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EVALUATION OF INTEGRATED MANAGEMENT TO REDUCE THE CRISIS WITH APPROACH TO SPATIAL DATA INFRASTRUCTURE

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ABSTRACT

As management is one of the most important elements for all activities of the current world and as Iran is one of the most hazardous countries in terms of natural disasters, the issue of management gains special importance in crisis. The main purpose of crisis management is reducing crisis risk and the ways to achieve this goal are various and have been evolved over the time. Crisis management includes a disaster before the beginning to the end and the operations after the disaster. While occurrence of each accident, the Committee of Crisis and Disasters analyzes the situation from different dimensions using existing instructions and makes the best decision and provides it for the involved organs. Due to importance of time, the main part of the process of crisis management is taken before the disaster. Reducing the risk of crisis with the integration in its heart with spatial planning is required. In this regard, spatial data infrastructure (SDI) provides required conditions for collecting and maintaining spatial data to facilitate sharing the data and creating an integrated management. Therefore, the objective of this study is to evaluate spatial data infrastructure as a context for realization of integrated management to reduce risk of probable crises using descriptive-analytical method.

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Key words: spatial data infrastructure, crisis risk reduction, integrated management

INTRODUCTION

Despite the increasing ability of societies and governments to cope with natural crises, people and infrastructures exposure to risk are also increasing; therefore, the risk of natural crises is increasing. The level of being at risk in a special place depends on hazard, vulnerability, and resiliency. As it is mentioned herein: crisis risk= hazard × vulnerability- resiliency

In this relation, vulnerability is a potential condition for pain that is resulted by a crisis and resiliency is a kind of bearing power making a critical society or system retrieving from crisis using all resources; in this case, the society can bear the occurred conditions without being collapsed. However, it is not simple to ascertain quantity of resiliency; hence, the other methods are employed in this case. The previous equation will become:

A) Crisis risk= hazard × Vulnerability × Cost

B) Risk= Probability × Implication

C) Risk= hazard × (Vulnerability/Capacities)

D) Risk= f (hazard, Vulnerability, being at risk) (Sutanta, 2012).

Increasing complexities and mutual effects between human activities and natural phenomena sometimes make natural risks a part of unnatural crises. Natural phenomena may be changed through human activities becoming human crises of course at a larger scale. Land use and changes in land use can change natural trend of risks creating human-made risks. Therefore, land use management and land use changes are essential to reduce effect of natural crises. This issue is subjected to examination of natural crises based on development planning.

Since 80% of required information for urban management have spatial aspects such as land properties, roads network, urban services; infrastructure (such as water, electricity, phone, sewage, etc.), emergency services, garbage collection, recreation areas, etc., this information has some properties such as large scale, high discrimination power, difficult accessibility, rapidly changing, etc. Experiences of developed countries show that since spatial aspects of information are vital for management, decision-making, and planning, technology of spatial data systems and infrastructures of urban spatial data would promote effect of urban management activities, in particular in scope of crisis management. Therefore, use of these advanced spatial technologies to design and implement various projects is a key presumption for sustainable urban development

(Bhandari, 2010). Therefore, spatial data infrastructure creates an environment for owners of spatial data providing a field for information sharing, notifying about spatial data, and presenting the most appropriate methods for data accessibility; in such environment, spatial data owners can achieve their organizational goals matching with each other and using various technologies. Such environment can be created through designing, implementing and maintaining those mechanisms that facilitate sharing, accessibility, and use of spatial data. Undoubtedly, if such mechanism is implemented and proposed in cities, the data generating organizations can perform in a harmony spending a high cost and time to develop and maintain data. Accessibility and usability of spatial data that is created by different organizations subjected to their management mission would make it essential to create spatial data infrastructure as a database for spatial data storage and simple accessibility. In fact, creation of a spatial data infrastructure as a bed for management is essential to create an integrated crisis management.

METHODOLOGY

This study is a fundamental and applied research in terms of objective. This is fundamental study since it leads to development and expansion of science theoretically and is applied since it aims at solving a practical problem existing in real world. It should be noted that fundamental researches are the bases for applied researches, because every applied research is undertaken in framework of a scientific theory based on the scientific concepts, principles, and rules. In terms of value, the extant study is a descriptive-analytical research that analyzes current situation. This is also a casual-comparative study, since the occurred crises in Tehran megacity, Iran indicate lack of integrated management to reduce crisis risk that has harmed the society. Hence, it is required to identify challenges to integrated management of crisis risk reduction based on an optimal model for crisis management through a casual research. In this case, world experiences should be used to adapt integrated management of risk reduction in Iran with developed countries based on the optimal form of crisis management in world.

