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"Iran Activities on SDI and Data Sharing for Disaster Management Case Study : Recent Earthquake on August 11, 2012. GPS-Based Analysis of the Crustal Deformation in NW Iran" *

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Permanent Committee on GIS Infrastructure for Asia and the Pacific

"Iran Activities on SDI and Data Sharing for Disaster Management

Case Study : Recent Earthquake on August 11, 2012. GPS-Based Analysis of the Crustal Deformation in NW Iran "

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Summary

Wisdom-based development depends on having the correct information and making decision and programing based on this information. However, scientific studies indicate that more than 80% of the data required by organizations in various decision-making, management, planning, implementation and even the daily operations, are inherently spatial data or have spatial characteristics. Also has been observed that the main part of all decisions, relates to location or have spatial effects. Therefore, in order to achieve sustainable development based on wisdom, existence, availability and use of appropriate, reliable and high-quality spatial data in process of decision-making and planning is inevitable. In other words, a proper spatial infrastructure is necessary for sustainable development. For this reason, spatial data infrastructure is used in many of today's governments at national, provincial and local levels. Iran is one of the most tectonically active zone in Alpine-Himalayan seismic belt where has been shaken by largely destroying historical and instrumental earthquakes. The shortening between Arabian and Eurasian plates in Iran is mainly distributed on Zagros and Alborz belts. Several GPS campaigns were carried out on different networks between 2000 and 2008 and provided the horizontal velocity field in Iran. In these works, continuous and campaign GPS networks are used to better understand the tectonic deformation in different active parts of the country. These techniques will bring us more precise information on crustal information (shortening and strike-slip rate in Iran as horizontal movements, subsidence and uplift as vertical movements). Results from IPGN (Iranian Permanent GPS Network) stations in Azerbaijan province show 1.8 to 4.5mm/year movement that reaches to 6-8 mm/year in some stations. In 11 August 2012, two earthquakes with the magnitude of 6.0 and 6.2 occurred in Azerbaijan province close to the city of Ahar at 38.55N and 46.87E. Time-series obtained from IPGN stations in the vicinity of Earthquake clearly reveals the land movement. Multi-Purpose geodetic network has also been extended in Iran which is used for geodetic projects. Re-measurement of this network together with IPGN data can provide more information on co-seismic and post-seismic deformation of the crust. For this purpose, NCC completed the re-observation of the network and results will be published very soon.

Keywords: SDI-Clearinghouse-Metadata-Geoportal-Disaster Management-GPS-Geodynamics-Iran-Fault-Tectonic-Earthquake

1- Introduction

The main goal of many societies and countries is to gain sustainable development. All definitions of sustainable development are pointing to the same item: "equilibrant and multilateral development in economic, social and environment sectors". In past eras, natural resources and capital were regarded as the main subject of development, but at present, wisdom is regarded as the main subject of development. Sustainable development based on wisdom is vision and goal of many societies and countries in the world as well as Iran. wisdom based development emphasizes that decision making and planning should be performed by enough knowledge about environment, existing and impressing events on society, current activities, future plans and society requirements. Such knowledge is obtained by having precise and reliable information from current and future situation.

Wisdom-based development depends on having the correct information and making decision and programing based on this information. However, scientific studies indicate that more than 80% of the data required by organizations in various decision-making, management, planning, implementation and even the daily operations, are inherently spatial data or have spatial characteristics. Also has been observed that the main part of all decisions, relates to location or have spatial effects. Therefore, in order to achieve sustainable development based on wisdom, existence, availability and use of appropriate, reliable and high-quality spatial data in process of decision-making and planning is inevitable. In other words, a proper spatial infrastructure is necessary for sustainable development. For this reason, spatial data infrastructure is used in many of today's governments at national, provincial and local levels.

Spatial data infrastructure (SDI) is a set of policies, standards, accessing networks, technologies, spatial data, organizations and people which facilitates and cooperates different tasks for optimum spatial data producing, collecting, accessing and utilizing. In other words, SDI provides a platform to discover, evaluate and utilize spatial data for users and producers in all levels of government, private sectors, academia and others. The objective of implementation of SDI is to achieve a powerful platform dealing with spatial data to ease, simplify and enable interoperability throughout all levels of government and private sectors.

