Making Gwadar A Sustainable City of Pakistan

A CASE STUDY FOR EARTHQUAKE AND TSUNAMI

Final Research Report

Submitted by

Tahir Mehmood (Assistant Meteorologist)

National Seismic Monitoring Center (NSMC)

Pakistan Meteorological Department (PMD)

Cabinet Secretariat Aviation Division, Pakistan

Visiting Researcher

Asian Disaster Reduction Center (ADRC) Kobe Japan

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Disclaimer

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The views expressed in the report do not necessarily reflect the views of the ADRC. The boundaries and names shown and the designations used on the maps in the report also do not imply official endorsement or acceptance by the ADRC.

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The response of Japan towards international community to reduce their vulnerabilities against natural hazards is tremendous. This effort is not only knowledge sharing but also give an encouraging message to the world that whatever fellow human beings are in misery, we need to help them out regardless of creed, color or nationalities. I would like to take opportunity on behalf of government of Pakistan to extend my heart-felt gratitude to government of Japan for their valuable contribution in this regard.

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I am confident that the knowledge and experience that I got from Japan will help to improve our seismic and tsunami monitoring techniques and hence ensure public safety and economic prosperity of the people of my country.

Tahir Mehmood

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1. Introduction to Pakistan and Gwadar

Pakistan is located in South Asia. It lies between latitude 23°30′ to 36°45′N and longitude 61°to 75°31′E. Iran, Afghanistan, India and China are located in South West, West, East and North of the country respectively as shown in (Fig-1). Southern region have a coastal belt along Arabian Sea. In the northern part of the country high mountains of Himalayas and Hindukush ranges dominate the region with some mountain peaks of above 8000 meters. History reveals that country has suffered from many natural disasters in the past especially due to floods and earthquakes. Both of these has caused massive loss of life and inflicted heavy infrastructure losses. These natural disasters have provided many important lessons which must be taken into account for any future planning.

Gwadar city is located on the Southwestern Arabian Sea coastline of Pakistan, in Balochistan province. Under development as a free trade port, it is the district headquarters of Gwadar District of Balochistan province. It is about 533 km from Karachi and 120 km from the Iranian border and 380 km northeast of the nearest point in Oman across the Arabian Sea. Gwadar Port is located at the mouth of the Persian Gulf, just outside the Strait of Hormuz, near the key shipping routes in and out of the Persian Gulf. It is expected that Gwadar will become a future economic hub and a modern port and a modern city in near future. The Gwadar Development Authority (GDA) is charged with the execution of master plan which was approved by the Government of Pakistan in 2003 related to zoning and international infrastructure networks development. It is usually difficult in an already urbanized environment in Pakistan to mitigate hazard and develop a disaster management system. Gwadar provides us an opportunity to develop a sustainable city which will remain safe city in case of any natural disaster. Here only case of earthquake and tsunami disaster is considered. A scheme out of the lessons learned from earlier earthquake disasters in Pakistan will help in achieving desired target.

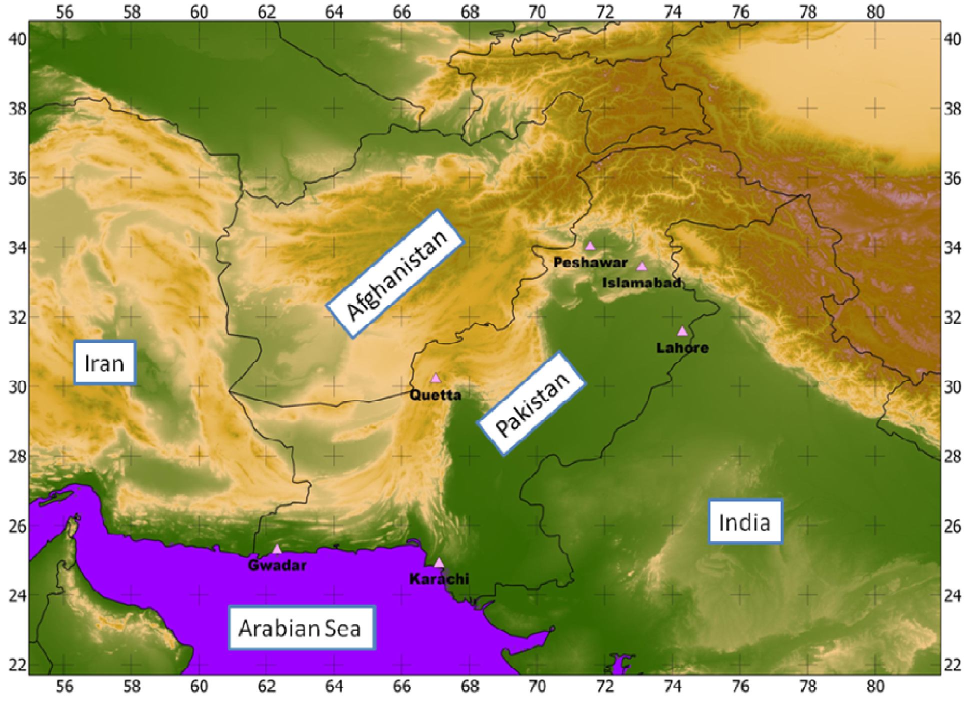

Figure-1. Geographic location of Pakistan and its main cities including Gwadar

2. Disaster Management in Pakistan

Geographic location of Pakistan makes it vulnerable to heavy floods caused by monsoon rainfalls and sometimes urban flooding. Through the history of Pakistan cyclones have hit the coastal areas of Pakistan from time to time. Due to frequent occurrence of these events the disaster management system was mainly based on flood disasters but after 2005 earthquake new scheme was evolved to cope with the situation. So the disaster mitigation and management system and policy can be divided into two eras mainly i.e. pre 2005 earthquake and post 2005 earthquake. The Structure for Disaster Risk Management of Pakistan is shown in (Fig-2).

Organizations like Pakistan Meteorological Department (PMD), Geological Survey of Pakistan (GSP) etc are working for hazard analysis and disaster mitigation work. Provincial and District Disaster Management Authority (PDMA, DDMA) under supervision of National Disaster Management Authority (NDMA) implement the policy through different institutes. The disaster management system in Pakistan is working in a two pronged arrangement. On one side scientific and technical institutes provide the technical guidelines and early warning and on other hand organizations work for rescues, relief and rehabilitation in their legal capacity. National Disaster Management Commission (NDMC) focuses to handle both pre and post disaster situation in the country.

Figure-2. Disaster Management Organiszation Structure of Pakistan (Source: Slide no. 25 of presentation by Nadeem Abro (NDMA), on National Disaster System & Laws in Pakistan, 2011).

2.1 Disaster Management System

2.1.1 National Level (National Disaster Management Commission (NDMC) and National Disaster Management Authority (NDMA)

Pakistan had suffered from flooding from time to time in the history but the 2005 earthquake also known as Kashmir earthquake was a special scenario with massive damage to houses, hospitals, schools and most importantly transportation infrastructure damages caused by the landslides. However it provided an opportunity to develop a system that will work towards disaster risk reduction and disaster management. Under the Article 89(1) of the Constitution of the Islamic Republic of Pakistan, National Disaster Management Commission (NDMC) was formed in 2006 which works under Prime Minister of Pakistan. The NDMC implements its decisions and policies through National Disaster Management Authority (NDMA) which works at national, provincial and district level. The mission statement of NDMA is "To achieve sustainable social, economic and environmental development in Pakistan through reducing risks and vulnerabilities, particularly those of the poor and marginalized groups, and by effectively responding to and recovering from all types of disaster events." (Source: http://www.ndma.gov.pk/AboutNDMA.php)

The futuristic approach of NDMA includes following important points

1. Institutional and legal arrangements for disaster risk management
2. Hazard and vulnerability assessment
3. Training, education and awareness
4. Disaster risk management planning
5. Community and local level programming
6. Multi-hazard early warning system
7. Mainstreaming disaster risk reduction into development
8. Emergency response system
9. Capacity development for post disaster recovery

In top to bottom governance system and decision making process, Pakistan has three levels of governances i.e. national, provincial and district government. At the provincial levels, the Provincial Disaster Management Authorities (PDMAs) are the focal points of the disaster management and at district level District Disaster Management Authorities (DDMAs) are established to handle disasters.

2.1.2 Provincial / Regional Level (Provincial / Regional Disaster Management Commissions (PDMCs) and Provincial/ Regional Disaster Management Authorities (PDMAs)

Provincial/Regional Disaster Management Commissions (PDMCs) established in each province/region. Under PDMCs, Provincial/Regional Disaster Management Authorities (PDMAs) in Punjab, Balochistan, Sindh, Khyber Pakhtunkhwa (KP) provinces and also in Gilgit-Baltistan (GB) and Azad Jammu & Kashmir regions (AJK) established. PDMCs are the policy making bodies and PDMAs are coordinating and implementing policies at provincial/regional levels. The functions of PDMAs are same as that of NDMA did at national level. PDMAs are concerned about disaster management in their respective provinces/regions.

2.1.3 District and Municipal Level (District Disaster Management Authorities (DDMAs) and Municipal Disaster Management Authorities (MDMAs)

District Disaster Management Authorities (DDMAs) shall be established by the provincial government in hazard prone areas on a priority basis. The District Authority will comprise of the Nazim, District Coordination Officer (DCO) and Police Officer (ex-officio), EDO health and Tehsil Nazims. The local government can nominate other officers as members of the DDMA or MDMA. They may include EDOs for education, red crescent, NGOs, media, private sector, fire services, or any other local stakeholders. Municipal Disaster Management Authorities (MDMAs) will be established in urban areas and cities on similar lines. DDMA and MDMA will formulate district disaster risk management plan based upon local risk assessment and coordinate its implementation, review development plans of government departments and provide guidance on mainstreaming disaster risk reduction measures in these plans. Also, encourage involvement of community groups in disaster risk reduction and response by providing them necessary financial and technical assistance for implementing community level initiatives

2.2 Role of Pakistan Meteorological Department (PMD) in Disaster Risk Reduction

Under the legal framework NDMA is the lead organization to develop strategies and disaster management. However many scientific institutes like PMD is working as a principle component to provide guidelines for hazard, risk and vulnerability assessment and early warning systems. Here only role of Pakistan Meteorological Department (PMD) is described due to great importance in both pre and post disaster events. Pakistan Meteorological Department (PMD) is one of the lead organizations working in the field of meteorology, seismology, aviation meteorology and allied fields. After the Indian Ocean Tsunami of 2004 “Up gradation of Seismic Network of Pakistan” as basic component of tsunami early warning system was initiated. The project is successfully completed and tsunami early warning center is working in Islamabad and backup center at Karachi. The project was part of a system initiated under the “Multi Hazard Early Warning System in Pakistan” which is now successfully implemented by development of specialized centers for early warning of tsunami, cyclones and in part flash flood. Alongside early warnings basic component of seismic hazard analysis, tsunami modeling and flood hazard maps have been created by PMD.

