and financial preparations, implementation of legislation and policies, trainings and awareness programs, proper coordination and long-term monitoring would have their sound contributions to the learning from and adaptation to disasters. Ibrion [1] and Ibrion et al. [2, 4, 12] brought to attention that over the time the earthquake disasters in Iran have provided many lessons to be “learned” and with great potential to contribute to the socio-cultural learning and cultural memory about earthquakes and earthquake disasters. Learning from earthquake disasters is a long-term complex process, which involves various levels of participation and accountability for and requires an integrated disaster risk management and a sustainable framework such as an earthquake culture [1, 4].

2.1. Earthquake disaster risk in Japan and learning from large earthquake disasters over time

Aspects of learning from the earthquake disasters in Japan were investigated mainly through the case studies of five earthquakes and large earthquake disasters – *Great Nobi Earthquake*

1891, *Great Kanto Earthquake 1923*, *Great Hanshin-Awaji* or *Kobe Earthquake 1995*, *Niigata Chuetsu 2004* and *Great East Japan* or *Tohoku Earthquake 2011* – which affected various places of Japan, over a period of more than a century (**Figure 1**).

The **Great Nobi Earthquake** with Ms. (surface-wave magnitude) of 8.0 took place on 28 October *1891*, in the central part of Japan, north of Nagoya, in the Nobi Plain. This rural area and the cities of Osaka and Nagoya were terribly affected and more than 7300 people died. All the buildings that were heavily influenced by foreign architecture, especially English, collapsed. The Great Nobi Earthquake indicated the beginning of adaptation of the foreign buildings techniques, particularly European and American, to the Japanese nature and culture. This earthquake disaster was considered the "Bing Bang" for the Japanese seismic architecture and building construction in Japan. It encouraged the Japanese inventions of materials, architecture and buildings techniques designated to have seismic resistance. Almost a decade after the Great Nobi Earthquake, the seismology in Japan started to become institutionalized and attracted important funds from imperial and governmental institutions. From the beginning of the twentieth century, Japan started to be recognized worldwide not only as an earthquake country, but also as a front-runner in the production of knowledge about earthquakes [13].

On 1st September *1923*, Tokyo, Yokohama city and the surrounding towns and villages were shaken by the *Great Kanto Earthquake* with a magnitude of 7.9. The earthquake was followed shortly by a tsunami, a strong typhoon and a violent fire, which broke out all over Tokyo. The death toll and destruction, particularly from fire, were immense. It reached between 120,000–140,000

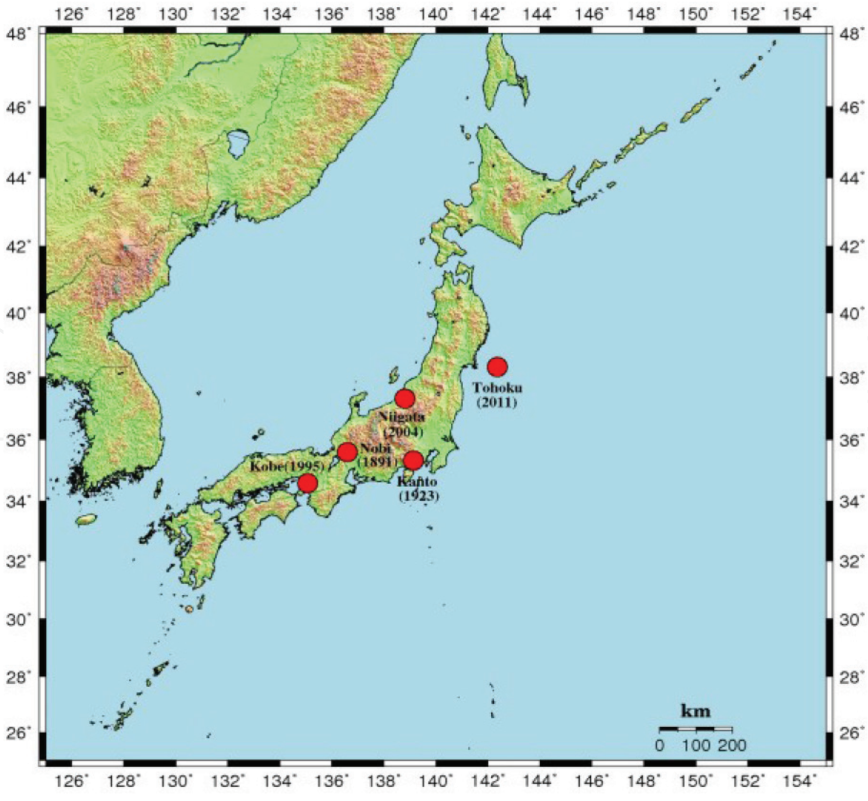

Figure 1. Japan-earthquakes and earthquakes disasters over more than a century. Source: Prof. Mohammad Mokhtari and Mr. Arash Islami, International Institute of Earthquake Engineering and Seismology (IIEES).

people and almost 2.5 million people were left homeless. The Great Kanto Earthquake contributed to the emergence of both a "culture of catastrophe" and a "culture of reconstruction", not only in Tokyo and Yokohama, but also in the whole Japan [14]. Starting from 1924 and based on the lessons from the Great Kanto Earthquake, Japan introduced and applied the first national seismic design code for the building design. Decades later, after the Fukui 1948 earthquake, in 1950, the Buildings Standard Law was adopted. Over the last half century, the building codes in Japan have been continuously revised and updated after the earthquake disasters. For instance, updates took place after Tokachi-oki in 1968, after Miyagi 1978, Kobe 1990, Niigata Chuetsu 2004. The amendment of the Building Standards Law in 1981 was particularly important because it offered the introduction of current earthquake engineering laws [15, 16]. Since 1960, the day of 1st September (the day when the Great Kanto Earthquake and a typhoon occurred) was designated as the "Disaster Prevention Day" in Japan. Every year, on this day, public awareness and educational programs are conducted all over the country, in order to commemorate and keep alive the memory about disasters in Japan [15].