Following items are some benefits of implementation of SDI in national, regional and local levels:

- Reaching sustainable development
- Improving the effectiveness
- Reducing data collection and maintenance costs
- Promoting data quality and compatibility
- Improving availability of spatial data access
- Outreaching data reuse
- improving the quality of planning and decision making

The present tectonics in Iran results from the north-south convergence between the plates of Arabia to the south-west and Eurasia to the north-east (Jackson and McKenzie, 1984) at a rate of about 22 mm/yr (Nilfouroushan.,2003; Vernant *et al.* 2004) Fig.1. It involves a young continental collision (Falcon, 1974; Berberian and King 1981) except along the Makran, its south-eastern margin, where oceanic crust of Arabian plate subducts northward beneath south-east Iran (Byrne *et al.* 1992). Within Iran, most of the deformation is accommodated in the major belts (Zagros, Alborz, Kopeh-Dag) and along large strike-slip faults which surround blocks (Central Iran, Lut and the southern Caspian sea) with moderate relief and seismicity (Jackson and McKenzie 1984; Berberian and Yeats, 1999).

This convergence is accommodated almost entirely in the Alborz (6–8 $mmyr^{-1}$) and Zagros Mountains (6–9 mmyr-1), the remaining deformation being located somewhere in the south Caspian basin. At the southeastern margin of the Arabia-Eurasia collision zone, along the Makran, the shortening is absorbed by subduction of oceanic lithosphere beneath southeast Iran at 19.5 mm yr^{-1} (Vernant *et al.* 2004) In the Persian gulf no shortening is observed (Tatar *et al.* 2002). As previously proposed on the base of the seismicity (Jackson & McKenzie, 1984) and recently confirmed by geodetic measurements (Vernant *et al.* 2004), central Iran does not significantly deform and acts as a backstop of the Zagros Mountains. Since the central Iranian block (CIB) moves at 14 mm yr^{-1} to the north relative to Eurasia, the relative velocity between the CIB and the Arabian plate is 7 mm yr^{-1} in a North-South direction. According to this situation, it is important to monitor the crustal deformation using geodetic data such as VLBI, SLR, InSAR, and GPS. Among them GPS has several advantages (continuous collection, cheaper, and more compact) and therefore it is easier to construct lots of observation stations. With the recent advance in GPS receivers technology and scientific software's (Bernese, Gamit/Globk, GIPSY and

OASIS) and using precise satellite orbit and clock; we can achieve the accurate stations positions and their velocities for geodynamic applications. So in 2005 National Cartographic Centre of Iran (NCC) started to build a GPS continuous observation network for crustal deformation monitoring and estimating geohazard in Iran. The network consists of 120 GPS observation site which distributed in the active part at the country. To reach the goals we also benefited the studies and remarks of GSI (Geological Survey of Iran) and IIEES (International Institute of Earthquake Engineering and Seismology).This article introduce Iranian Permanent GPS Network (IPGN) and final result from analysis center.

2-NSDI in the fifth development plan

The implementation of NSDI has been entrusted to "National Cartographic Center" based on the Fifth Development Program of I. R. Iran in June 2010. In this way, NCC has established National SDI Cooperating Committee in order to pursue related duties, continually. The establishment goal of National SDI Cooperating Committee is to provide the way for executing governmental organizations for participating, collaborating and also easing inter-organization cooperation in order to implement NSDI. The committee is chaired by NCC. Its members are ministries undersecretaries or general directors/ national organizations which are administrators or the main users of spatial data. At present, members of the committee are Ministry of Interior, Ministry of Roads and Urban Development, Ministry of Agriculture JAHAD, Ministry of Energy, Ministry of Petroleum, Ministry of Industry, Mine and Trade, Ministry of Information and Communications Technology, Iran Department of Environment, Geological Survey of Iran, National Geographical Organization, National Cartographic Center, Iranian Space Agency, State Organization for Registration of Deeds and Properties, and Statistic Center of Iran. Other ministries and organizations would be invited in case.

The duties of the committee are as below:

- Examination and use of discretion on resolutions, policies and standards in order to notify and perform in executive organizations
- Establish proper relationship among counselors and implementers of national SDI projects with executive organizations in order to hold meetings, referral, interview, exchange of views, data collection and etc.
- Reflecting the point of views of executive organizations and existing issues of SDI establishment in the organizations, in order to find solution of issues
- Cooperation and pursuing of performance of the committee resolutions in the executive organizations

Furthermore, it's necessary to organize some special workgroups in order to establish NSDI under supervision of the committee. On the other hand, counselors group composed of university professors pursue all SDI implementation phases and related items and report their results to the committee.