THEORETICAL LITERATURE

National Incident Management System of USA (NIMS)

NIMS can be mentioned as one of programs of Federal Emergency Management Agency (FEMA). NIMS is a systematic system to integrate cooperation between governmental organizations and institutions at all levels and non-governmental organizations and private sectors to manage crises and threats regardless of the cause, size, place, or complexity of crisis in order to reduce life, property, and environmental losses. NIMS is the major infrastructure of National Preparedness System (NPS) that provides a model to crisis management and required operations at the time of crisis. The purpose of NIMS is presenting a joint-stock cooperative bank approach to crisis management. For this purpose, NIMS employs a flexible and standard methods of crisis management emphasizing on common principles with approach adjusted to operational structure and integrated management of resources (www.fema.gov).

Integrated data system of crisis management in Japan

According to experience obtained from great Hanshin Awaji earthquake, crisis management system of Japan is improving to an integrated system of crisis management that contributes to correct initial estimation of catastrophe and information exchange between relevant organizations; in this case, decisions can be made properly and rapidly with minimum error. The most underlying factors of integrated data system of management crisis are as follows:

- Initial evaluation of damages caused by earthquake: this data system receives earthquake intensity then is activated automatically to earthquakes above 4 on the Richter scale. This factors estimates intensity and scale if damages to buildings and human within 10 minutes.
- Initial evaluation of damages using satellite: initial evaluation system of damage would provide initial estimations of damage size using artificial satellites at the time of incident at a large scale with wide-area visibility.
- Information sharing system: this system publishes the information provided by disaster management agencies using an available GIS map (Hosseini Jenab et al., 2013).

DFNK data infrastructure

DFNK data infrastructure consists of three components including a database, Clearinghouse, and portal. Development of database includes of estimation of existing and required data. Clearinghouse is a service catalogue with metadata that allows users to retrieve data based on a specific subject, time and place and portal presents general information to visitors and provides online documents, data and software to project members.

Designers have proposed several suggestions for technology infrastructure as follows: design of distributed software for flexibility in integration using Java and XML[1] for independency of platform and a comprehensive model with components aligned with international standards (Kohler and Wachter, 2006).

Integrated Information System of Natural Disaster Management (ISNDM)

ISNDM is a practical and communicational system has been developed in GIS-based Disaster Reduction of Chinese Academy of Sciences during 3 years. This is a simple but comprehensive system to mitigate natural crises. This system consists of 5 main modules including pre-information of crisis, social and economic information, crisis evaluation, database of factors caused by crisis and database of crisis scenarios. ISNDM consists of some operators including data collection, data processing, data storage, and data distribution.

In case of data collection, ISNDM can receive simultaneous information of crisis from different references such as ministries, organizations, provinces, cities, etc. through input ports. In case of data processing, a large number of data from various resources such as land monitoring systems, satellite images, etc. can be processed rapidly then combined with social-economic information then depicted in a GIS platform to evaluate crisis dynamically. To store data, ISNDM stores simultaneous data of first day in Real-Time Database then data of second day are transferred to a Historic Database to be used in future. Database is usually updated immediately and a large number of data such as geographical, social-economic, and former crises information are stored in database. Also, crisis data are distributed on the internet with a FTP through a specific network to be used by users and for their general information (Wu et al., 2007).

Integrated Management of Crisis Risk Reduction

Mitigation of crisis risk of earthquake depends on performance of vital arteries to maintain performance of a city before and after crisis. According to severe interaction between theses arteries and dependency of them to each other, behavior of these arteries and their interaction at the time of incidents should be studied. The main issue is that dependency of arteries in not just physical independency between two vital arteries so that they are depended to each other in terms of information also external factors such as environmental, political, and social factors. Each of these factors should be examined using infrastructural systems and facilities. For instance, some

[1] Extensible Markup Language

options such as power plants, transmission and distribution lines, electricity posts, feeders, control and dispatching centers should be examined in electricity network. In water network sector, pumping stations, refineries, wells, reservoirs, transmission and distribution pipelines should be tested. Therefore, different urban organizations are dependent to each other and require better performance in ordinary and critical conditions to prevent from interfering with performance of organizations. In this regard, different urban organizations need an integrated management, in particular in critical conditions, to become aware of actions, to share information, etc.