An important step towards the institutionalization of disaster risk reduction and learning from disasters occurred in 1961, when the Disaster Countermeasures Basic Act was legislated. This legislative act had important consequences for Japanese disaster risk management and established the fundamental disaster prevention laws. In 1962, the national coordinating body for disaster management was established (the Central Disaster Management Council of Japan), which has role in formulating the overall policy for disaster risk management and is chaired by the Prime Minister. A special committee of the National Diet (Japanese Parliament) closely monitors disaster risk management and disaster risk reduction progress [15, 16].

On the 17 January *1995*, *the Great Hanshin-Awaji* known also as the *Kobe* earthquake with M_W (moment magnitude) 6.9 occurred in Kobe and its vicinity; 6437 people died and Kobe suffered massive destructions and damages. After this earthquake, many lessons were identified and their implementation was carefully monitored. The Kobe earthquake brought to attention various shortfalls of the earthquake disaster management in Japan. Until the Kobe 1995, Japan had government-centered disaster management policies and practices and the role of government was dominant in disaster preparedness and response. However, after the Kobe earthquake, the importance of local communities in disaster response and disaster management strongly emerged. Between 1 and 1, 5 million volunteers from outside Kobe contributed to help the survivors in the first months after earthquake [17]. After Kobe 1995, the role of volunteers and NGOs in disaster preparedness, mitigation, rescue, relief, reconstruction, and recovery considerably increased. More than 16 national laws were adopted in Japan in order to improve cooperation among various governmental levels and civil society organizations. The day when the Great Hanshin-Awaji Earthquake occurred, the 17 January, was declared by the government as the "Volunteer Day" and the days between the 15 and the 21 January were designated in Japan as the "Disaster Reduction and Volunteer Week" [18]. The Disaster Countermeasures Basic Act was revised by the government and a major revision was implemented in 1995, with the main focus to improve the immediate response system. In January 2001, a new position of the Minister of State for Disaster Management was created in the Cabinet Office and was fully dedicated to inter-ministerial planning and coordination. The new minister can also act on behalf of the Prime Minister for the Central Disaster Management Council [15]. Based on the lessons from Kobe earthquake disaster, the seismic engineering

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standards for road bridges were revised in 1996 and 2002 and their implementation closely monitored. Seismic engineering standards for railways were revised in 1998 and seismic reinforcement of elevated tracks, bridges, supporting pillars and the tunnels of Shinkansen and main artery lines were also closely monitored [16]. The Hyogo Prefectural Government with financial and technical support from the Cabinet Office organized the Disaster Reduction and Human Innovation Institution (DRI), in 2002, as a center for research and study of disaster risk management together with a museum facility in Kobe. The aims were to promote the lessons from the Kobe 1995, increase earthquake risk awareness among the younger generations and improve earthquake disaster management in Japan. The DRI museum exhibits the devastations of the Kobe earthquake disaster and reconstruction process. The Kobe's survivors were asked to convey their disaster experiences and invited to act as volunteers at the museum [15].

Just a few months before the 10th anniversary of the Kobe 1995, on 23 October *2004*, an earthquake with M_w 6.8 occurred, in *Chuetsu* region, *Niigata* Prefecture. It caused 68 fatalities and more than 4805 injuries. Moreover, another earthquake occurred in Niigata prefecture on 16 July 2007 with M_w 6.8. After the Niigata 2004 earthquake, the system of the Shinkansen trains was upgraded to avoid derails due to earthquakes. Few years after the Niigata Chuetsu 2004, the Japan Meteorological Agency (JMA) launched on 1 October 2007, the Earthquake Early Warnings (EEW) system [16].

On 11 March *2011*, an earthquake with M_w 9.0 occurred in the Tohoku region, with the epicenter near the Japan Trench off the coast of Japan. The *Tohoku* earthquake known also as the *Great East Japan Earthquake* was 45 times more powerful than the Great Kanto Earthquake in 1923, and 1450 times more powerful than the Great Hanshin-Awaji Earthquake in 1995. Less than half an hour later, the earthquake was followed by a massive tsunami, which reached to height of 40 m in some areas over the land. The nuclear reactors at the Fukushima Daiichi Nuclear Power Plant were seriously affected and uncontrolled radiation was spread in the atmosphere, water and land [17]. The number of dead people reached 20,000, but the death and destruction from the Tohoku earthquake itself was much less than previous earthquakes, because of learning from previous earthquake disasters and progress of earthquake disaster preparedness and earthquake disaster risk management [16]. Nevertheless, the magnitude of this earthquake exceeded the hazard level of any earthquake in Japan ever considered for earthquake disaster risk management and emphasized that Japan needs to be prepared for the worst scenario of hazard and disaster. "Prepare for the worst case" was recommended in Japan ([16], p. 231). The EEW system and seismic reinforcement of houses and critical infrastructures effectively reduced the number of casualties from the earthquake. After the EEW system was activated, on 11 March 2011, all Shinkansen trains were safely slowed down and stopped with no derailments or injuries to passengers on board. Moreover, because of seismic reinforcement of elevated rail tracks and bridges, none of them collapsed. All households in Japan connected to city gas service are equipped with micro-chip controlled gas meters which automatically shut down gas flow when an earthquake with a seismic intensity stronger than 5 is detected in area. Due to the learning lessons from the large-scale fire occurred in Kobe in 1995, on 11 March 2011 the gas flow to each household was stopped and the Sendai City Gas Service interrupted all the supplies from their gas factories [15]. The social learning occurred between the earthquake disasters of Kobe 1995 and Tohoku 2011 positively affected relief and reconstruction efforts after the 2011 events. For instance, gas, water, electricity were reconnected after 1 week. The

Operation Comb had as result the reopening of the railway service and roads in 4–15 days and the repair of bridges took one weak. Radios were distributed immediately and internet and phone lines were restored within 3–7 days. The construction of housing units started in 8 days and more than 100,000 people were housed in 3–4 weeks [18].

The disaster management of Japan registered many improvements, as since Kobe 1995, a government crisis center was on duty 24 h of 7 days with a stand-by emergency team. Moreover, the Japanese government took action just 4 min after earthquake and an Emergency Disaster Response Headquarters, headed by the prime minister, was organized within 30 min. Immediately after the Tohoku 2011, the National Committee for Emergency Management headed by Prime Minister was assembled. A national emergency state was declared in Japan and more than 100,000 troops of the Japan Self-Defense Forces (JSDF), both active and reserve troops, were started to be deployed and reached in affected areas within hours. JSDF reached to 107,000 people; they were fully equipped and deployed operations with 540 aircrafts and 60 vessels. They rescued 19,000 disaster victims – almost 70% of the people rescued in the cascading Tohoku disaster [16].