It is important to mention that PMD in collaboration with NDMA and UNESCO-IOC has developed standard operating procedure for earthquake information and tsunami early warning dissemination to NDMA and concerned stakeholders. Earthquake information is also communicated to media directly from centers of PMD. To handle disasters the department has established following specialized early warning centers:

- National Weather Forecasting Center Islamabad (NWFC)
- Marine Meteorology & Tropical Cyclone Early Warning Center Karachi (TCWC)
- National Drought Monitoring Center Islamabad (NDMC)
- National Seismic Monitoring and Tsunami Early Warning Center Karachi （NTWC）
- Flood Forecasting Division Lahore (FFD)
- Flood Forecasting and Warning System for Lai Nullah Basin Islamabad

Pakistan Meteorological Department (PMD) also launched District-wise Phone Based Weather Information Service in August, 2015 with the collaboration of Center for Language Engineering (CLE), of University of Engineering and Technology (UET), Lahore. This is completely automated system which will pick the weather forecast of any district from the computer model archive of PMD. Weather information service provides weather forecast of 139 districts of Pakistan. DG, PMD further informed that more details on weather information will be added and the number of phone lines will be increased and specialized weather information system for farmers of different districts of Pakistan will also be launched soon.

3. Disaster Management in Japan

Japan is located in Circum-Pacific Mobile Belt and due to this reason seismic and volcanic activities occur in Japan constantly. Although, the country covers only 0.25% of the land area on the planet, the number of earthquakes and active volcanoes is quite high. Also, because of geographical, topographical and meteorological conditions, the country is subject to frequent natural hazards such as typhoons, torrential rains and heavy snow. Every year there is a great loss of people's lives and property in Japan due to disasters. Up until the second half of 1950's, numerous large-scale typhoons and earthquakes caused extensive damage and thousands of casualties. However, with the progress of society's capabilities to address disasters and the mitigation of vulnerabilities to disasters by developing disaster management system, promoting national land conservation, disaster information communication systems, and disasters has shown a declining tendency.

The Japanese Government, in accordance with the Disaster Countermeasures Basic Act, annually submits to the National Diet a report, the White Paper, which includes overview of disasters occurring in Japan, various statistical data and disaster management measures taken by the Government. The Disaster Countermeasures Basic Act has constantly been reviewed and amended since its first enactment, and with lessons learned from the Great East Japan Earthquake 2011, provisions were added including enhancement to the measures concerning support activities mutually done by local governments in 2012 and the measures for ensuring for smooth and safe evacuation of residents and improving protection of affected people in 2013. In 2014, provisions were added for strengthening measures against unattended cars in order to promptly clear them from the roads. The outline of disaster management system in Japan is shown in Fig-3 below

Figure-3. Disaster Management System of Japan (Source: Cabinet Office of Japan, 2015)

3.1 Disaster Management System

3.1.1 National Level (Central Disaster Management Council)

Prime Minister of Japan is Chairperson of Central Disaster Management Council which established in the Cabinet Office based on Disaster Countermeasures Basic Act. The Minister of state for disaster management is empowered to direct the policies of administrative departments with regard to disaster management which is one of the most important items on the Cabinet's agenda and he plays a central role in policy making in the field of DRR and DRM.

Under the Disaster Countermeasures Basic Act, all public institutions as well as legal bodies involved in public business designated by the Prime Minister (such as the Bank of Japan, and corporations running public operations such as electricity and transport) are obliged to participate in the Central Disaster Management Council. At the national level, responsibility for the coordination of disaster response relies on the Minister of State for Disaster Management. Collectively, these designated public institutions play supportive role to the Government in formulation of disaster management policy and plan, and individually they prepare and develop their own disaster risk reduction operation plans based on the Basic Plan for Disaster Management and bear a range of responsibilities regarding finance and resources for disaster and cooperation. Other private companies also contribute to disaster reduction, for example, participation in the evacuation drills, preparation and transportation of rescue materials and so on.

3.1.2 Prefectural Level (Prefecture Disaster Management Council)

Local level is classified as Prefectural (Regional or Provincial) and Municipal Governments. The Prefectural Disaster Management Council has the same structure as that the Central Disaster Management Council has at national level. Governor of the prefecture acts as Chairperson of Prefecture Disaster Management Council. Main responsibilities are formulation, promoting and implementation of local disaster management operational plans at prefecture level.

3.1.3 Municipal Level (Municipal Disaster Management Council)

Municipal level is broad in varying names city, town and village, but in principle organizational structures of disaster management is common. Mayors of cities, towns and villages act as Chairman of Municipal Disaster Management Council. Formulation of municipal disaster prevention plans and implementation of comprehensive disaster countermeasures are the key responsibilities for municipal disaster management council.

3.2 Role of Asian Disaster Reduction Center (ADRC) in Disaster Risk Reduction

The Asian Disaster Reduction Center was established in Kobe, Hyogo prefecture, in 1998, with mission to enhance disaster resilience of the member countries, to build safe communities, and to create a society where sustainable development is possible. The center works to build disaster resilient communities and to establish networks among member countries through many programs including personnel exchanges in the field of disaster risk management (DRM) and disaster risk reduction (DRR).

The center addresses DRM and DRR issues from a global perspective in cooperation with a variety of UN agencies and international organizations such as the International Strategy for Disaster Reduction (ISDR), the Office for the Coordination of Humanitarian Affairs (OCHA), the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), the World Meteorological Organization

(WMO), and the World Health Organization Regional Office for the Western Pacific (WHO/WPRO). Main activities of ADRC are

- Information Sharing(Organizing International Meetings & Seminars, Disaster Information, Publications, Development of Tools, such as Global Identifier Number (GLIDE)
- Human Resource Development(Seminars &Trainings, VR Programs, Developments of Tools such as Total Disaster Risk Management (TDRM)
- Building Community Capabilities(Development of Community Based Hazard Mapping (CBHM) & Town Watching Method, Tsunami Awareness Projects)

(Source: http://www.adrc.asia/aboutus/index.php)

➢ **Visiting Researcher Program**

ADRC's Visiting Researcher Program polish skills of researchers from member countries in the field of disaster risk management (DRM) and provides opportunities for member countries to learn more about disaster risk reduction (DRR) and DRM and to incorporate DRR concepts into the policies of their countries. Through this program six to eight researchers from different countries get a chance to conduct research in preparedness, response and recovery against natural hazards every year.

4. Seismotectonic Framework of the Pakistan Region

Over the geological time scale Indian plate has moved northward and rotated in counter clockwise direction. Tethys Ocean has entirely been consumed between the Eurasian, the Arabian and the Indian plates (Powell, 1979). Present day tectonics is marked by collision and thrusting along Main Boundary Thrust (MBT), Pamir, Himalayas and the Hindu Kush region forming the northern plate boundary. On the western side the tectonics of colliding Indian and Eurasian plates are governed by transform plate boundary consisting of the Chaman and Ornach-Nal fault zone with left lateral strike slip motion (Fig-4). In the southern, most areas i.e. west of Ornach-Nal fault zone the oceanic litho sphere is subducting below the continental crust. In terms of structural trends, the Main Boundary Thrust (MBT) and allied thrust faults form an elongated zone in NW-SE direction whereas western margin along Chaman and Ornach-Nal fault zone exhibits a dominant North South trend. Due to compressional regime of the Arabian plate, the Chagai arc and the Makran zone have structural trends in an East West direction. The structural trends observed on local scale around Quetta have two distinctive natures i.e. thrust and strike slip. The Chaman fault zone located on western side of Quetta city and Suleiman arc and Sibbi trough on eastern side of the Quetta city.

The Chaman fault was first discovered in 1893 after the 1882 earthquake which offset the Quetta-Chaman railroad by 75cm in left lateral movement (Griesbach 1893). The fault is a left lateral transform fault. It is considered responsible for famous 1935 (Ms=7.7) earthquake. Lawrence and Yeast (1979) divided it into four segments. First is the active fault which is a linear feature and extends without interruption the entire length of segment. Alluvial fans are cut by this segment of the fault with visible marks in aerial photos over areas of bedrock. The second part is the Chaman fault zone which is one kilometer wide and an active fault zone present in this zone. The third segment is the Chaman fault system which is a series of four or five branches that curve away from the main trace towards south west and west. The fourth is the Chaman transform boundary which includes the Chaman, Ornach-Nal and other faults and constitutes the boundary between Indian and the Eurasian plates.

The Sulaiman lobe or Sulaiman arc is a broad (>300 km) and gentle (<1° sloping hills) fold-and thrust belt that is tectonically active. It is developed by transpression as a result of the left-lateral strike slip motion along the Chaman fault and southward thrusting along the western terminus of the Indian subcontinent (Sarwar and DeJong 1979; Lawrence et al. 1981). The present day structural style and tectonic of the Ziarat area was developed due to the interaction between Suleiman lobe, the Chaman fault and the Sibbi trough. Two major thrusts, the Gogai Nappe and the Babai Nappe are also present along with associated strike slip faults (Niamatullah et al. 1989).

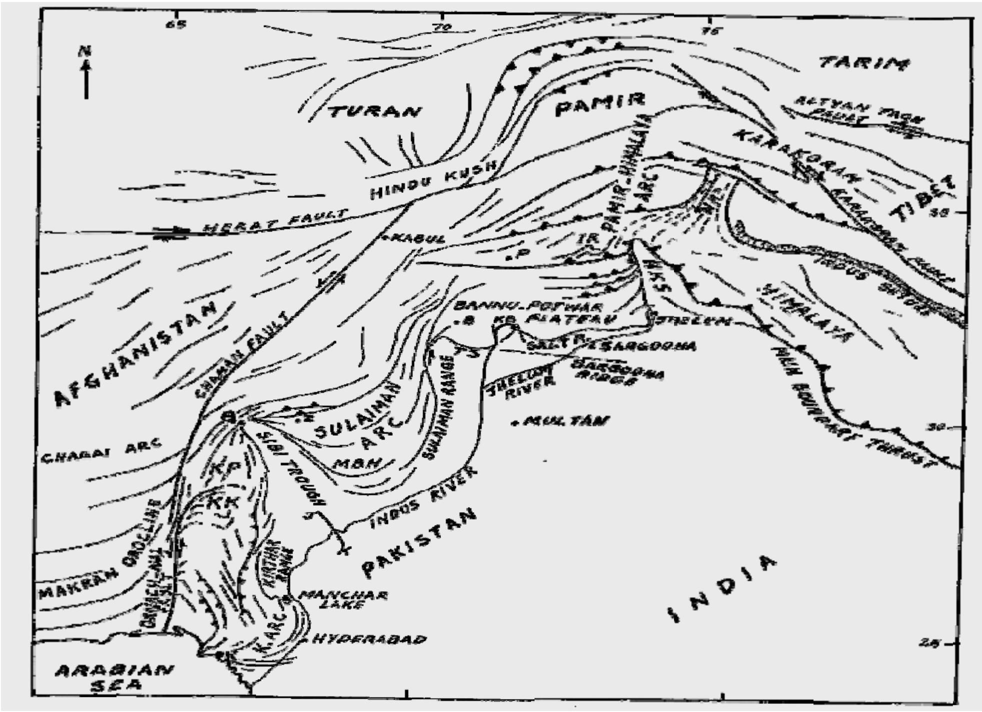

Figure-4. Regional tectonic map of the area. B-Bannu, HKS-Hazara Kashmir Syntaxes, JK-Jacobabad Khairpur high, K-Karachi, KB-Kalabagh, KK- Khuzdar Knot, KP-Kalat Plateau, MBH-Mari Bugti Hills, NH-Nanga Parbat Haramosh massif, P-Peshawar, TS-Trans Indus Salt Range, Q-Quetta, Z-Ziarat (Sarwar and DeJong,1979).