3-NSDI and National Cartographic Center (NCC)

Considering NSDI implementation has been entrusted to NCC in June 2010, NCC is responsible for pursuing, steering and cooperating of SDI implementation in all local to national levels. Furthermore, NCC as the stakeholder of producing basic spatial data in the country has produced coverage maps of more than 95% of the country in 1:25000, 1:50000, 1:100000, 1:250000 and 1:1000000 scales. On the other hand, NCC has established SDI section under its GIS department in August 2010 in order to pursuing related duties, continually. The establishment goal of SDI section is to create an official institute in order to establish relationship between different SDI levels in country and to pursue the designed strategic plan in different SDI levels. Since 2005, a comprehensive study in field of national SDI has been performed that its results are in compilation of national SDI strategic plan. This study is the base of national SDI implementation. The phases of the designed strategic plan would be executing based on the 7 years schedule.

The important outlines of the strategic plan are as below:

1. Establishment of national SDI cooperating committee and SDI's preliminary cooperating structure in institutions and provinces.
   a. Meetings of Cooperating committee are held regularly. In these Meetings achievements of activities and future programs are informed and discussed.
   b. NCC is pursuing to establish SDI's preliminary cooperating structure in institutions and provinces.

2. Developing the general pattern for provincial and local SDIs
   a. In order to achieve a general pattern for establishment of provincial and local SDIs, study of four provinces and eight cities is in progress. The outcome of these studies will notify as "the general pattern of establishment of provincial and local SDI" to all provinces and cities.
3. Study and establishment of Organizational SDIs
   In order to promote processes and quality of spatial data management in an organization as well as making possible more effective cooperation in establishment of national SDI, it is necessary that each executive organization attend to accomplish its organizational SDI design and establishment in harmony with national SDI policies, standards and methods.
   In this respect, it is necessary that each organization prepare metadata of its spatial data, based on compiled standard by NCC entitled "The minimum considered metadata for documentation in national SDI ". Furthermore, these organizations should design and implement their spatial databases and prepare their catalogue services and then register them in national geoportal.
4. Study and establishment of disaster management SDI
   a. Disaster management of country using spatial data and services in different phases of disaster management would be significantly promoted. At the moment there is not such an approach. The goal of disaster management SDI is to provide a platform to manage, share and use of spatial data in all phases of disaster management.
   b. This will be done in collaboration with Interior ministry according to the schedule.
5. Technical, policy making and outreaching workgroups
   a. National SDI improvement proportionally and according to requirements, different workgroups will establish including representatives of executive organizations to exchange the views and cooperate in implementation of NSDI.
6. training , culturizing and improving the level of awareness
   a. Considering the need for culturizing and promotion of knowledge level in this field, NCC holds training courses in different levels for experts and managers.
   b. Holding annual conferences is another activity of NCC in this field.
   c. Other activities will persuade according to NSDI action plan.
7. Designing and establishing the national spatial data clearinghouse
   a. The national spatial data clearinghouse network has been designed according to architecture of 2nd generation of the clearinghouse networks, which is based on spatial web services.
      This generation of clearinghouse is on the basis of the geoportals, the catalogue services and the spatial services. This generation provided the users with the more appropriate methods to search and access to standardized spatial data. The popular clearinghouses in the world belong to the second generation. The below figure illustrates the schematic structure of the second generation clearinghouse that is on the basis of one geoportal, catalogue services and spatial services.

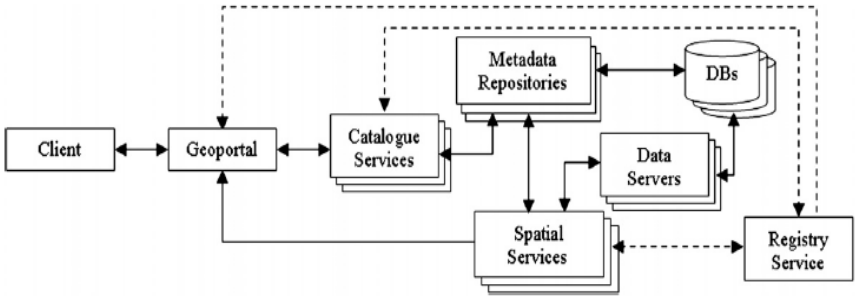

Figure 1: Schematic structure of the second generation clearinghouses

The main elements of the second generation clearinghouse can be summarized as follows:

- Geoportal provides the entry point for spatial information on the web. Geoportal is a website on the Internet in which the spatial content including the spatial data and spatial services are found.
- Catalogue Services enable the metadata distribution on the spatial data resources and searching metadata and querying it.
- Metadata Repository stores the information about the spatial data (in database).
- Spatial Services which are connected to the data server provide the various services such as spatial data representation and loading for the user.