After the Tohoku 2011 disaster, the Prime Minister Naoto Kan acknowledged the help received from over 130 countries, 30 international organizations and 670 NGOs. This was a different attitude if compared with the situation after the Kobe earthquake in 1995, when the Japanese government displayed an extreme reluctance to receive help. Moreover, the American military forces were invited to help Japan and the operation Tomodachi (friend) took place. With the help from USA forces, on 13 April 2011, the Sendai Airport was reopened to commercial flights [19]. The Central Disaster Management Council of Japan commissioned a special Committee for Technical Investigation on Countermeasures for Earthquakes and Tsunamis in order to draw lessons from 2011 disasters. Based on the findings of this committee, the Disaster Countermeasures Basic Act was revised twice, First Amendment in 2012 and Second Amendment in 2013, in order to prepare Japan for large-scale disasters [15].

2.2. Earthquake disaster risk in Iran and learning from large earthquake disasters over time

Aspects of learning from the earthquake disasters in Iran were investigated mainly through the case studies of 15 earthquakes and large earthquake disasters – *Silakhor 1909*, *Salmas 1930*, *Torud 1953*, *Buyin Zahra 1962*, *Dasht-e Bayaz 1968*, *Ferdows 1968*, *Karzin-Qir 1972*, *Tabas 1978*, *Golbaf 1981*, *Sirch 1981*, *Rudbar 1990*, *Zirkuh (Qa'enat) 1997*, *Bam 2003*, *Ahar 2012* and *Shonbeh-Bushehr 2013* – which affected different places in Iran, over a period of more than a century, see **Figure 2**.

On 23 January *1909*, *Silakhor* earthquake with M_w 7.4 occurred in Silakhor valley. More than 8000 people died, more than 65 villages were destroyed and town of Bahrain (nowadays Dorud) and the city of Borujerd suffered damages [20]. At that time, Persia (the country name changed to Iran in 1935 under Reza Shah Pahlavi) was ruled by the Qajar dynasty and suffered the consequences of the 1907 Anglo-Russian Convention. Within the geopolitical landscape of Persia at that time, the earthquake disaster occurred in the shadow; neither relief

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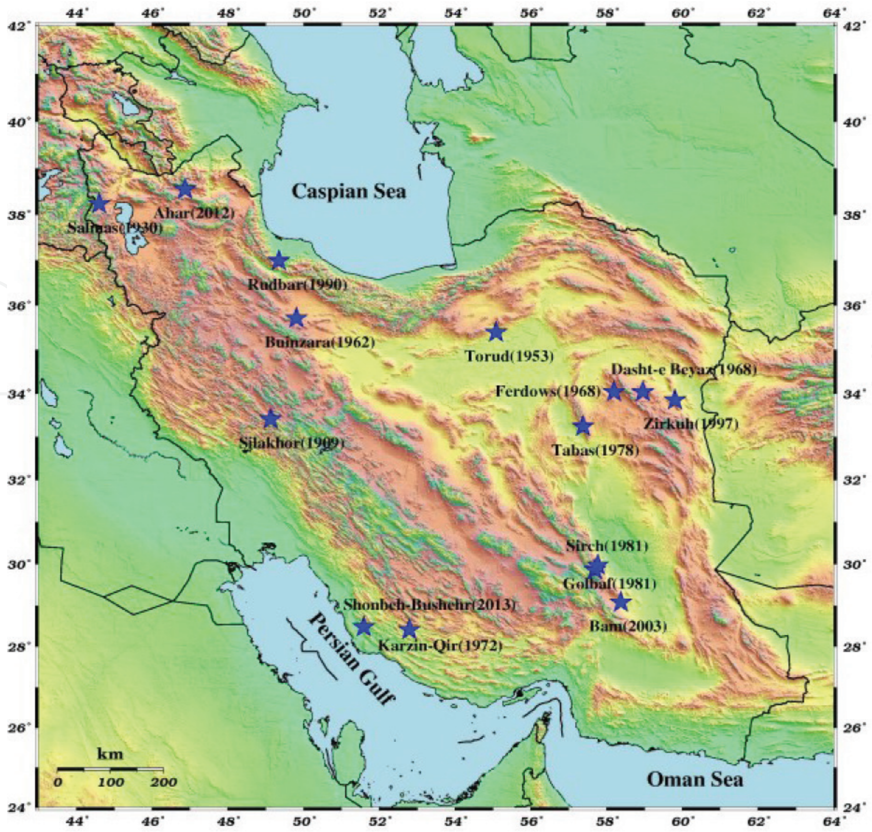

Figure 2. Iran-earthquakes and earthquakes disasters over more than a century [1].

was sent to the affected areas, nor reconstruction efforts were supported by the authorities or competing powers in Persia, Russia and England.

Salmas earthquake with M_w 7.1 occurred on 7 May *1930*, in Salmas Plain and mountains areas, northwest of Iran. The cities of Dilman and Kohneh Shar together with other 60 villages were destroyed and around 2514 people died. An alarming foreshock, which occurred in the morning before earthquake, significantly contributed to lower the number of deaths. The majority of population in the area spent the night of the earthquake outdoors and casualties occurred only among the population that did not feel the foreshock or perceived it just as a small tremor. Reaction of the local population to this warning foreshock drew attention to the existing level of earthquake risk perception in the area. The official attempts for rescue and relief in Salmas and other affected areas were impacted by a severe condition of roads after earthquake [20].

On 12 February *1953*, *Torud* earthquake with M_w 6.5 occurred in the central part of Iran on the margins of Dasht-e Kavir (literally "Great Salt Kavir") killing 930 people. Torud earthquake was investigated by the Iranian-Armenian professor Setrak Abdalian, who inaugurated the practice of earthquake geology in the field in Iran. Almost 3 years after Torud, progress towards the study of earthquake geology in Iran was registered, as in 1957, the Institute of Geophysics was established at the University of Tehran as an institution monitoring and reporting the seismic activity in Iran [20]. One of the first legal steps taken in Iran towards disaster mitigation was the establishment of the Civil Defense Organization in 1958. This organization operated under the Ministry of Interior and was supported by the Army Forces and the Red Lion and Sun Society (RLSS) of Iran [21].