Makran Subduction Zone lies between Arabian and Eurasian Tectonic Plates with a triple plate junction at eastern end of the subduction zone involving three plates namely Indian, Eurasian and Arabian (Fig-4 and Fig-5). The Makran region is exceptional in zone of closure of Tethys as it is the only segment east of the Mediterranean and west of the Andaman arc in which subduction of oceanic lithosphere is still an ongoing process. All other Tethyan segments in the Middle East are now experiencing continental tectonics. However, geological evidence is indicative of suturing of smaller continental blocks within this Tethyan belt (Fig-4) like the Lut and Afghan blocks (Stoneley, 1974, Stocklin 1974 and Powell 1979). Makran region is defined as a trench arc system with active subduction continuing. Study of the stratigraphic records suggests that the Makran arc-trench system may have evolved throughout most of the Cenozoic era (Stonely 1974). Other important feature in Arabian Sea is Murray Ridge. Murray Ridge (Fig-5) is a low to moderate seismic zone. It is nearly 420 km long and 20 to 50 km wide northeast trending asymmetric in the northwest Arabian Sea. It is a part of the Arabian-Indian plate boundary undergoing uplift since the early Miocene (Clift et al. 2002). Plate boundary in the vicinity of the Murray ridge is also made up of transform segments that strike sub parallel to the Owen fracture zone in Arabian Sea. The theory of spreading centers for Murray ridge was presented by Quittmeyer and Alan (1984) and later supported by Shafiq et al. (2011).

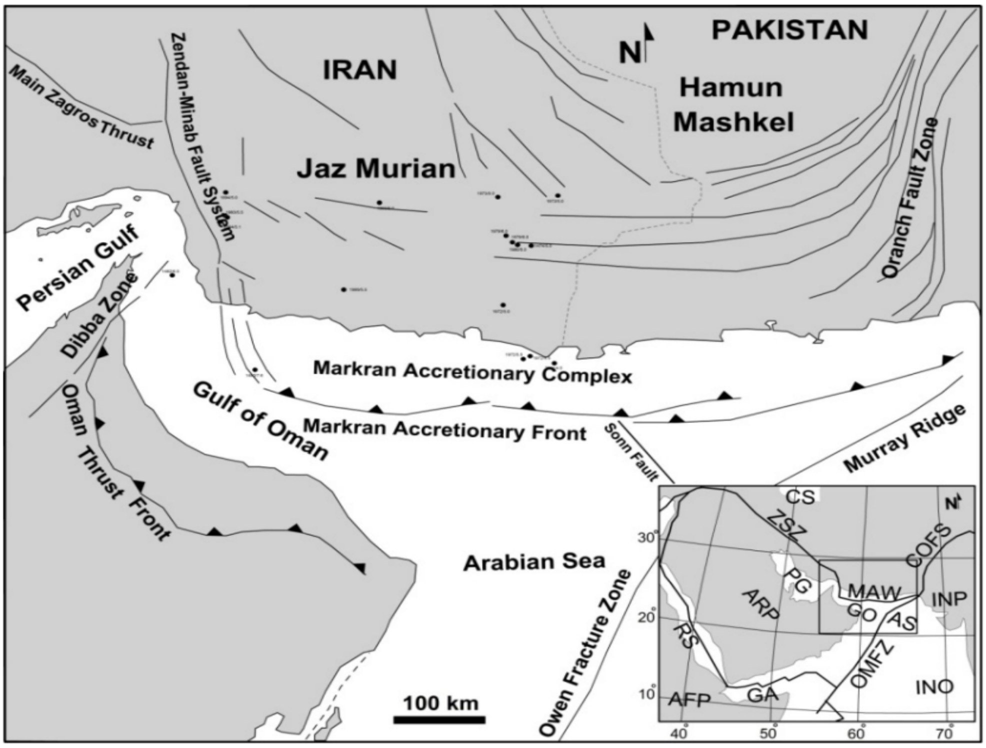

Figure-5. Plate tectonic setting of the Region. Explanation: AFP; African Plate, ARP; Arabian Plate, AS; Arabian Sea, COFS; Chaman Oranch Fault System, CS; Caspian Sea, GA; Gulf of Aden, GO; Gulf of Oman, INO; Indian Ocean, INP; Indian Plate, MAW; Makran Accretionary Wedge, OMFZ; Owen Murray Fault Zone, PG; Persian Gulf, RS; Red Sea, ZSZ; Zagros Suture Zone (after Mokhtari et al. 2008).

5. Destructive Earthquake Events Affected Pakistan during the Past Decade

5.1 26th October 2015 Earthquake (Mw=8.1)

An earthquake of magnitude Mw=8.1 (PMD) occurred on 26th October 2015 that struck South Asia , at 14:09 PST (09:09 UTC) with the epicenter at Hindukush region(45 km north of `Alaqahdari-ye Kiran- wa Munjan), Afghanistan having depth 193 km. An aftershock of 5.3 magnitude struck 40 minutes after the main event. Mobile phone services were choked for several hours because of the high voice traffic. Tremors were felt in Pakistan, Tajikistan and Kyrgyzstan. The earthquake was also felt in the Indian cities of New Delhi and Indian Administered , and in the prefectures of Kashgar, Aksu, Hotan, and Kizilsu in Xinjiang, China while damage was also reported in Afghan capital Kabul. Khyber Pakhtunkhwa (KP) province of Pakistan is badly affected due to this earthquake. According to National Disaster Management Authority (NDMA) preliminary state of losses and damages last updated on 14th November 2015: 279 died, 1,820 injured, and 1,04,067 houses damaged (completely, partially). (Source: http://www.ndma.gov.pk/new/disasters/losses.php)

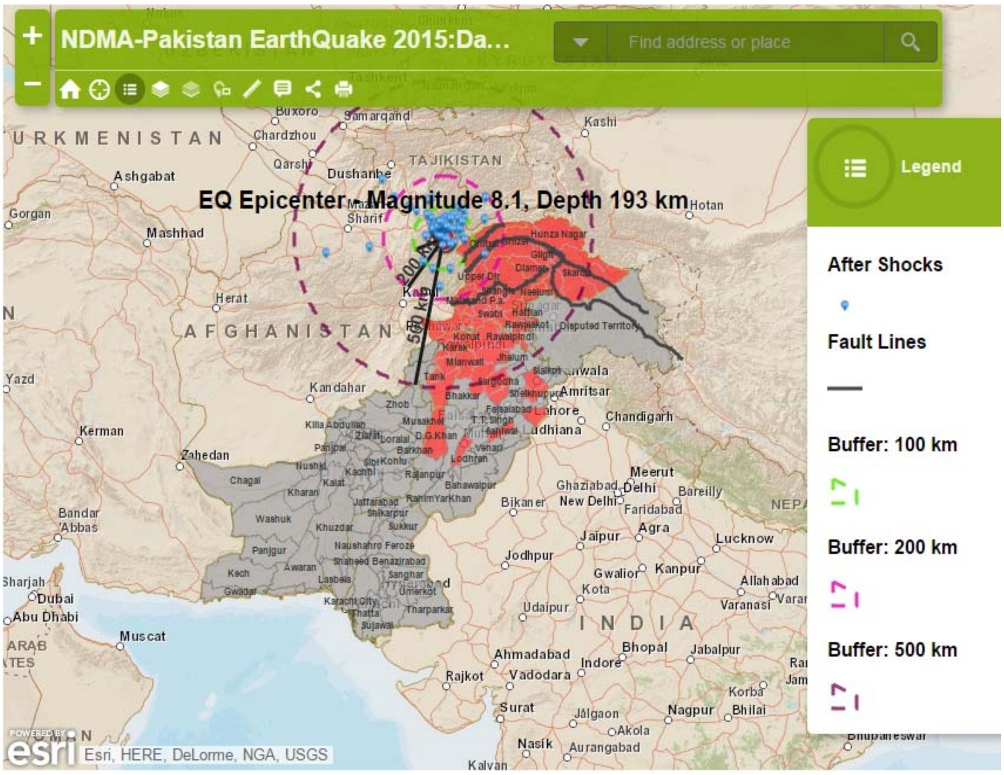

Figure-6. Pakistan Earthquake 2015-Interactive Map, NDMA
(Source: http://www.ndma.gov.pk/new/disasters/gismap1.php)

5.2 16th April 2013 Awaran Earthquake (Mw=7.7)

It was most significant earthquake occurred on 16th April 2013 located near Pakistan-Iran Border Region. It had a magnitude of Mw=7.7 and intermediate depth of 76 km. It is located in the area with very low population density and a big desert so no widespread damages were observed. However nearest town of Musakhil located 90 km away was badly damaged. Many people were injured and some were killed. The event was widely felt in the region. In Pakistan all main cities experienced the strong shaking including Karachi, Quetta, Islamabad and Lahore. It was felt in New Delhi and as far away as Dubai due to its large magnitude. The event is associated to Makran Subduction Zone where Arabian Plate is subducting. According to National Disaster Management Authority (NDMA): 386 died, 816 injured, and 46,756 houses damaged (completely, partially). (Source: http://www.ndma.gov.pk/new/aboutus/EQ_Awaran_13.pdf)

5.3 18th January 2011 Earthquake (Mw=7.2)

An earthquake of magnitude Mw=7.2 occurred on 18th January 2011 in Southwestern Pakistan, Balochistan province (Dalbadin Region). The area has complex tectonics due to interaction of Indian, Eurasian and Arabian plates. Both thrust and strike slip earthquakes are dominant in this region with minor, localized normal faulting events. This earthquake posed constraints in depth and focal parameters due to lack of data for evaluation of parameters from Pakistan, Iran or Afghanistan region. Normal faulting mechanism has been proposed by many researchers for this earthquake. The mechanism for the earthquake after re-evaluation was strike slip which is contrary to normal faulting.