- Registry Service is where the spatial services and catalogue services are registered to be found by a geoportal.

b. NCC has designed and implemented national geoportal based on this architecture. National geoportal as the input clearinghouse network port has been designed and established in order to create proper tools for search, retrieve, access and share the spatial data. This portal prepares search possibility in distributed spatial data sources using catalogue services of participant organizations in SDI platform.

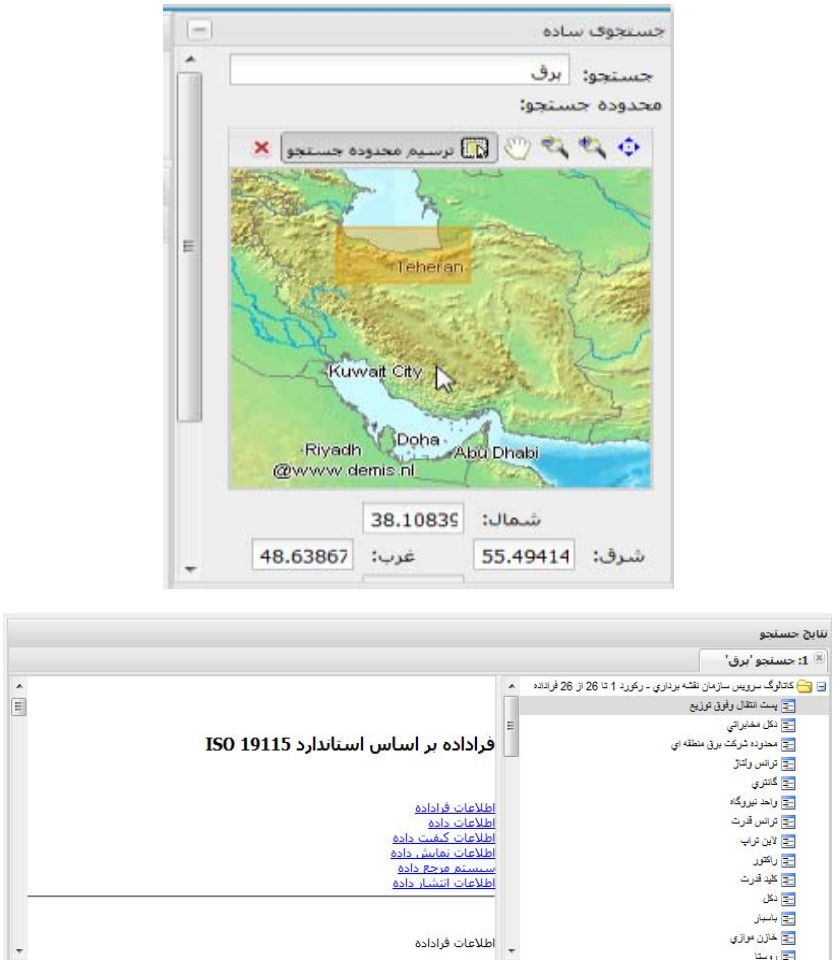

Figure 2: some views of implemented geoportal

c. Furthermore, NCC is creating its catalogue service and other spatial services and registering them in national geoportal.

d. It is necessary that each executive organization design and create its spatial services (especially catalogue service) based on this architecture and registers them in national geoportal in order to form national clearinghouse.

Performance evaluation and improvement of national spatial data clearinghouse.

This item will be performed after launching the network and registration of catalogue services of organizations in national geoportal.

8. Compiling required standards and instructions

a. National metadata standard has been compiled based on ISO 19115 standard.

This standard proceeded to metadata that has a key role in documentation and thus searching and notifying spatial data. This Standard is a profile of international standard "Spatial information-metadata ISO 19115" from ISO/TC211 standard series. Minimum details in metadata are determined by international standards that make possible to search and identify spatial data. These minimum details are compiled to facilitate clearinghouse activities.

b. National standard of spatial data in medium and small scale is compiling.

c. National standard of spatial data in large scale is intended to compile.

d. Other required standards and instructions will be compiled according to NSDI action plan.