On 1st September *1962*, *Buyin Zahra* earthquake with M_w 7.0 occurred in the southern Qazvin area, south-west part of Tehran. More than 12,000 people died, almost 3000 people were injured, Buyin Zahra and other 91 surrounding villages were destroyed. Within few days after the Buyin-Zahra earthquake disaster, at the request of governmental institutions of Iran, the United Nations Educational, Scientific and Cultural Organization (UNESCO) sent two missions to Iran in order to study the Buyin-Zahra earthquake and investigate further seismological and engineering aspects. The Buyin-Zahra 1962 marked the beginning for study of large magnitude earthquakes in Iran. Moreover, in 1962, the Geological Survey of Iran (GSI) was established in Tehran, based on a special fund project from the United Nations Development Programme (UNDP), with financial contributions from both the United Nations (UN) and the Imperial Government of Iran. GSI started to proceed to a systematical geological investigation of all parts of Iran. After the Buyin-Zahra 1962, the director of UNESCO convoked an international seminar, at the University of Tehran and a preliminary report about the first Iranian buildings code was discussed at this seminar. This code was prepared based on the United States Uniform Building Code and the San Francisco's, California Code [20]. After Buyin Zahra 1962, a Committee for Assisting the Injured was established and the board members were both from Army forces and from the RLSS [21].

Dasht-e Bayaz earthquake with M_w 7.1 occurred on 31 August *1968* in an arid area of the eastern part of Iran. More than 10,000 people died and more than 160 villages either were destroyed or suffered damages.

On the western part of the Dasht-e Bayaz fault and almost 20 h after the Dasht-e Bayaz earthquake, on 1 September *1968* and also 3 days later, two earthquakes with M_w 6.3 and 5.5 respectively, occurred in the *Ferdows* region. The town of Ferdows and many other villages were almost destroyed and more than 750 people died [20]. The first national Iranian code for the seismic resistance building design, known as the Iranian Standard ISIRI (Institute of Standards and Industrial Research of Iran), code no. 519, was approved and started to be implemented in Iran from 1969, immediately after the Dasht-e Bayaz 1968 earthquake disaster [20]. After the Dasht-e Bayaz 1968 earthquake, the Committee for Assisting the Injured in Iran established the Rescue and Relief Organization as a sub-branch of RLSS in order to conduct the emergency disaster response in Iran [21]. After the Dasht-e Bayaz 1968, a second UNESCO mission was deployed to Iran. For the first time, after an earthquake in Iran, the National Cartographic Center of Iran took aerial photos at a scale of 1:7500 for the earthquake affected areas. After Dasht-e Bayaz 1968, a systematic investigation of the large-magnitude earthquakes was deployed in Iran. A joint project dedicated to research of Iran's seismicity commenced between the Technical Bureau of the Plan and Budget Organization of the Imperial Government of Iran and the Imperial College of Science, London. Moreover, in 1971, the first research department of Tectonics and Seismotectonics was established at the Geological Survey of Iran by Dr. Manuel Berberian. In 1973, Ali Akbar Moinfar established the first strong motion network of Iran. In 1976, the satellite imagery, more precisely ERTS (Earth Resources Technology Satellite) called later Landsat, was used for the first time in Iran for active fault detection and earthquake studies [20].

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Karzin-Qir earthquake, with M_w 6.9 occurred on 10 April *1972* and more than 5000 dead people and 1710 injured were registered in 50 villages [20]. After the Karzin-Qir earthquake, the role of Civil Defense Organization (CDO) of being in charge with disaster risk management in Iran increased. At that time, CDO had important roles in disaster risk management of Iran, as was responsible to assure the coordination among various governmental institutions during the disasters and crisis emergencies. Other responsibilities targeted to promote disaster preparedness and public safety in Iran. After the Islamic Revolution in 1979, in Iran, the CDO was dissolved and its functions were transferred to the Basij Mostaz'afin (Revolutionary People Union) [21].

Tabas earthquake with M_w 7.4 occurred on 16 September *1978*; the town of Tabas, was terribly affected and 85% of its inhabitants were killed as 11,000 of its 13,000 inhabitants died. Nevertheless, the total number of deaths reached to 20,000, as other 90 villages around Tabas suffered destruction or severe damage [20]. Just few months later after Tabas 1978 earthquake disaster, Reza Shah Pahlavi left Iran and the Islamic Revolution took place in 1979. Furthermore, between September 1980 and August 1988, the 8 years Iran-Iraq war occurred. Focus of Iran and the resources of country were concentrated on other dramatic events and then, far from learning from large earthquake disasters and building an earthquake culture in Iran. After the Islamic Revolution in 1979, the crisis management responsibilities were transferred to the Prime Minister's Office. However, in 1989, the position of Prime Minister was dissolved in Iran.

During Iran-Iraq war time (1980–1988), on 11 June *1981*, *Golbaf* earthquake with M_w 6.6 destroyed the town of Golbaf, situated near Kavir-e Lut, southeastern part of Iran and 1400 people were killed. On 28 July *1981*, 47 days later, the area was again severely affected by the *Sirch* earthquake with M_w 7.0. At that time, 25 villages were completely destroyed, and between 800 and 1300 people died (Berberian 2014). During the hardship of the Iran-Iraq war, various actions in Iran added to efforts towards learning from earthquakes and earthquake disasters in Iran. The Department of Tectonics and Seismotectonics, at Geological Survey of Iran, had a great contribution to the seismotectonics knowledge about Iran. Active faults for the Greater Tehran and Qazvin area were mapped and many fieldworks were conducted after each earthquake which took place in this period of time. The second revised Iranian code for seismic resistant design of the buildings, ISIRI code no. 2800 was approved in February 1988 and for the first time, a map with active faults of Iran was used for its preparation [20].