5.4 29th October 2008 Balochistan Earthquake (Mw=6.4)

An earthquake of magnitude Mw=6.4 occurred on 29th October 2008 near Chiltan hills, Balochistan province, in Pakistan with a foreshock of magnitude 5.0 Mb. Depths of events were 15 and 12 km, respectively. The intensity of the main shock was VIII in and around the Ziarat-Pashin areas while the Peak Ground Acceleration (PGA) recorded at Quetta area (60 km from the epicenter) was 0.17 m/s^2 (horizontal component) and 0.06 m/s^2 (vertical component). As no surface rupture was found, the source mechanism and aftershocks were only tools for finding fault dimensions. The source mechanism was found to be strike slip for both events, and aftershock trend was NW-SE suggesting the strike slip nature of the fault. These results disagreed with the existing description of the fault system in the area which was previously thought to be thrust in nature. According to National Disaster Management Authority (NDMA) Compensation Disbursement figure: 164 died, 173 injured and 9,761 houses damaged (completely, partially). (Source: http://www. ndma. gov.pk/ new/aboutus /EQ_2008 .pdf)

5.5 8th October 2005 Earthquake (Mw=7.6)

Earthquake of 8th October 2005 having magnitude Mw =7.6 occurred in the Kashmir region. The United States Geological Survey (USGS) and European-Mediterranean Seismological Center (EMSC) have reported the epicenter of this earthquake in the syntaxes, while the Indian Meteorological Department (IMD) has reported it further west. Aftershocks of the earthquake as reported by Pakistan Meteorological Department (PMD) and USGS lie NW of the main shock epicenter in the Indus Kohistan Seismic Zone (IKSZ). The earthquake occurred at the western extremity of the Himalayas, where the arc joins the Karakorum, Pamir, and Hindukush ranges. The newly deformed area occupies a 90-100 km long northeast trending strip extending from Balakot, Pakistan, southeast through Azad . It cuts across the Hazara syntaxes, reactivating the Tanda and Muzaffarabad faults. North of Muzaffarabad the surface rupture coincides approximately with the MBT, on the south-western flank of the syntaxes. The fault offset was 4 m on average and peaks to 7 m northwest of Muzaffarabad. The rupture lasted for 25 s and propagated up dip and bi-laterally with a rupture velocity of about 2 km/s (Philippe et al., 2006). The heavily damaged area north of Muzaffarabad, Kashmir shows the maximum deformation. There are known active faults stretching to the northwest and southeast near the epicenter, which reveal some 46 uplift on the northern side and dextral, right-lateral strike-slip activities (Fujiwara et al., 2006). The known active faults are divided in two fault groups, the Muzaffarabad fault, northwest of Muzaffarabad and the Tanda fault, southeast of Muzaffarabad (Nakata et al., 1991). According to National Disaster Management Authority (NDMA) as of November 2005 total death stood at 87,350, although it is estimated that the death toll could reach over 100,000. Approximately 138,000 were injured and over 3.5 million rendered homeless (EERI Special Earthquake Report, 2006). (Source: http://www.ndma. gov.pk/ new/aboutus /Earthquake2005.pdf)

6. General Seismicity of the Region, Seismicity & Tsunami Monitoring in Pakistan

Earthquake activity in Pakistan can be distributed in four main zones i.e. Hindukush, Suliman arc, Quetta zone and Makran zone. The most active region is Hindukush seismic zone with frequent seismic activity. It is a subduction zone and exhibits intermediate to deep seismic events. The clustering of events northern parts of Pakistan (Pak-Afghan border region) is caused by this seismic zone. The average depth in this zone is 250 km. Earthquakes from this zone are widely felt in the country but are not destructive due to deep focus.

The Suleiman range is a southerly trending belt of folds and faults whose northern end is situated to the west of the Salt Range. This feature has been seismically active in modern times with the activity characterized by small magnitudes as shown in Fig-7. The historical record, on the other hand, indicates that moderate-size earthquakes do occur in this region. The level of the documented historical activity is also low. Activity that does occur in this region is scattered; it does not appear to be directly related to the north-northeasterly trending structures which are dominant at the surface here (Quittmeyer and Jacobs, 1979).

The Quetta zone is most significant due to its shallow seismicity caused by left lateral transform Chaman fault. It is responsible for many destructive earthquakes. The famous Quetta earthquake of 1935 is associated with this fault with Mw=7.7 and devastated the town of Quetta, Balochistan and the adjoining areas on the morning (origin Time: 21:33 UTC) of May 31, 1935. Nearly 35,000 people were killed, most of those fatalities in Quetta alone. Tremors were felt over much of Pakistan and as far as Agra in India. The earthquake, almost completely destroyed the city of Quetta. The earthquake is related to left lateral strike slip fault famously known as Chaman fault. Some of the most significant earthquakes are located in this zone as shown by red circles in Fig-7. Makran region is unique in terms of its seismicity. In this zone there is no regular pattern of seismicity however when an earthquake occurred it’s usually a large magnitude earthquake. No foreshocks or aftershocks are observed even after large magnitude earthquakes in the region. The most significant earthquake having magnitude Mw=8.1 in 1945. It generated a tsunami and approximately 4000 people were killed along the coast.

Pakistan Meteorological Department is lead organization for seismology and its allied fields in Pakistan and operates a network of monitoring stations shown by red and blue stars in (Fig-7) below

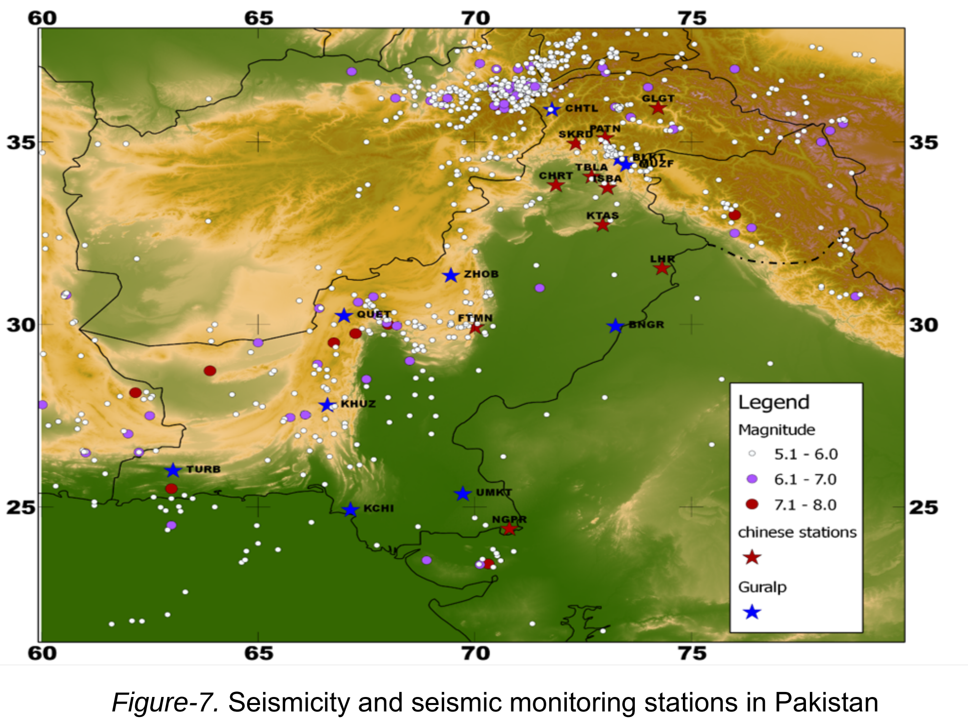

Figure-7. Seismicity and seismic monitoring stations in Pakistan

We further divide the seismic stations sub-networks into two groups:

- The Guralp Network system which has been purchased by the PMD
- Pak China Seismograph Network (PCSN) (courtesy of China)

Combined, the Guralp and the PCSN include 20 stations (10 each) out of which 18 are working till date. Most stations reside in remote locations and require solar panels and batteries for power.

National Seismic and Tsunami Monitoring Center

Pakistan Meteorological Department (PMD) holds the responsibility for seismic monitoring and tsunami early warning in Pakistan. It is the liability of the PMD to disseminate earthquake information to Government, non Government organization and to public after the occurrence of any event. The seismic monitoring technologies have been rapidly changed in the world. The seismic monitoring equipments have changed from analogue to digital technology. This enhanced the capability of the monitoring equipments.

PMD had been using paper recording equipments since 1954. The 2004 Indonesian earthquake of magnitude 9.4 which generated disastrous Tsunami and subsequently Muzaffarabad Kashmir earthquake of magnitude 7.6 were the wakeup call not only for Pakistan but also for the whole world. During the past few years PMD has enhanced multifold its abilities to monitor seismic activity. Since 2005, PMD upgraded and replaced all analogue seismic equipment with state of the art technology. We further divide the seismic stations sub-networks into two groups:

- The Guralp Network system which has been purchased by the PMD
- Pak China Seismograph Network (PCSN) (courtesy of China)

Twenty remote seismic monitoring stations were established from north to south of Pakistan included Azad Jammu & Kashmir area with broad band (120s) sensors. Timing was also improved by using GPS at each remote station. All stations are linked with central recording stations at Karachi and Islamabad through satellite communication system. Beside broad band stations, a parallel program of short period (1s) sensors for the close monitoring of fault and local seismicity is running. Such data is communicated to central recording station through internet and radio. Also SeisComP system installed at PMD to monitor seismicity. To monitor the tsunami if occur in the Indian Ocean and anywhere in the world, a tsunami warning system has also been established in PMD. The PMD monitoring capability is now from east coast of Australia to the Atlantic Ocean. PMD has also developed link through special line with Japan and Hawaii warning centers. PMD has improved digital data processing and analysis in time and frequency domain within two to three minutes after the occurrence of any earthquake. The digital data recording and processing with international data has greatly improved the evaluation of source parameters.

The National Seismic and tsunami Monitoring Center issues monthly reports of local activity, a monthly catalog of earthquake activity in Pakistan and neighboring countries (Afghanistan, Iran, China, India), and special-interest bulletins on local seismic events. Earthquake information provided in these reports is subject to revision as new information becomes available. An archive of all cataloged seismic event locations and magnitudes and related waveform data from the PCSN and Guralp is maintained by the Center on computer servers at the PMD. Continuous waveform data and associated station metadata from all available seismic stations is permanently archived at regional monitoring centers (Karachi, Lahore, Peshawar).