It should be mentioned that dependency has different types and various researchers classified these types of dependencies. For instance, Rinaldi and Kelly classified dependencies to three categories:

1) Physical dependency: occurs when infrastructures' levels have a physical relation with each other. This kind of dependency between levels is suitable to quantify uncertainties.
2) Informational dependency: it occurs when arteries are related to information and its transmission. This dependency has become more significant with expansion of informational technologies based automation and computers in recent years. If a part of infrastructure depends on distributed information among other parts, this kind of dependency will emerge in performance of infrastructure due to need of data transfer and computed control.
3) Geographical dependency: occurs when several different arteries are affected by a natural incident. When surrounding environment of an infrastructure is changes- in other words, when infrastructure is affected by its surrounding environment- it is geographical dependency (Rinaldi et al., 2001). In fact, these dependencies should be identified based on an integrated management in critical conditions.

Spatial Data Infrastructure

The term "spatial data infrastructure" (SDI) was used for a set of spatial data servers in 1990s that was interacted with each other based on spatial standards deploying spatial data infrastructure to meet needs of users in spatial scopes such as observation, editing, transferring, and spatial analysis information. The selected standards for this purpose consist of web-based spatial services proposed by Open GIS Consortium (OGC). This consortium with 8 members was established in 1994 to provide open source facilities to deploy infrastructures for spatial data interaction in the world. This consortium attracted more than 400 members through expansion if internet networks and propensity toward online spatial services and publishing of different types of open source products in this field so that these standards became global rapidly. Nowadays, more than millions of spatial data layers are available to public in framework of the mentioned services. These services can be used by spatial data custodians to provide users with their required services employing open source facilities and different spatial services without sharing their data with others. Accordingly, holding long and ineffective sessions is not the required case to agree with other spatial data providers about sharing informational layers. Such feature of these spatial services led to introduction of global idea of SDI. Before advent of SDI technology, spatial management was not practical globally and could not be beyond the national GIS. It is natural that any measurement cannot be global action without having global standards.

As it can be seen in figure 1, 4 dimensions including policy, organization, data, and infrastructure are required to actualize an integrated management of crisis risk reduction. The policy provides the field to set required rules and policies through an integrated framework. Rules are based on performance of organizations involved in crisis management and data standards are based policies. Policy is indicated in governmental rules and regulations. Clearly, policy shows rules and regulations related to organization involved in urban management and implementation of integration operations. It should be noted that these regulations should implement locally too.

According to organizational aspect, it seems that various organizations involved in urban management ad critical conditions perform individually. Local planning and management organizations are responsible for spatial planning and reducing local crises so that they follow their goals, programs, and policies without any compatibility with other urban management organizations; such situation can be attributed to uncertain rules and regulations in local organizations. Apparently, there is not an optimal relationship between urban management organizations, in particular local and national crisis management and their counterparts in the context of spatial planning, while organizational interactions are essential to implement integrated management.

There are two considerable issues in field of data; first of all, the data relate to city, urban management, and urban crisis management should be prepared by organizations within an organizational framework they these data should be shared in a database so that future sharing of data by organizations leads to creation of spatial data infrastructure. These data consist of spatial data of city providing by each organization based on its tasks and responsibilities. Second point is related to collected data in database that should be standard within a certain framework; in this case, a standard level is selected for data in which, data are prepared and shared in database. Similarity or relation between data is a vital factor that enables organizations to access to data immediately and use them.

Also, an infrastructure is required to integrate crisis risk data with spatial plan, to facilitate organizations' collaboration, and to have public participation. A planning supporter system has been proposed to facilitate spatial plan development based on risk data. An infrastructure is also anticipated to transfer and share data among involved governmental organizations. This infrastructure consists of 3 important parts including network access, policies, and standards.