In November 1989, just few months before Rudbar 1990 earthquake disaster, based on the 24th UNESCO General Conference Resolution DR/250 and the Iranian governmental ratification, an organization named the International Institute of Earthquake Engineering and Seismology (IIEES) was established. IIEES is part of the Ministry of Science, Research and Technology and in 1999, it was approved to become a research center of Iran and has as aim to reduce earthquake risk and to improve earthquake mitigation in Iran.

Rudbar earthquake with M_w 7.3 occurred half an hour after midnight, on 21 June *1990*, in the northern part of Iran, southwest side of the Caspian Sea. The Rudbar earthquake affected both rural and urban areas. The most affected areas were the towns of Rudbar, Manjil, Lowshan and Harzehvil and many villages in Gilan and Zanjan provinces. The city of Rasht suffered also damages. More than 40,000 people were killed, more than 60,000 people were injured, and 700 villages were destroyed [20]. A major lesson brought by Rudbar earthquake disaster was the massive damage caused by earthquake-induced landslides [4]. After the Rudbar 1990, in terms of disaster risk management, the leadership was transferred to the National Disaster Task-Force (NDTF), which was part of the Ministry of Interior. The Ministry of Interior was officially assigned as the executive agency to oversee and coordinate all activities with reference to disaster prevention, mitigation, emergency relief and rescue operations, rehabilitations and reconstruction. In addition to the central Disaster Task-Force, there were also provincial, district or municipality and sub-district Disaster Task-Forces. In 1991, the National Committee for Natural Disaster Reduction (NCNDR) was established as a policy-making organization for disaster risk reduction in Iran; the NCNDR was part of the Ministry of Interior and the Minister of Interior was the head of NCNDR [21].

On 10 May *1997*, another large earthquake disaster took place after the *Zirkuh (Qa'enat)* earthquake with M_w 7.2. According to official figures, about 1568 people died and 2600 were injured. After the Zirkuh 1997, starting from 1998, the technique of InSAR (Interferometric Synthetic Aperture Radar) was used for the first time in Iran, for study of the Gowk Fault and associated earthquakes. Towards the implementation of technology for seismological studies in Iran, a Iranian-French collaboration was defined by IIEES and the first-large scale Permanent Global Positioning System (IPGN) was implemented with 25 sites in Iran, 2 in Oman and 1 in Uzbekistan [20].

Bam earthquake with M_w 6.6 occurred on 26 December *2003* and the Bam city, in Kerman province, was totally destroyed. The town of Baravat and the villages around also suffered damages. The death toll passed more than 40,000 people. The cultural landscape of Qanats, gardens of Khorma trees, Arg-e Bam and their associated cultural beliefs had a strong impact on the local earthquake risk perception before this earthquake [5, 6].

After Bam 2003, the authoritative command of disaster risk management in Iran was given to the President of Iran. General Policies on Natural Hazards Risk Mitigation and Disaster Management were prepared by the Expediency Council of Iran in 2005. However, many of these policies are yet pending to be implemented in Iran. Moreover, in 2008, the National Disaster Management Organization (NDMO) with national, city and provincial structures was established in Iran for disaster risk management and risk mitigation. Many difficulties were registered for coordination of various organizations, lack of expertise for implementations of different plans and policies, lack of regular updates and supervision and especially, the allocated budget was not sufficient. The Integrated Disaster Risk Management (DRM) in Iran suffers of many shortcomings as many institutions and organizations are working individually with no effective collaboration among them. Moreover, DRM laws and regulations, policies and plans did not take in account local conditions and community based preparedness and participation to disaster reduction and disaster risk management. Effectiveness of many earthquake disasters plans and policies has not been satisfactory in Iran, as many of them were not applied in practice, properly monitored and without adequate legal enforcements for their application [22].

On 11th August *2012*, two earthquakes-*Ahar* earthquakes- with a magnitude of M_w 6.4 and 6.3 respectively, occurred at an interval of 11 min, in northwest part of Iran, northeast side of Tabriz. Ahar and Varzeqan towns suffered damages, 300 people died and more than 3000 suffered injuries. Rescue and relief reached the area very late [20].

On 9th April *2013*, at 16.22 local time, *Shonbeh-Bushehr* earthquake with M_w 6.4 occurred in Dashti district, south-west part of Bushehr province and 37 people died and 850 were injured. The Building and Housing Research Centre (BHRC) as part of the Ministry of Housing and Urban Development is conducting periodical revisions of the Iranian code of practice for the seismic resistance design of buildings in Iran. However, the implementation of the seismic building codes is still on long way to become in practice in Iran.

3. Discussions

All the above earthquakes and earthquake disasters in Japan and Iran, over more than a century-time period, shall be considered as important wake-up calls towards the learning from large earthquake disasters and building an earthquake culture. Their death toll (**Figure 3**) have required long-term sustainable strategies for earthquake disaster risk reduction in Japan and Iran. The disaster of Shonbeh-Bushehr 2013, Iran, with 37 people dead, was not presented in **Figure 3**.

A probability density function (PDF) of the number of the dead people in Japan and Iran was plotted and a wide scatter is seen for Iran case, while a narrower scatter with lower mean value is observed for Japan (**Figure 3**, right). It should be noted that for the Tohoku 2011, only 6% of 20,000 death people were taken in account for plotting of the PDF, as according to estimations, the majority of death was caused by the tsunami drownings and only 6% of causes of death were caused by collapse of buildings and fires after earthquake [18]. Moreover, with reference to Great Kanto 1923, the death toll was not consider for the PDF, as there is a significant uncertainty about the number of dead people associated with earthquake. In fact, the majority of death was caused by secondary hazards such as fires, tsunami, landslides, drowning in the water [14].