Achievements of National Seismic and Tsunami Monitoring Center

- Paper published in NRIAG Journal of Astronomy and Geophysics titled as Parameterization of 18th January 2011 Earthquake in Dalbadin Region, Southwest Pakistan
- Several Meteorologists have completed their M.Sc in Seismology and few more are carrying out their MS and PHD research in different countries like Japan and China, in the field of Geophysics.
- Probabilistic seismic Hazard Assessment for the city of Quetta, Pakistan
- Hazard Assessment, Risk Analysis and Seismotectonic study of earthquake prone areas of Pakistan has been done.
- Maintenance of Data Bank of all seismic event locations and magnitudes and related waveform data from the PCSN also known as Jopen and Guralp on computer servers.
- Timely press release of all the Major events occurred in Pakistan and rest of the world. The Center really made a difference in quick recording and analysis of the event that occurred on 24th September, 2013 at 11:29:50 GMT of magnitude 7.7, depth 12 km, and location 120 km SW of Khuzdar, Balochistan, Pakistan.

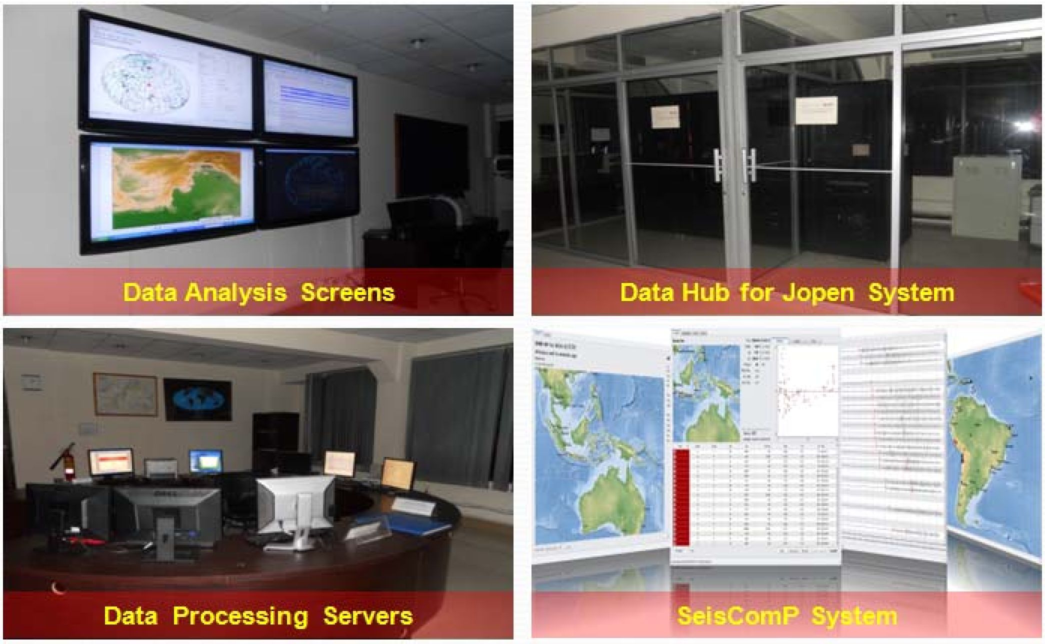

Figure-8. National Seismic and Tsunami Monitoring Center (Pak-China Seismograph Network (PCSN) also known as Jopen, and SeisComP System).

7. General Seismicity of the Region, Seismicity and Tsunami Monitoring in Japan

Japan is located at a point on the earth's surface where four of more than 10 tectonic plates covering the globe are crushed against each other, making it archipelago susceptible to the earthquake disasters. Nearly 20% of the world's earthquakes of magnitude 6 or greater have occurred in or around Japan. Japan has suffered great damages from the massive intera plate earthquakes produced by the plate subduction such as the Great East Japan Earthquake 2011 also known as the 2011 Tohoku Pacific Offshore Earthquake (name assigned by the Japan Meteorological Agency). It was the most powerful earthquake of Mw 9.0 ever recorded to have hit

Japan, and the fourth most powerful earthquake in the world since modern record-keeping began in 1900. It generated tsunami in Miyako in Tohoku's Iwate Prefecture and also caused nuclear accident at Fukushima Daiichi Nuclear Power Plant Complex. More than 18,000 people killed mainly due to tsunami and about 390,000 houses destroyed (completely, partially). Japan also suffered from inland crustal earthquakes caused by the plate movements such as the Great Hanshin-Awaji Earthquake 1995. It was of magnitude Mw= 6.9 and intensity on Japanese Shindo intensity Scale 7, occurred on 17th January, 1995 in Southern part of Hyogo prefecture. Due to this earthquake 6,437 died and 249,000 houses damaged (completely, partially) (Cabinet Office of Japan, 2015). The Great Kanto Earthquake, the worst in Japanese history, hit the Kanto plain around Tokyo in 1923 and resulted in the deaths of 105,385 people. Earthquake distribution around Japan (1960-2011) is shown in (Fig-9) below

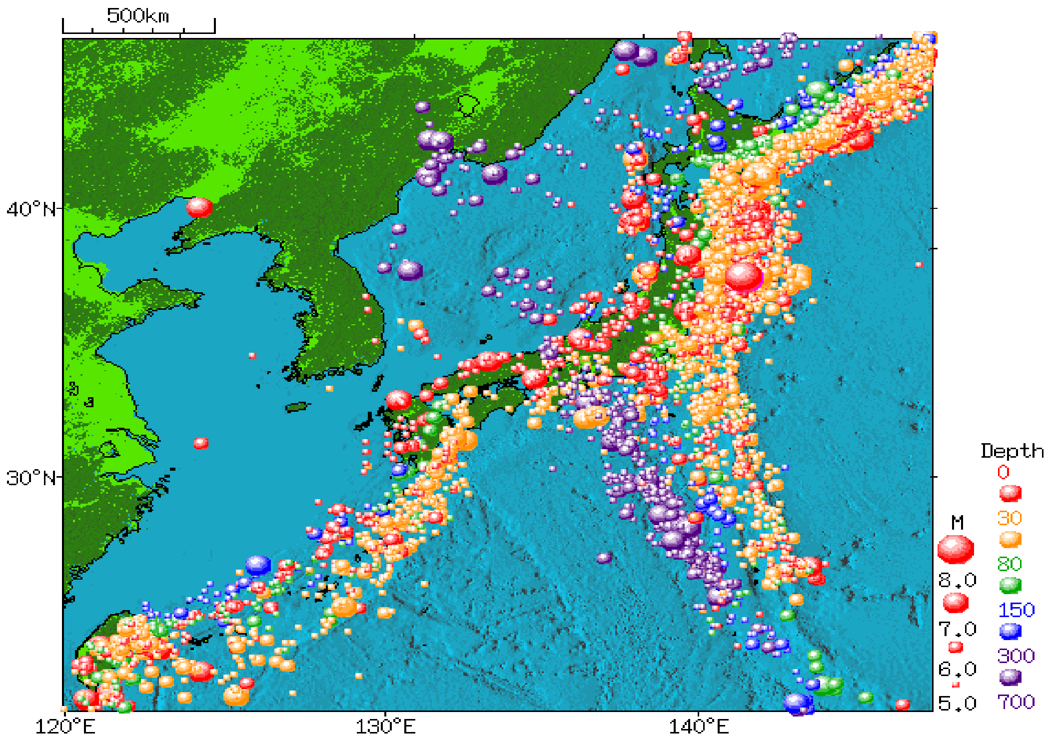

Figure-9. Earthquake distribution around Japan (1960-2011), JMA
(Source: http://www.jma.go.jp/jma/en/Activities/image/earth-fig01.png)

To constantly monitor seismic activity, Japan Meteorological Agency (JMA) operates an earthquake observation network comprised of about 4000 seismic intensity meters and 300 seismographs managed by local governments and the National Research Institute for Earth Science and Disaster Prevention (NIED). Sites of seismic intensity meters and seismograph stations are shown in Fig-10 and Fig-11 respectively. The data collected are input to the Earthquake Phenomena Observation System (EPOS) at the headquarters in Tokyo and the Osaka District Meteorological Observatory on a real-time basis.

Japan Meteorological Agency (JMA) operationally monitors earthquakes, tsunamis and volcanic activity throughout the country and issues relevant warnings and information to mitigate damage caused by these disasters. When an earthquake occurs, JMA immediately issues information on its hypocenter, magnitude and observed seismic intensity. If the seismic intensity is 3 or greater, the Agency issues a Seismic Intensity Information report within one and a half minutes. The information is provided to disaster prevention authorities via dedicated lines, and reaches the public through local governments and the media. This information also plays a vital role as a trigger for the initiation of rescue and relief operations related to earthquake disasters.

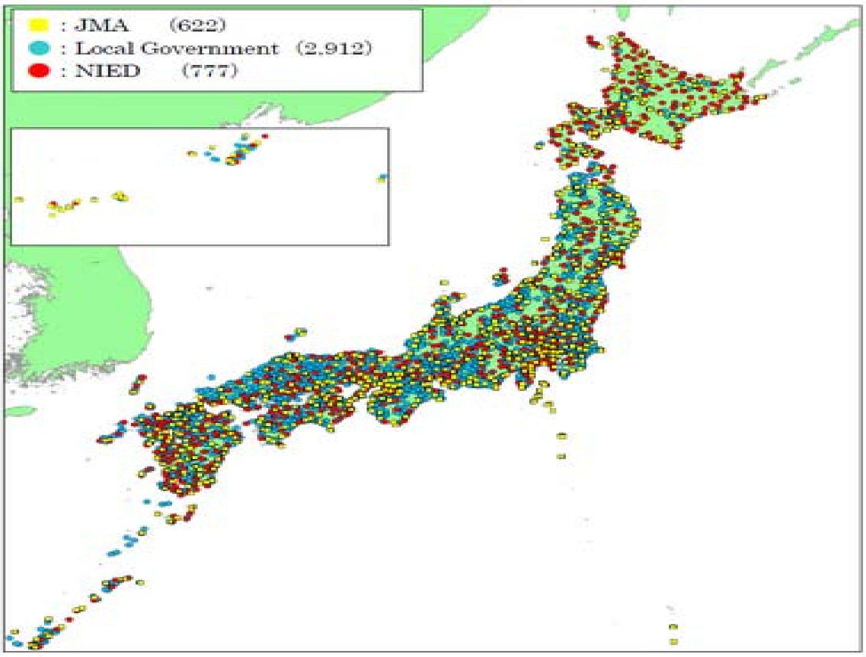

Figure-10. Sites of Seismic intensity meters (Source: JMA)