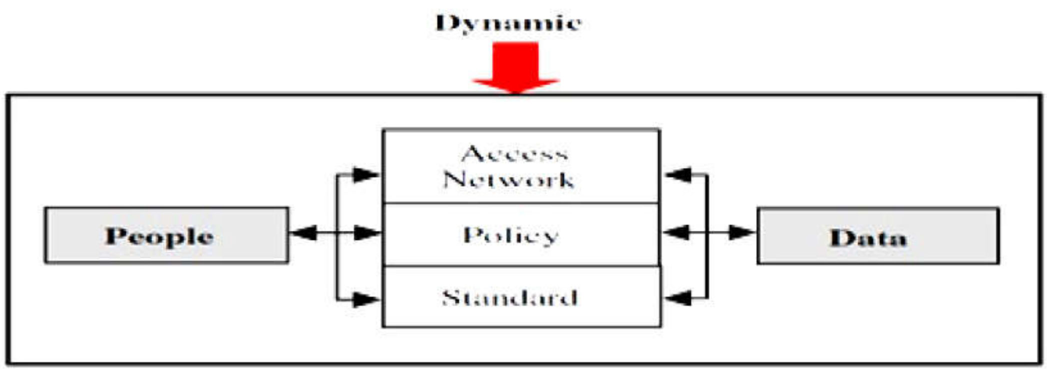

Fig.1. Components of spatial data infrastructure (SDI)

SDI usually points to technological and political collection and accessible organizational arrangements that lead to spatial data accessibility. SDI is a basis to discover and evaluate user needs to spatial data that is satisfied through governmental levels, commercial sector, non-beneficiary sector of universities and citizens. The word of infrastructure is used to promote concept of reliability and supporting environment and is similar to a road or telecommunication network that is ease of access to spatial and geographical data in this case. SDI is a database not a collected of separated data and such infrastructure is indeed the host for geographical data that provides enough number of documents to discover, embody and evaluate data as well as methods for geographical data accessibility. To create a functional SDI, the required organizational agreements should be available to match and handle this infrastructure at local, regional, national, and trans-national levels (Sutanta, 2012).

Tehran Spatial Data Infrastructure (TSDI)

Administration of SDI and Systems of Mapping Organization of Iran has made experts focusing on open sources technologies and establishing standard spatial and metadata services with approach to national SDI deployment recently in accordance with the national mission; in this regard, there are now more than thousands of spatial services and ten thousands standard spatial metadata that can be used on the web. For instance, a work set in past that consisted of different organizations with similar work had no digital spatial data and all data were on paper before using map tools. Organizations and institutions created their own specific SDI gradually using different software and facilities. These databases were different in terms of structure and work environment. Organizations established their activities in various environments such as CAD, Microstation, Arc Map, etc. in last case, the spatial data relationship method between different organizations, as can be seen in figure 2, is similar to Spaghetti Model not following a specific rule. The method and protocol were selected based on data to make relationship with spatial databases considering interests of beneficiaries without any unity. For instance, if municipality needs to make relationship with healthcare network, they can reach unanimity on data transfer holding sessions and agreements between themselves.