In Iran, there is no linear correlation between magnitude and number of dead people, as even a medium magnitude earthquake caused one of the highest number of death, such as the

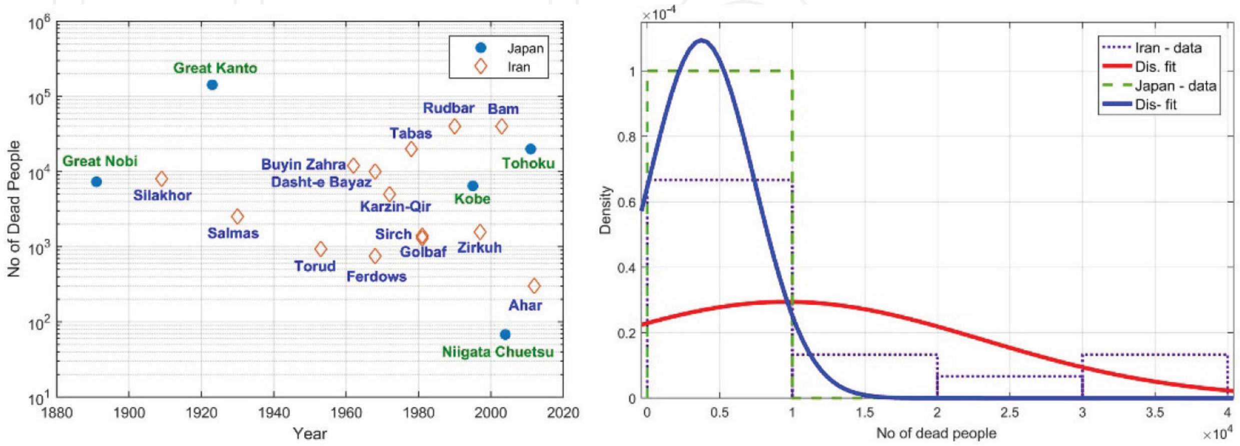

Figure 3. Earthquakes and earthquake disasters in Japan and Iran over more than a century: The number of dead people versus year (left) and the probability density function (PDF) of the number of the dead people (right).

earthquake in Bam in 2003. However, in Japan, there is almost a linear correlation between the magnitude of earthquakes and the number of dead people (**Figure 4**). This lack of correlation in Iran and existence of linear correlation in Japan highlights that the magnitude of earthquakes directly affects the number of fatalities and extent of destruction and damage in Japan, while in Iran, there is an increased complexity with regard to the factors affecting earthquake consequences.

In Iran, it is seen that all the 15 earthquakes are less than 7.5 magnitude, while in Japan, the magnitude is much higher and can reach 9 (**Figure 4**).

The probability density function (PDF) of the earthquakes' magnitude in Iran and Japan, over more than a century- and the probability paper plot of the Normal distribution are shown in the **Figure 5**.

A normal distribution was derived from the magnitude distribution of earthquakes in both Iran and Japan, as illustrated in the probability plot in **Figure 5**. The mean values of the normal distributions are 6.88 for Iran and 7.72 for Japan. The variance for Iran is 0.146 and for Japan is 0.817. This indicates a wider scatter of magnitude for Japan. It is also interesting to observe that while an earthquake with magnitude of 8 or higher is towards the tail of the distribution with low probability in Iran, such high magnitude earthquake has a high probability to occur in Japan (**Figure 5**). Despite the lower mean value for the earthquakes in Iran, this did not lead to a lower number of fatalities. This further confirms the lack of linear correlation between magnitude and number of dead people in Iran and the complexity of

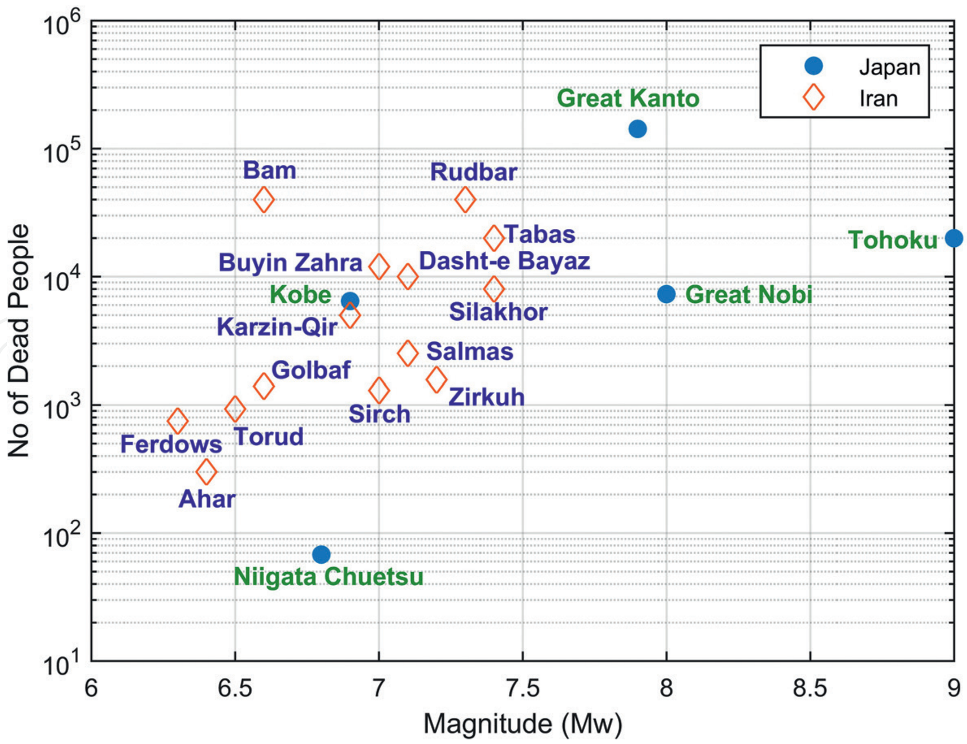

Figure 4. Earthquakes and earthquake disasters in Japan and Iran over more than a century and the number of dead people versus magnitude.