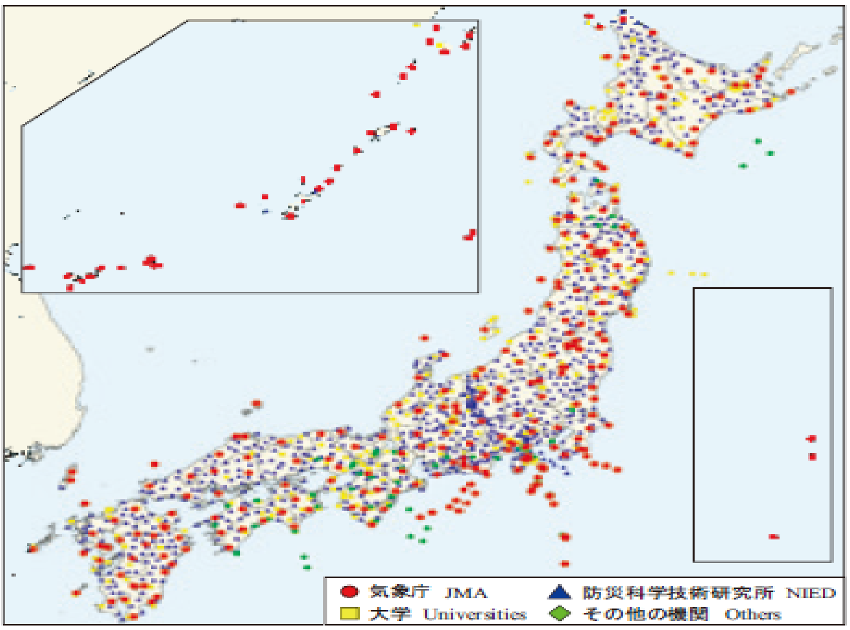

Figure-11. Sites of Seismograph stations (Source: JMA)

Japan surrounded by the water on all sides with long and complex coastlines, Japan is highly vulnerable to earthquake-generated tsunami. In reality, there has been several damages caused by various tsunamis in the past, including the Meiji-sanriku Earthquake Tsunami (1896), Nihon-kai-Chubu Earthquake (1983), Hokkaido Nansei-oki-Earthquake (1993) and latest Great East Japan Earthquake (2011). In addition to local tsunamis generated earthquakes near the coast, Japan has also suffered major damage from the onslaught of distant tsunamis generated by open-sea earthquakes. In 1960, a tsunami generated by the Chile earthquake crossed the Pacific Ocean and reached the shores of Japan about 22 hours later, killing 142 people.

When tsunami is expected to cause coastal damage, the Japan Meteorological Agency (JMA) issues a tsunami warning or advisory within 2-3 minutes after the earthquake and then follow up with announcements about the estimated height and arrival time of the tsunami. The information is transmitted immediately to disaster management organizations and media outlets, and further forwarded to the residents and maritime vessels. Tsunami countermeasures such as expediting the announcement/transmission of tsunami forecasts and improving coastal embankments (tidal embankments) and tide preventation gates have been carried out. The Cabinet Office in cooperation with relevant ministries has prepared guidelines for the creation of tsunami hazard map and the designation/development of tsunami evacuation buildings by local governments and disseminating the guidelines. Flow of issuance of information about tsunami and earthquake is shown in (Fig-12) below

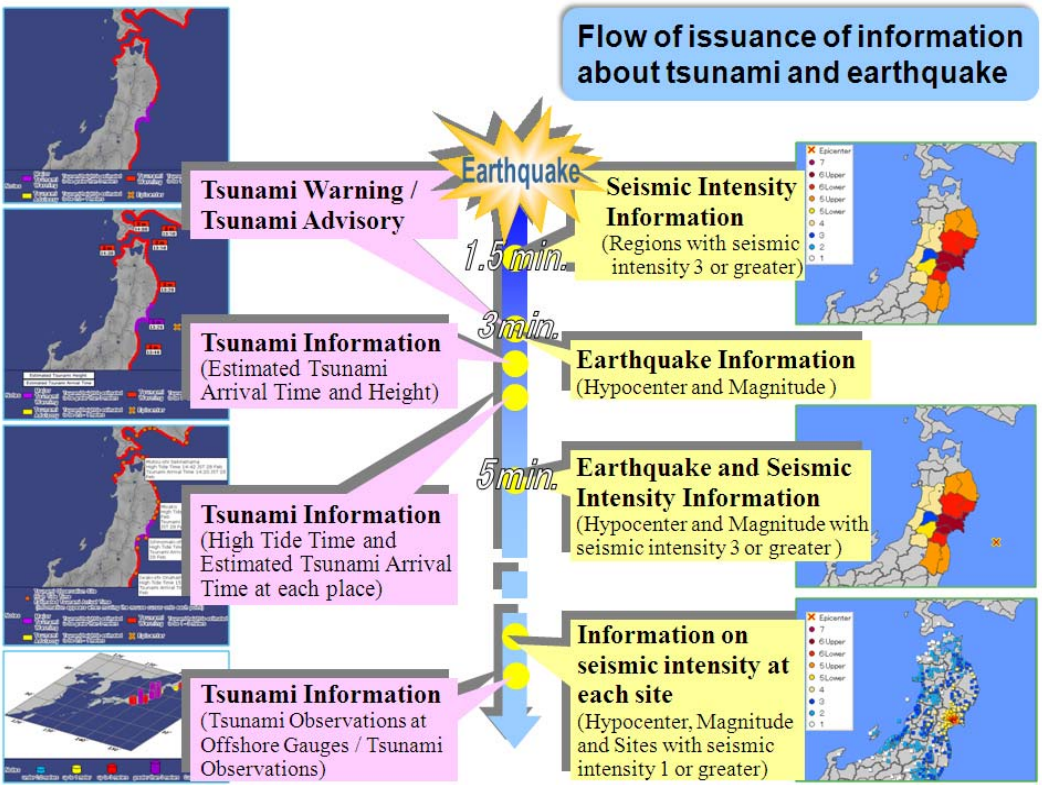

Figure-12.Time sequence for issuance of information on tsunamis and earthquakes (JMA)
(Source: http://www.jma.go.jp/jma/en/Activities/image/earth-fig05.png)

8. Gwadar City Development

8.1 Theme of the Gwadar City Development

Uncontrolled urbanization is becoming a major problem in Pakistan and cities are growing in unplanned manner with growing pressure on infrastructure in already overpopulated cities. This rapid urbanization process and population growth trend around few major cities is creating social, economic and environmental issues which consequently result in vulnerable cities to disasters. Balochistan province consists of approximately 40% area of Pakistan territory whereas population density is very low. Out of 184 million population of Pakistan (2014) only 5% lives in this province. The vast area of the province and available natural resources stipulated the development of this area.

Gwadar is selected for development to work as a strategic future economic hub in the region. Located at coast line a new deep sea port has been developed. A detailed map of master plan of the city is shown in (Fig-13) below

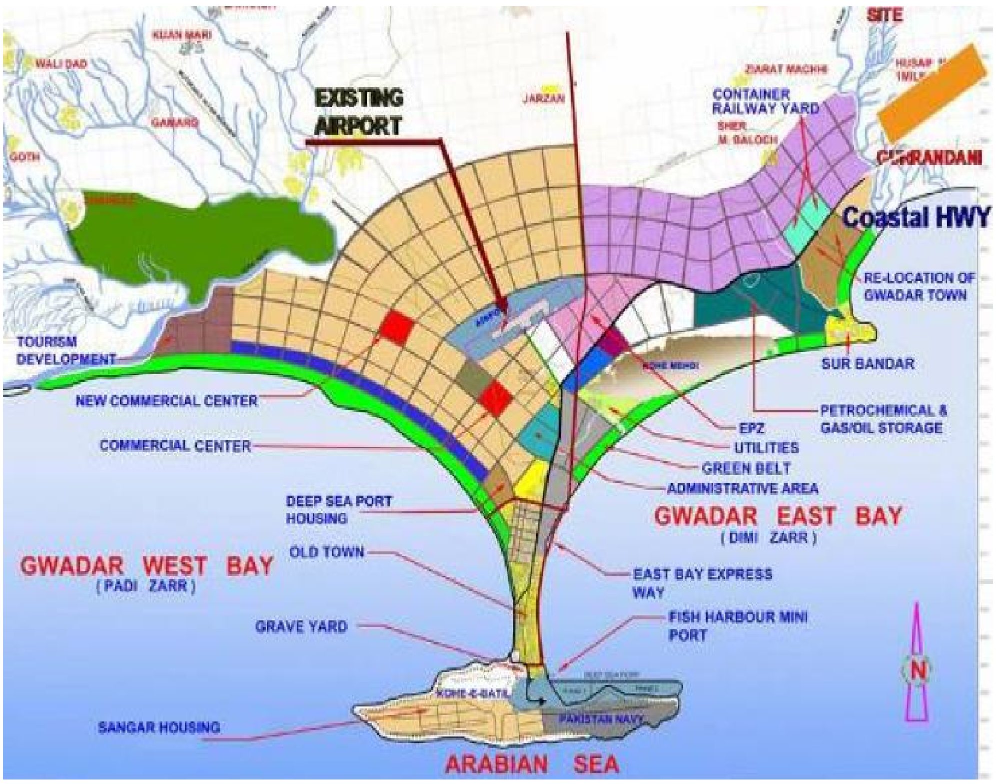

Figure-13. Master Plan of Gwadar city, Pakistan

From the perspective of earthquake and tsunami disaster mitigation and management it is important to note that different seismic hazard analysis and tsunami modeling studies exist for Gwadar city. As per building codes of Pakistan, areas or cities with ground acceleration greater than 0.32 g are considered in seismic zone-4 which is highest level. Gwadar is considered in Zone-3 in building code of Pakistan (BCP SP2007). Nasir et al. (2012) has developed scenario of tsunami for Gwadar city as shown in (Fig-14)

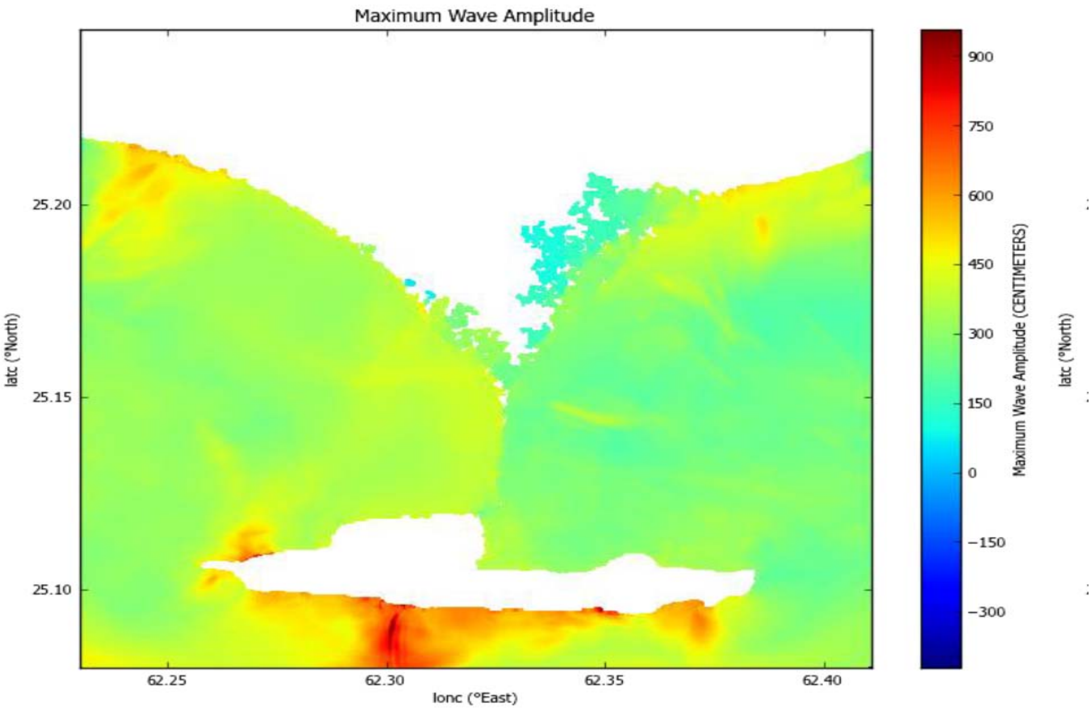

Figure-14. Tsunami inundation modeling for Gwadar, Pakistan (Source: Nasir et al. 2012)