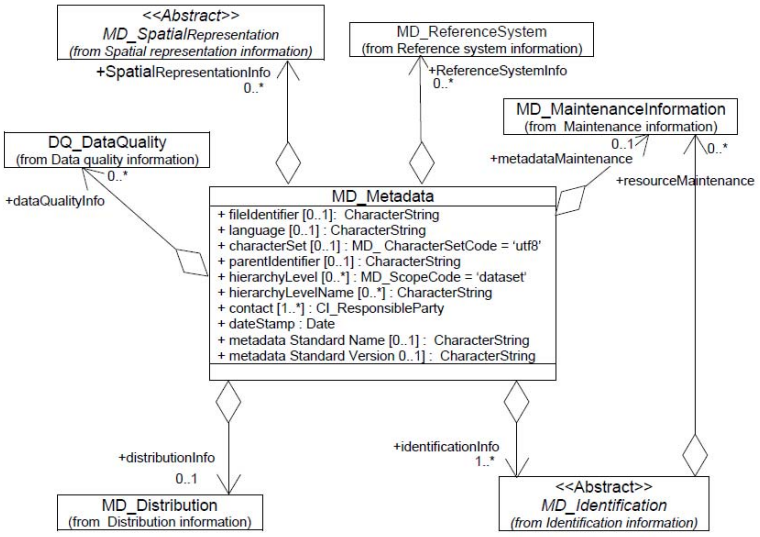

Figure 3: Essential classes diagram of metadata standard

9. Segregation of top secrete and ordinary data
    a. Organizations often avoid giving or sharing their spatial data because of security issues, while the majority of these data are not top secret and have no limit to share. So it is necessary to segregate top secret and ordinary data, and share then via SDI platform.
    b. Segregation of top secretes and ordinary data could be done after compiling the final version of spatial data standards in related workgroup.
10. Performing Cost-Benefit analysis for SDI and compiling initial financial model.
11. Providing, completing and organizing of topographic based maps and organizing spatial data of other organizations.
    a. Providing, completing and organizing of topographic maps in medium and small scales for the whole of country is in progress.
    b. Other data will be prepared and organized by stakeholder organizations according to NSDI action plan.

4-Communication with International SDI societies

In order to improve the implementation of SDI, NCC has established international technical cooperation.

Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP) is a regional organization of United Nations. The establishment aim of committee is to provide a planning power for optimizing the consumption of resources, improvement in economic, social and environment issues and effectiveness of the region countries by SDI development and the most uses of it. NCC is an executive member of PCGIAP and has undertaken the chairmanship of 2nd workgroup of PCGIAP called Geospatial Data Management and Service. Likewise, NCC is a member of 1st workgroup of PCGIAP called Geodesy Technologies and Applications.

Furthermore, NCC is one of the main permanent members of International Steering committee for Global Mapping (ISCGM). The whole world maps provision in small scales with the participation of world countries is one of the main committee's responsibilities. Some countries such as Iran, has presented their data completely which are available now, while some other countries' data are in revising or developing phases.

Another international task of NCC is communicating with Global Spatial Data Infrastructure (GSDI) and attending in GSDI conferences. GSDI association is the first SDI global institute which pursues vast goals like promotion and increases the outreaching, information and standards exchanging in the field of infrastructural subjects in all levels of SDI from local to global.

5- Case Study : GPS-Based Analysis of the Crustal Deformation in NW Iran,Recent Earthquake on August 11, 2012

Iran is one of the most tectonically active zone in Alpine-Himalayan seismic belt where has been shaken by largely destroying historical and instrumental earthquakes. The shortening between Arabian and Eurasian plates in Iran is mainly distributed on Zagros and Alborz belts. Several GPS campaigns were carried out on different networks between 2000 and 2008 and provided the horizontal velocity field in Iran. In these works, continuous and campaign GPS networks are used to better understand the tectonic deformation in different active parts of the country. These techniques will bring us more precise information on crustal information (shortening and strike-slip rate in Iran as horizontal movements, subsidence and uplift as vertical movements). Results from IPGN (Iranian Permanent GPS Network) stations in Azerbaijan province show 1.8 to 4.5mm/year movement that reaches to 6-8 mm/year in some stations. In 11 August 2012, two earthquakes with the magnitude of 6.0 and 6.2 occurred in Azerbaijan province close to the city of Ahar at 38.55N and 46.87E. Time-series obtained from IPGN stations in the vicinity of Earthquake clearly reveals the land movement. Multi-Purpose geodetic network has also been extended in Iran which is used for geodetic projects. Re-measurement of this network together with IPGN data can provide more information on co-seismic and post-seismic deformation of the crust. For this purpose, NCC completed the re-observation of the network and results will be published very soon.