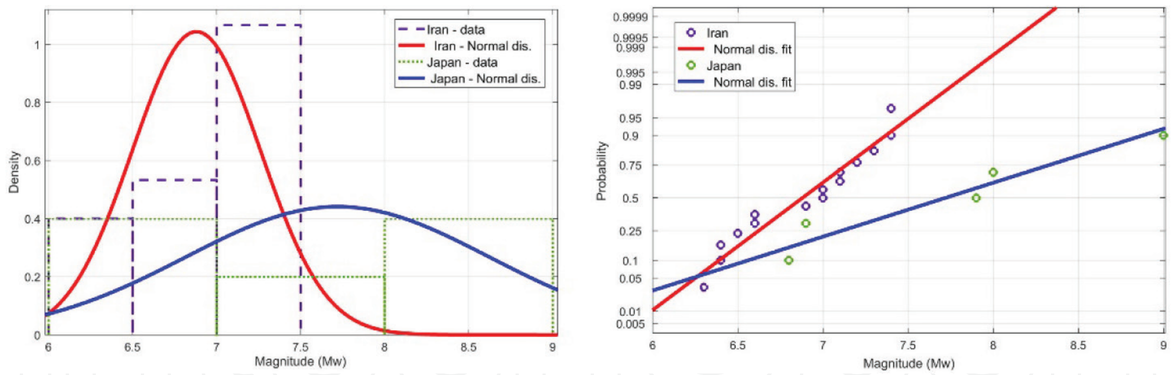

Figure 5. Probability density function (PDF) and the probability paper plot of the normal distribution of the earthquakes' magnitude in Iran and Japan.

factors concurring in an Iranian earthquake disaster. From the Japanese perspective, Japan has learned the lessons from earthquake disasters over time, but the magnitude and seismic intensities of earthquakes has high impact on the number of fatalities.

Japan long-term experience of earthquake disasters has encouraged a culture of prevention [15], a seismic culture [23] and a culture of Lessons-Learned [16]. Over the time, Japan learned how to prepare for and to respond to earthquake disasters and how to foster an earthquake culture, and to learn from disasters. Over the last century and in the present century, learning from earthquake disasters, building of the earthquake culture and earthquake disaster risk reduction were not among the national priorities of Iran. The earthquake culture in Iran is still far from becoming a reality of the present time [1].

Learning from large earthquake disasters in Japan and Iran have been impacted by various factors, **Figure 6**. As a remark, the landscape of factors that have influenced and impacted learning from large earthquake disasters in Japan and Iran, as presented by **Figure 6** is non-exhaustive and other factors can be further identified. Some of the factors are non-existent for Iran, like Earthquake Early Warning (EEW), museums and monuments about preservation of memory from earthquake disasters, accountability of governance and decision makers for earthquake disaster risk reduction (EDRR).

The impact of these factors on the learning in Japan and Iran was not constant over time and further introspection is required about their dynamism over the time.

In **Figure 6**, it can be observed for the case of Japan that science and technology has had both a negative and positive impact on the learning from large earthquake disasters. After March 2011 cascading disasters, in Japan, the trust of society in government and especially, the confidence in science and technology and overreliance on scientific information were dramatically shaken. Many voices from the Japanese society expressed that the Tohoku 2011 disasters was seen as divine punishments for strong beliefs of the Japanese people about their supremacy and control over nature through science and technology. The Tohoku 2011 disasters were believed to be tough lessons for the Japanese nation, because its people had supposedly become arrogant and disrespectful towards the power of nature. A politician declared that "this disaster is divine punishment for our selfishness". At a conference of the Seismological

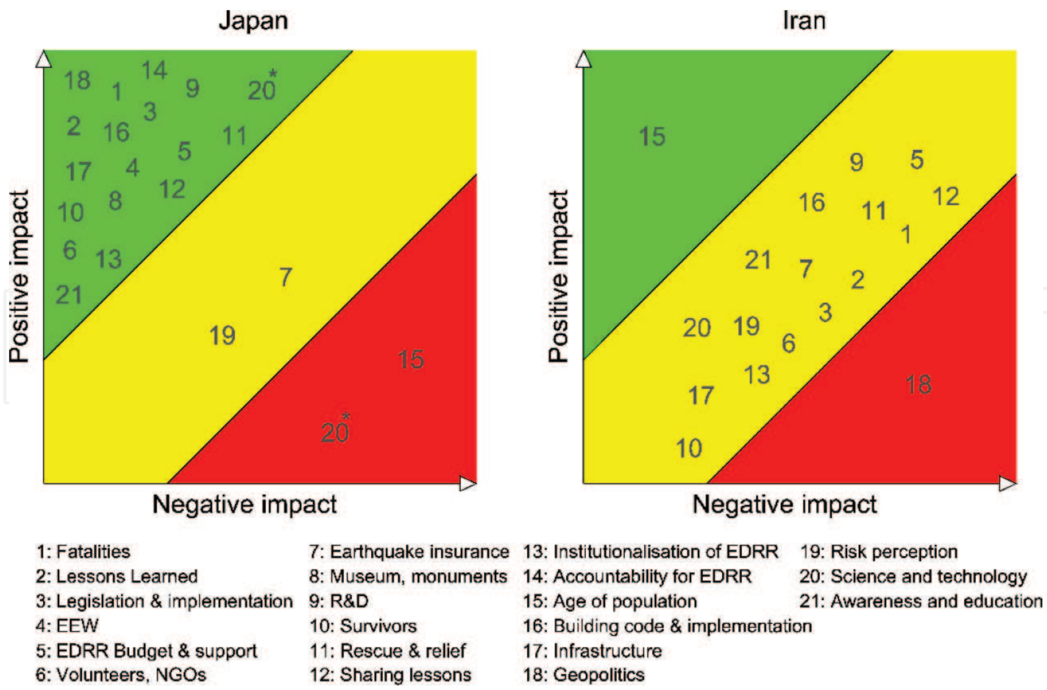

Figure 6. Overview of a non-exhaustive landscape of factors that have affected learning from large earthquake disasters in Japan and in Iran.

Society of Japan, there were many Japanese earthquake researchers who categorized the Tohoku 2011 disaster as a "failure of seismology". The reasons why the Tokohu 2011 events were categorized as "unforeseen" (souteigai, in Japanese) were seen as unacceptable ([17], p. 73). Moreover, the myth of nuclear safety in Japan was seriously shaken among society. After the Tohoku 2011, in addition to scientific knowledge, the importance of local knowledge about disasters and disaster preparedness started to strongly revive in Japan [17].