8.2 Lessons from History for Future Development

The earthquakes in past decade in Pakistan provided a glimpse of scenarios related to social, economic and technical issues. In case of 2005 earthquake all type of structures were damaged i.e. from poorly constructed stone masonry homes to relatively modern brick masonry homes, government developed schools and hospitals to multistory reinforced concrete structures. Destruction of high rise building "Margalla Tower" in Islamabad about 100 km away from epicenter raise serious concern. In context of the previous experience of 2005 earthquake following main aspects are identified which are directly related to future disaster mitigation and better disaster management in planned Gwadar city. The important observations are given below:

- Lack of knowledge about hazard, vulnerability and risks of any sort of natural disaster specially earthquakes and tsunami.
- Non existence of landuse and land control regime
- Lack of enforcement of building control

8.3 Problems for Future Sustainable Development

8.3.1 Core Issue-I

Article 6.5 (III) of the national plan for multi hazard early warning system points out a core issue as below

"*inadequate user orientation of early warning systems partly due to dominance of scientific, technological and engineering perspectives in early warning and the weak role of social, political, economic and cultural considerations*" (Cabinet Division, Government of Pakistan).

It is important to note that local people do not consider tsunami a threat as knowledge of previous event is forgotten by the people due to above mentioned scenario. In the briefing paper by NDMA it has been pointed out in following manner

"*Local knowledge about tsunami was non-existent both at DDMA and community level. However, as cyclone is a more recurring phenomenon, people are more aware of it.*"

"*Even though an announcement was made by the Naib Nazim in the market about the drill, none of the people present in the market took part in the drill that indicates need of large scale awareness campaign for the communities". (*Source: http://ndma.gov.pk/Docs /DRR%20for%20 tsunami-%20Paper.pdf)

These problems are directly related to social setup and mental framework of the people at first step, as they do not consider it important and secondly to economic factors in the region. These problems still persist even though lot of efforts is made for mass awareness of people to highlight the importance. From the administrative point of view for community awareness responsibilities are defined in the "National Disaster Management Plan in the Islamic Republic of Pakistan". In its section 3.2.4 it is the responsibility of PDMA to promote general education and awareness and at community level for disaster mitigation is responsibility of DDMA under section 3.2.5.

8.3.2 Core Issue-II

In the Article 6.5(vii)of the national plan for multi hazard early warning system the same problem was pointed in slightly different manner i.e. ***"****Inadequate landuse planning as risks are not always considered above other criteria; non-compliance with appropriate land use controls and standards undermine the effectiveness of warning advice and response plans"* (Cabinet Division, Government of Pakistan). The problem of landuse control is of dual nature. At first step the institutional intervention has not been decided in a clear manner as it is evident from section 8.9 of Gwadar development plan and national disaster management plan. Secondly the poor enforcement mechanism for landuse and building construction is observed and suffered losses during earthquakes in past decade.

In section 8.9 of Gwadar Integrated Development Vision the role of institutes or governments for Strategic Interventions and Institutional Links is divided into three categories i.e. short term medium term and long term (Government of Balochistan and IUCN Pakistan 2007). The enforcement of building control laws in coastal areas and demarcation of prohibited areas safety against tsunami and cyclone is considered in only medium term interval and will be responsibility of coastal area development authority which seems to be a higher order organization. In short term only cyclone is considered with district government as lead department. In the National Disaster Management Plan the enforcement of land use and control is responsibility of NDMA, PDMA, and DDMA along with the contribution from planning commission of Pakistan.

8.3.3 Core Issue-III

In Pakistan engineers, technical institutes and development agencies have experience of developing new cities and at least three cities are well planned but in life line infrastructures no hazard resistant methodologies are part of the governing law. No emphasis on designation and knowledge of evacuation routes and centers. This portion of the disaster mitigation and management may require some financial burden which is difficult to manage in the hard economic conditions.

9. Possible Solutions and Remedies

9.1 Mass Awareness using Media and School Education

From the experience of local community, they consider floods due to heavy rainfall and specially cyclones a major threat. However as mentioned in earlier the knowledge at both community and District Disaster Management level lacked about earthquake and tsunami. The following possible solutions to this issue given below

- Province government is part of disaster management system in the form of Provincial Disaster Management Authority (PDMA) and heads all disaster related matters in province. Also province government is responsible for all education system and syllabus in the province. It makes relatively easy at management level to decide and promote disaster education in school system specially in newly developing city it can be declared compulsory.
- Media has become a powerful tool in Pakistan. In 2005 earthquake media played a very positive role and provided motivation for volunteers and acquisition of relief goods and answer questions in the mind of people about earthquakes. The same positive role of media can be used by arranging a special hour when all channels broadcast such information. The consensus in this regard can be achieved through already existing media regulatory authority.
- All enforcement and regulation officers at their appointment to Gwadar district must be given at least one month special training course to visualize the master plan, hazards and vulnerability issues and the scheme of enforcement bylaws. There are specialized institutes in Pakistan like Pakistan Engineering Council and National Institute of Public Administration and this course will provide a forum to combine policy making and administration in technical manner.
- Regular drills for any sort of emergency.

9.2 Landuse Scheme

The city is facing a dual threat of earthquake and resulting tsunami. A bird eye view of the Gwadar city at present (Fig-15) indicates the severity of the problem. It is evident that a good landuse and land control plan is solution of half of the problems in disaster management in case of Gwadar. The area with highest population density (at present) is most vulnerable to tsunami disaster in short and medium term whereas more urbanely developed areas is expected to suffer in medium to long term scenario. It is evident that there is no shortage of available land for residential schemes and urban development. Comparison of Fig-13, Fig-14 and Fig-15 suggests that old town area is most vulnerable. Following remedial measures can be adopted

- This must be reallocated to a safer location preferably near railway yard or around container movement facilities. This will provide work opportunity for relocated population near their houses. Also they are located near main road so access to sea for fishing will also be easy. This is expected to provide dual opportunity for fisherman community to work i.e. in fishing or cargo terminal to uplift the socio economic conditions.

- A strict ban on any kind of development and construction must immediately be imposed in this area. Due to vast availability of free land it is easy to manage this problem in its present scenario as population is expected to increase from 0.1 million to 1 million in coming years. There is need to identify more areas vulnerable to tsunami and constructing only parks. Model vertical development project (maximum three stories) or colony can be started to relocate these people. The number of stories is kept to three keeping in view the earthquake, social setup and low maintenance cost related to facilities in higher buildings.

Figure-15. Current landuse situation in Gwadar.

9.3 Lifeline Facilities and Evacuation Centers

It is the experience from past floods in Pakistan that schools, collages serve as the basic evacuation centers but in case of earthquake or tsunami the case will be different as experienced in 2005 earthquake. Most of the lifeline facilities (water, power, transport) in Pakistan are not earthquake resistant. It is very difficult to retrofit an existing infrastructure however Gwadar provides an opportunity to build a city with lifeline infrastructure as secure as possible.

- If not all, at least some designated roads or highways, pipelines for water supply and power supply system must be building keeping in view earthquake, tsunami, fire and urban flooding hazard. These specially designed lifeline facilities must be developed keeping in mind the evacuation routes and evacuation centers so that in case of disaster lifeline facilities combined with evacuation centers will create a sustainable life support and safety environment.

- From Fig-14 and Fig-15 it can be seen that road possibly used for evacuation will be inundated by tsunami so a vertical evacuation scheme must be implemented in the hammer head side of the city which already has higher elevation.

10. Japan as World Leader in Disaster Management

Japan has continuous efforts in reducing the post disaster effects. In this regard Japan has excellent organizational structure and also there are latest innovations and application of technology in disaster management practices. Japan also shares its research, methods and techniques with the whole world particularly with the Asian countries on regular basis. In a result of its valuable contribution Japan is widely recognized in the world because of its improved disaster management system.

A comprehensive research on causes of earthquakes, tsunamis and volcanic eruptions related issues and preparedness to minimize the effects from these natural hazards is according to latest research. Japan has devised effective disaster management system to contribute not on national but international level by sharing its research, methods and techniques on disaster risk reduction and disaster risk management with other countries through JICA and ADRC. There are several other agencies in Japan who also contribute to the international community. Comparative studies of Japan with other countries differentiate Japan as world leader in this field. Japan has established its disaster management system on national level as following: The system is existing in all the 47 prefectural governments and 1,760 municipalities (cities, towns and villages) under the national (central) government in Japan.

10.1 Community Based Disaster Risk Management and Drills

Community Based Disaster Risk Management is the process which includes the identification, analysis, treatment, monitoring and evaluation of hazards by the community. It is lesson learned from Great Hanshin-Awaji Earthquake 1995 that the neighbors or the people from surrounding areas were first responders immediately after the disaster. They undertook precautionary measures and responded even before outside help arrived. So the awareness and capacity building of the community should be kept important in devising disaster risk reduction management plan.

The protection against natural hazards is possible if the potential of hazards, their causes and mitigation measures have already been taken. In Japan there is a perfect disaster risk reduction culture in the country. This country has latest research on the phenomena of occurring the disasters and advance technology is used to save the human lives and their property.

Method of practical disaster reduction drill has been modified. Now the participants are not given any prior information about their role in emergency or the nature of emergency is also not told in advance to them. So they need to make the decision and response to the situation based upon the information provided after the drill starts. It was experienced in Miki city, Hyogo Prefecture that all the workers of fire services department kept themselves active by doing some new experiments. Sometimes they were practicing to use fire fighting extinguishers in multi story buildings. They were in formal dress all the time so in case of emergency it is easy to move within moment. Not only fire department participated in the drill but all stakeholders related to disaster management like coast guards, civil defense, doctors, NGO's etc also participated in drill. Drills are very important to prepare the community and all functionaries of the government for any big disaster. Regular exercise of these drills promotes a culture of preparedness among all the corners.