6- IPGN Network Configuration

The IPGN network consists of two parts: base network and regional networks. The base network consist of 41 station which distributed in Zagros-Alborz-Lut-Kopet-Dag-Central Iran- Makran and east of Iran in order to monitor the total motion and geodynamics of plates boundary.

Regional networks are in tehran, tabriz and mashhad areas and the distance between the stations is about 25-30 km. Tehran as the capital with 12million population located in the southern mountain foots of central alborz in a highly active zone. In order to monitor tectonic deformation in this area 25 stations are established in different part according to geological and geodetical parameters.

In the western and eastern Azerbaijan and Ardabil Provinces, there are many active faults such as Tassouj and north Tabriz faults. Tabriz city is located along of Tabriz fault and historical earthquakes with Magnitude of 6 to 7 have recorded in this area. So in order to monitor this part 20 stations are established (Figure 4).

7- Recent Earthquake in Azerbaijan province

Azerbaijan block is one of the active zones in the country which has experienced many strong earthquakes in its history. Collected geodetic and seismic data shows that Azerbaijan has a high potential in this respect. Tabriz, Khoy-Maku and Nakhjavan are the most known and active faults in this zone. Latest results from GPS observations prove 1.8 to 4.5mm/year movement and it reaches to 6-8 mm/year in some stations. Results confirm a right-lateral strike slip rate on the order of 7 mm/year for the north Tabriz fault in agreement with previous studies (Masson et al 2006 and Vernant et al 2004) and shows the right lateral motion extends west into Turkey along the Chalderan fault (Djamour et al 2011) Velocity field from GPS data analysis is depicted in Fig 9. New measurements also show a lower extensional rate of 1-2 mm/year for the central part of the Tabriz fault (Djamour et al 2012).