The geopolitics in Iran and in the Middle East area, the complex and dynamic power structures in Iran had a strong negative impact on the learning from earthquake disasters and building an earthquake culture. Over more than a century, the earthquake disasters were frequently overshadowed by other disasters in Iran, such as: the 8 years Iran-Iraq war, intervention of foreign powers in Iran (Russia, UK, USA), political turmoil (Mosadeq 1953, Iranian Revolution 1979). Despite very rich oil and gas resources of Iran, the country focus and support have been shifted further from mitigation and preparedness for earthquake disasters and development of an earthquake culture [1]. One of the critical issues faced nowadays by the Japanese society is the aging of population, which can have serious negative impact on disaster preparedness. Japanese population is aging with the fastest rate in the world. According to extrapolations from existing trends, one in three people will be over 65 years old by 2050 [24, 25]. Moreover, Maki [24] highlighted that together with aging, massive migration of young population after the Tohoku 2011 disasters, and depopulation in many areas of Japan will jeopardize disasters preparedness, response and resilience in Japan. On the positive side, Iran has a higher percentage of young population compared to Japan. According to demographics, the median age for Iran is 29.4 and for Japan is 46.9 [26].

In Japan, a few years later after the Niigata 1964 earthquake, more precisely from 1966, the Earthquake Insurance Law was ratified and started to be implemented, but the earthquake

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insurance is still not well developed in Japan. In Iran, despite many earthquake disasters, the insurance penetration ratio is very low. Laws, regulations and policies in Iran, in the last decades, did not encourage development of a catastrophe insurance pool [27]. Earthquake disasters in Iran brought many lessons to be "learned" and with great potential to contribute to the social-cultural learning and social-cultural memory [1, 4, 12]. However, from the investigated case studies of large earthquake disasters, only few lessons were consistently oriented towards the earthquake disaster risk reduction in Iran [4]. In Iran, an institutionalization of earthquake disaster risk occurred in the last half century, but legislation, policies and practices need to be supported by adequate planning and budget, implemented, and continuously monitored [21, 22]. Moreover, the JICA report [21] drew attention to important shortcomings of the earthquake disaster risk reduction in Iran. The critical areas included were not limited to the implementation of legislation and policies in Iran, the lack of national, regional, urban and rural disaster prevention and disaster risk management plans, the funds and budgets not properly allocated for earthquake disaster mitigation, preparedness and emergency stages, lack of implementation of seismic codes and seismic retrofitting. In addition, measures and tasks related to disaster preparedness and disaster risk management were not clearly identified, defined and explained, at both national and regional levels.

Tohoku 2011 cascading disasters highlighted for Japan that "Preventive investments pay, but be prepared for the unexpected", as it is important to understand that "the risks from natural hazards can never be completely eliminated" [16]. Furthermore, the Tohoku 2011 cascading disasters (earthquake, tsunami and nuclear catastrophe) highlighted for Japan the absolute requirements for a dynamic learning from earthquake disasters, a sustainable earthquake culture and the necessity of continuous improvement towards an integrated earthquake disaster risk management.

Over time, a profound institutionalization of earthquake/disaster risk reduction efforts occurred in Japan. In addition, the required legislation, policies, practices and required budget exist and are being implemented and carefully monitored by the government and Parliament. Earthquake disaster risk reduction, which is mainstreamed in the national policies and Japan disaster risk management, is always part of the national political agenda. Moreover, security of financial resources and the required budget for earthquake disaster risk reduction is continuously assured [15]. Worldwide, an effective and sustainable way of learning from earthquake disasters and mega-disasters was shown by Japan and its status of earthquake nation [13, 16]. After a necessary adaptation to the Iranian local context, the Japanese culture of continuous learning from past earthquake disasters and continuous improvements of earthquake disaster preparedness can serve as a model for Iran [1, 4, 12].

4. Conclusions

An investigation of earthquakes and large earthquake disasters in Japan and in Iran over a period of more than a century brought to attention that a normal distribution was found to be a good estimate of the magnitude distribution for earthquakes in both Japan and Iran. In Japan, there is almost a linear correlation between magnitude of earthquakes and number of dead people. However, in Iran, there is no linear correlation between magnitude and number of dead people, as even a medium magnitude earthquake caused one of the highest number of death. This can be an indicator that the magnitude and seismic intensity of earthquakes directly affects fatalities and damages in Japan, while in Iran there is an increased complexity in the factors affecting earthquakes consequences.

There is a strong correlation between the earthquake culture and learning from large earthquake disasters. The learning from large earthquake disasters in both Japan and Iran requires existence of a dynamic system such as the earthquake culture. Nevertheless, the existence and development of the earthquake culture is conditioned by the dynamic learning from earthquake disasters over time.

Learning from large earthquake disasters in both Japan and Iran has either encountered medium or less impact from different factors or has been influenced in a negative and positive way. However, the rhythm of learning from earthquake disasters in Japan is much higher comparative with Iran. Over more than a century, Japan learned how to mitigate, prepare for and respond to earthquakes and earthquake disasters and foster an earthquake culture. Improvements may be still needed, but a steady progress towards the integration of the earthquake disaster risk management has occurred in Japan. On the other hand, in Iran, integration of earthquake disaster risk management is still lacking a structured approach and is requiring urgent and critical measures and actions.

Dynamic learning from earthquake disasters, a sustainable earthquake culture and an integrated earthquake disaster risk management can positively contribute not only to the earthquake disaster risk reduction, but also towards tsunami risk disaster reduction and nuclear safety in Japan and in other countries at risk around the world.

In Iran, an institutionalization of earthquake disaster risk reduction took place in the second half of the last century and there has been a favorable foundation and factors that can contribute to the building and development of an earthquake culture. However, after more than a century-time period of dramatic experiences of many large earthquake disasters, the learning from large earthquake disasters is slow and an earthquake culture is still pending to become a reality in Iran. Earthquakes and earthquake disasters contributed to status of Japan as an earthquake nation with a mature earthquake culture, but for Iran, this did not happen until present time.

Learning from the Japanese culture of dynamic learning from large earthquake disasters is recommended for Iran and other countries at seismic risk. Moreover, the Japanese earthquake culture can inspire adaptations and adoptions to the Iranian context and specificity of place.

A proactive approach to earthquake disaster risk reduction and improvement of the earthquake disaster risk management is required for both Japan and Iran. A reactive approach to learning based on the past earthquake disasters needs to be constantly supported by a proactive approach and dynamic learning. Future and even present earthquake disaster risk in Japan and especially, in Iran might well exceed the proportions of the seismic risk from the last century.

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Conflict of interest

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