Pakistan has scattered population in mountain areas. In many places there is no road access. The neighbors and the local community are supposed to be the first responder after any natural disaster. In order to minimize the loss of human lives, the capacity building of the local community on gross root level is very important. In Pakistan awareness campaign can be started with minimum resources by giving training to the school teachers in first phase. Course outlines should be drawn for all elementary students and disaster risk management course should be introduced as compulsory subject. The insurance companies and financial institutions can be motivated to conduct the drills and help the government in this regards.

ADRC arranged a field visit for researchers to Miki city to participate in a drill. A pictorial view of drill and community based disaster management activities will portray the expertise of Japanese people towards preparedness and mitigation in (Fig-16) below

Figure-16. Pictorial view of drill in Miki City, Hyogo Prefecture, September 2015.

Community Based Disaster Management activities are also held in Kobe University, Kyoto university and Kobe Shoin Women's College in Hyogo prefecture. It's a very good experience for us to learn more about how to behave and well prepared for disasters.

It has been observed during all drills and exercises in Japan that the full response to any natural or manmade disaster is from government agencies. In large scale disasters the governments cannot response everywhere. During that situation a gulf occurs between the government functionaries and the affected population. The non government organizations (NGOs) always fill that gap. Though Japan has latest technology and resources with full strength but importance of volunteers and NGOs cannot be denied during any emergency. It is lesson learned after large scale disasters in Japan, Pakistan and China that the NGOs, IOs and other humanitarian groups served dedicatedly since the day the devastating earthquake occurred. The tsunami 2004 is very good example to assess the capacities of these groups and their professionalism. So the capacity building of the NGOs is as important as for other stakeholders in field of DRR. These groups should be on board and need to develop a close liaison with them.

10.2 Lesson Learned from Japan

- During research period ADRC arranged lectures from experts, managed field visits for practical experience, meetings / discussions /experience sharing with the affected population of Great Hanshin-Awaji Earthquake 1995, drills and provided over all environments for research in disaster risk management. Comparing the circumstances and available resources in Pakistan, being Visiting Researcher with ADRC Japan, it was opportunity for us to learn and share experience of Japan in the field of DRR and DRM in our countries.
- Japan boasts flawless earthquake-proof structures, highly efficient tsunami early warning system and scientifically developed tsunami evacuation plan while Pakistan lacks application of building codes especially in high seismic zone areas and also tide gauges installed are not effective enough to issue timely warnings. Pakistan coastline has hardly any scientifically developed tsunami evacuation plan. We need to work for improvement of our early warning system and tsunami evacuation plan.
- Japan has a permanent, trained and well equipped staff to handle disasters and supply of necessary equipments / resources to affective people. Also, Japan investing huge amount on disaster management institutions and make more effective through scientific/ technical support too. Pakistan also has trained staff to handle disasters but lacking in application of latest technology in DM field due to financial constraints.
- It is evident to note that most of scientific and technical organizations are working in their domains, however due to strong socio economic conditions and strict controls and regulatory regime are main cause of handling hazards well in Japan. Pakistan's socio economic condition is not very good and also due to lack of strict controls and regulatory regime we are unable to tackle hazards well. We need to improve our monitoring capabilities.
- Japan has strong coordination among all disaster management stakeholders from government and non government organizations (NGO's) as observed during drill. So its lesson for us to work for capacity building of the NGOs because role of NGOs in disaster risk reduction and disaster risk management is as important as for other stakeholders.. These groups should be on board and need to develop a close liaison with them.
- Regular exercise of drills promotes a culture of preparedness among all the corners. In order to minimize the loss of human lives especially in hilly and scattered population areas in Pakistan, we need to work for the capacity building of the local community on gross root level like Japan.
- Japan has proper disaster awareness system while Pakistan lacks such system. Disaster awareness campaigns against hazards can be started with minimum resources by giving training to the school teachers in first phase. Course outlines should be drawn for all elementary students and disaster risk management course should be introduced as

compulsory subject. The insurance companies and financial institutions can be motivated to conduct the drills and help the government in this regard.

- Human resource development for disaster reduction is most important aspect of disaster reduction. A well trained person can easily coordinate all resources in post disaster scenario. There should be professionally sound personnel engaged in official capacity to carry disaster risk reduction activities. The local bodies, IOs, NGOs and member of the society need to have their professionally skilled human resources to combat any disaster for minimizing loss of lives and property.
- Personnel of police, fire services, para-military forces and NDMA, DDMA need to get themselves specially trained to develop an expert group of evacuators and relief managers.

11. Conclusions and Recommendations

Japan has appropriate policy, legal and institutional arrangements and implementing strategies and programs to minimize risk and vulnerabilities for sustainable, social, economic and environmental development. The credit also goes to the leadership of Japan who endowed the policy maker's decision. The picture of structural measures against the natural hazards especially against earthquake and tsunami is tremendous effort done by Japan. Japan built flawless heavy infrastructures, earthquake proof buildings, memorials, concreting river banks, dams, tsunami walls, tsunami gates and many other mega projects.

After devastating earthquake of 2005, Pakistan is gradually shifting from the simple disaster response to a more proactive approach to disaster risk management. National Disaster Management Authority (NDMA) is responsible for handling complete spectrum of disaster management in the country. Pakistan Meteorological Department (PMD) plays its role in disaster management and working for hazard analysis and disaster mitigation work.

It is evident that retrofitting of existing structures, preparation and mitigation of hazard in already existing cities is a very difficult task under tough socio economic circumstances .Urban planners in Pakistan has adequate knowledge of development of new cities which is evident from national capital Islamabad. As with the increase of knowledge about natural phenomenon newly identified hazard zones are emerging. It is mandatory for urban planning to take into account these hazards in the master plan of the city for sustainable future development. As Gwadar is still in a development phase, disaster mitigation and management plans can be incorporated easily before it becomes a very populated city in near future. It is evident that only improvised planning and schemes with low cost techniques will help create a city which can be considered safe, attractive and environmentally friendly in changing global phenomenon. It is recommended that policies and scenarios at national, provincial and district level must be developed for all types of disasters especially for earthquake and tsunami. Both pre disaster and post disaster policies must be implemented as a starting point for future sustainable and safe city in Pakistan. Pakistan can enhance its capacities by sharing rich experience of Japan knowledge and technology for risk assessment and early warning systems.

➢ References

- About ADRC available online at Asian Disaster Reduction Center (ADRC) at: http://www. adrc .asia /aboutus/index.php
- Building Code of Pakistan (BCP SP 2007) available online at Pakistan Engineering Council at: http://www.pec.org.pk/buildingcode.aspx
- Cabinet Division, Government of Pakistan (2006): National Plan, Strengthening National Capacities for Multi Hazard Early Warning and Response System.
- Cabinet Office, Government of Japan (2015): Disaster Management in Japan, p. 1-16.
- Clift PD (2002): A brief history of the Indus River. In, Clift PD, Kroon D, Craig J, and Gaedicke C (Editors), The tectonic and climatic evolution of the Arabian Sea region, Geological Society of Lon-don special publication, 195, p.237-258.
- Earthquake Information available online at Pakistan Meteorological Department at: http://seismic.pmd.gov.pk/seismicnew/index.html
- EERI Special Earthquake Report (2006): Learning from Earthquakes, The Earthquake of October 8, 2005: Impacts in Pakistan available online at National Disaster Management Authority at: http://www.ndma.gov.pk/new/aboutus/Earthquake2005.pd
- Fujiwara, S., M. Tobita, H.P Sato, S. Ozawa, H. Une, M. Korai, H. Nakai, M. Fujiwara, H. Yarai, T. Nishimura, and F. Hayashi (2006): Satellite data gives snapshot of the 2005 Pakistan earthquake. EOS Transactions AGU 87(7), p.73–77.
- Griesbach, C.L., (1893): Notes on the earthquake in Baluchistan on the 20th December 1892: Records Geol. Survey India, v.26, p.57-64.
- Government of Balochistan and IUCN Pakistan (2007). Gwadar: Integrated Development Vision. IUCN Pakistan, Quetta, Pakistan. viii+70, p.64.
- Lawrence RD, Khan SH, DeJong KA, Farah A, Yeats RS (1981) Thrust and strike slip fault in interaction along the Chaman transform zone, Pakistan. Geol SocLond 9: 63–370, Special publication.
- Monitoring of Earthquakes, Tsunamis and Volcanic Activity available online at Japan Meteorological Agency (JMA) at: http://www.jma.go.jp/jma/en/Activities/earthquake.html
- Most Recent Disasters in Pakistan available online at National Disaster Management Authority at: http://www.ndma.gov.pk/new/
- Nakata, T., H. Tsutsumi, S. H. Khan, and R.D. Lawrence (1991): Active faults of Pakistan, map sheets and inventories, Spec. Publ. 21, 141 pp., Hiroshima Univ. Res. Cent. For Reg. Geogr., Hiroshima, Japan
- Nasir Mahmood, Karam Khan, Zahid Rafi and Dr. Finn Lovholt : (2012) Mapping of Tsunami Hazard along Makran Coast of Pakistan. Pakistan Meteorological Department Technical Report No PMD-20/2012
- National Disaster Management Authority (NDMA) (October 2011), presentation by Nadeem Ahmed Abro, on " National Disaster System & Laws in Pakistan " slide no. 25 available online at: https://www.google.co.jp/?gfe_rd=cr&ei=3BkBVsDLNerM8gfuiZ7ICQ%20&gws_rd=ssl#q=National+disaster+system+and+laws+in+pakistan+by+nadeem+abro
- Niamatullah M, Durrani KH, Qureshi AR, Khan Z, Kakar DM, Jan MR, Ghaffar A (1989) Emplacement of Bibai and Gogai Nappes, NE of Quetta. Geol Bull Univ Peshawar 22:153-158.
- Powell C. M. 1979: A speculative tectonic history of Pakistan and surroundings: some constraints from the Indian Ocean: Geodynamics of Pakistan, p. 5-24.

- Quittmeyer RC, Alan LK (1984) Focal Mechanisms and Depths of Earthquakes in Central Pakistan: ATectonic interpretation journal of geophysical research 89(B4):2459–2470. doi:10.1029/JB089iB04p02459.
- Sarwar G, DeJong KA (1979) Arcs, oroclines, and syntaxes: The curvature of mountain belts in Pakistan. Geodyn Pak, p.341–350.
- Stoneley R (1974) Evolution of the continental margins bounding a former southern Tethys. In: Burk C, and Drake C (eds), The Geology of Continental Margins. Springer, Berlin, p. 889–903.