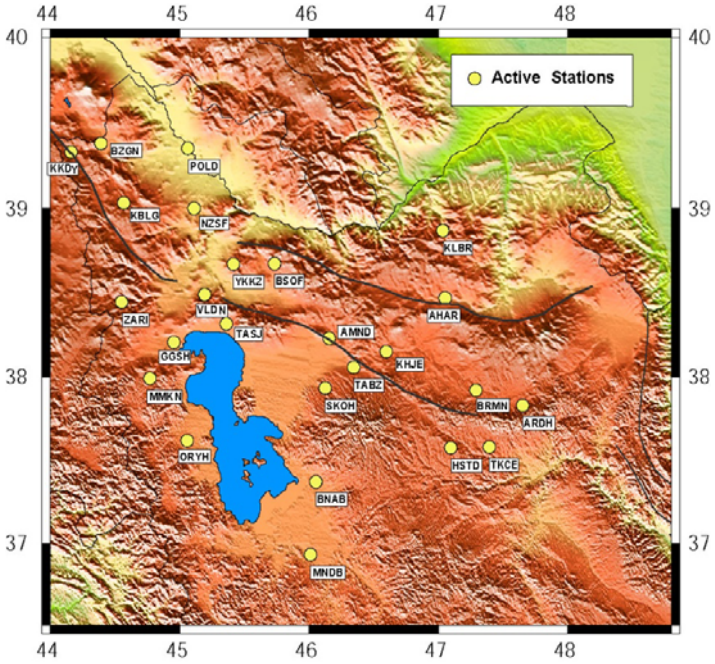

Figure 4: IPGN (Tabriz Network) in the north west of Iran

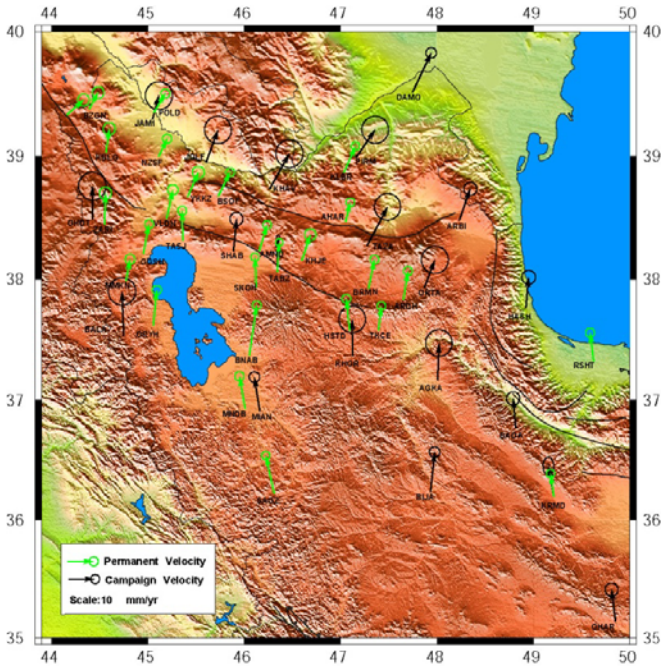

Figure 5: Azerbaijan GPS Network velocity field

In 11 August 2012, two earthquakes with the magnitude of 6.0 and 6.2 occurred in this zone close to the city of Ahar at 38.55N and 46.87E. Figures 10 and 11 show the locations of Iranian permanent GPS (Sadra Karimzadeh and Ziyadin Çakir 2012) and aftershocks (from IIEES) and focal mechanisms (from CMT) of recent earthquakes near Tabriz city within structural map of NW Iran adopted from IIEES. Fig 5 illustrates the land movement due to the earthquake (Ruegg 2012).

25 IPGN stations Exist in this zone where two of them are exactly in the area affected by the earthquakes. All

data from the stations were collected and analyzed by NCC. Results are illustrated in fig 6 and show that 3-4cm movements have been experienced by Ahar station.

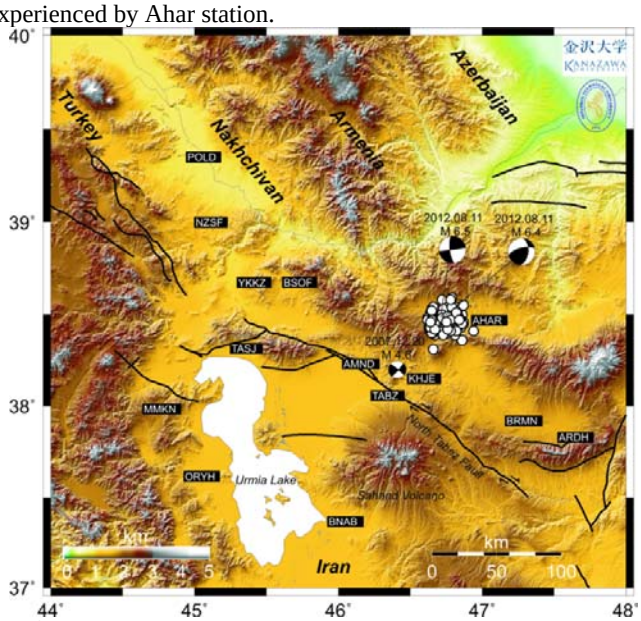

Figure 6: Locations of the main faults and Iranian permanent GPS stations are shown with 4 letter station names inside black rectangles. This map was prepared by Sadra Karimzadeh (Kanazawa University, Japan) and Ziyadin Çakir (Istanbul Technical University ,Turkey)

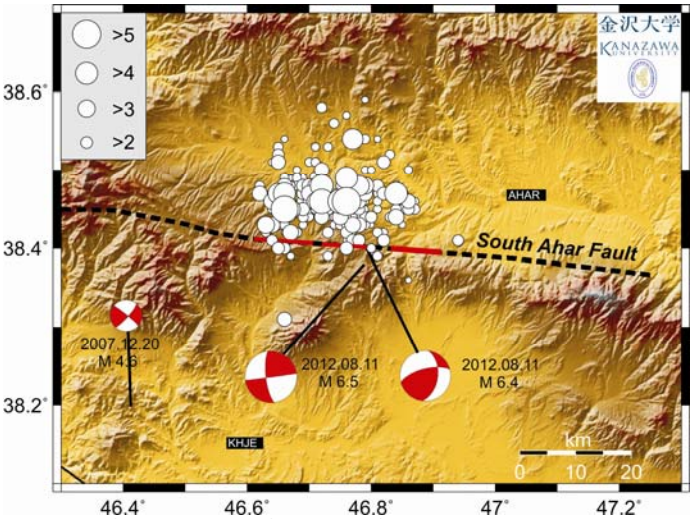

Figure 7: Aftershocks (from IIEES) and focal mechanisms (from CMT) of recent earthquakes near Tabriz city within structural map of NW Iran adopted from IIEES

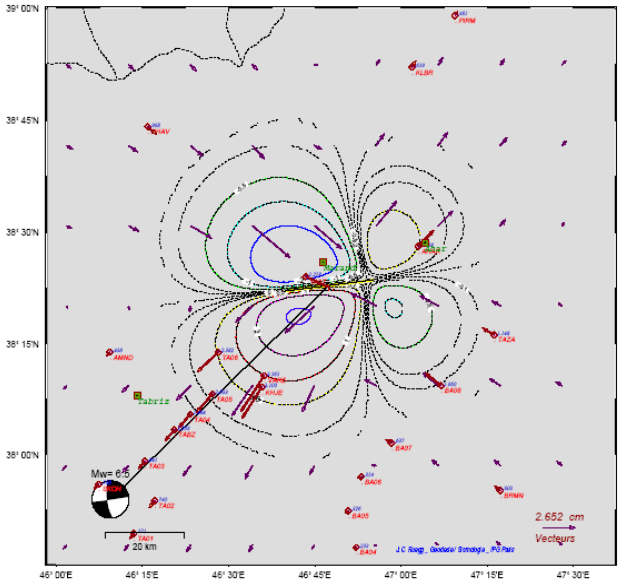

Figure 8: Land movement due to earthquake (Ruegg 2012)

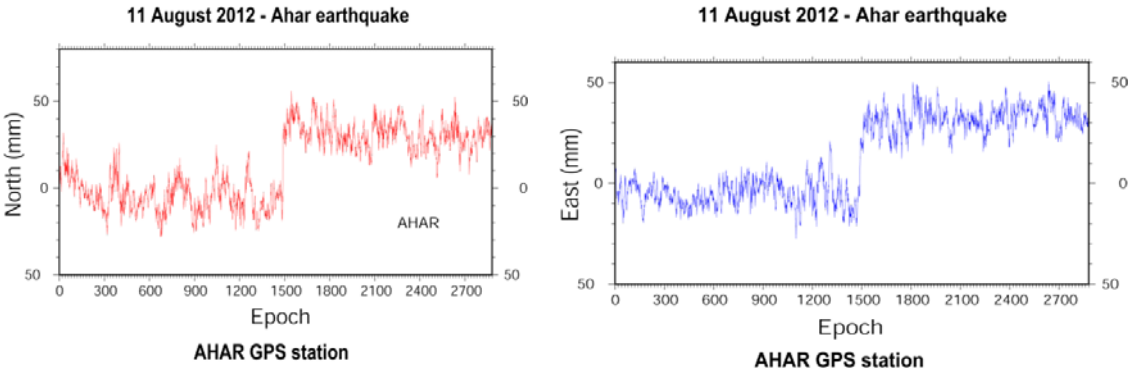

Figure 9: Movement of Ahar station due to earthquake

In addition to the IPGN, NCC has already established a Multi-Purpose geodetic network in Iran which is used for geodetic projects. Although the network is not as precise as IPGN but all stations monumented in bedrocks and measured by GPS for 24 hours. Fortunately, some of the stations of this network are in the affected area and re-measurement of the network can provide more information on seismic and post-seismic deformation of the crust. For this purpose, NCC completed the re-observation of the network and results will be published very soon.

8- Conclusion

Data Sharing based on SDI is one of the important policy for each country. Data sharing in disaster management has many benefits for country. Results from IPGN (Iranian Permanent GPS Network) and other geodetic networks have been showing enormous information about crustal deformation (plate motion-activity of active faults, uplift, subsidence) in different parts of the country. Nowadays, IPGN is also used as an active controlling system for GPS surveying. So, the usage of this network is not limited to crustal deformation. GPS metrology is another project which is just started. The next phase of this project is real time monitoring that starts this year. This system will be expanded to more than 700 permanent observation sites in the next years. Movement due to the recent earthquake is revealed by IPGN and more results from the campaign data will be published soon.

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