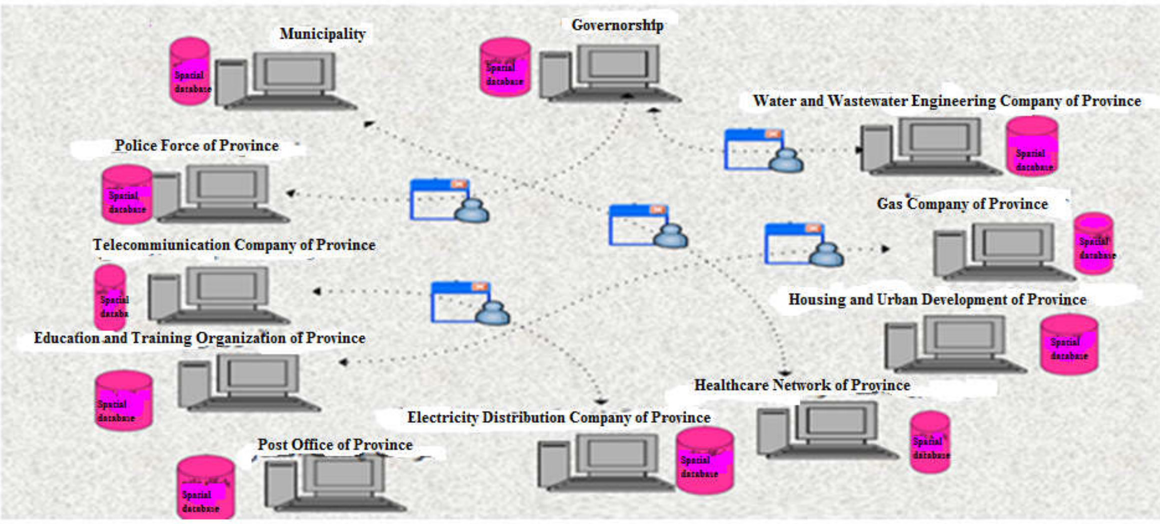

Fig.2. Digital data interaction between organizations based on Spaghetti Method

Privilege of this method is that organizations try to exploit from digital facilities, data storage and retrieval instead of using manual and traditional methods. Shortcoming of this method is data redundancy and difficulty in interaction with other organizations. In fact, this method cannot be called a model as there is not any specific order in it except for digital systems.

Provincial databases were introduced due to the broader communications at city, province, and country levels. In this database, spatial data of different organs are prepared similarly to be used by users in different provinces based on a similar form. Figure 3 depicts a kind of this database. To have a provincial spatial database, negotiations and agreements are required. It is determined in these sessions that each administration is responsible for what data and layers, what data are required, what layers and data can be used by administration, the used data are prepared based on what format and standard, what fields are required, etc. so that these options make these sessions longer and problematic.

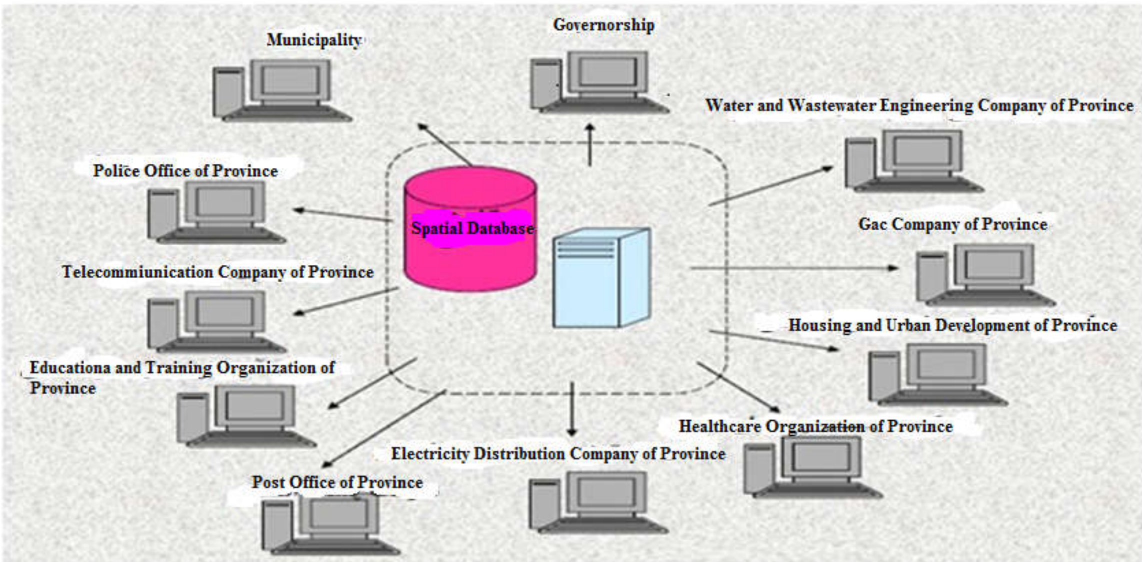

Fig.3. Centralized Provincial Database

Establishment of such database had some problems including:

1- As can be seen, formation of such set requires various session and the more the spatial scope of work, the longer and harder sessions between organizations will be. Hence, GIS and SDI implementation could not be beyond the national level, even they were not implemented at national level.

2- The other problem is data sharing. In such interactions, data should be centralized somewhere out of organizations to be used by others. In general, data sharing face numerous barriers such as resistance and sensitivities of data custodians not only numerous barriers such as resistance and sensitivities of data custodians in Iran but also all around the world. This problem is more outstanding in spatial data that are more sensitive. Sovereignty tools and influence of higher positions (for instance, governor at provincial level) should be used to make organizations sharing data. Such problems prevent from GCI development at a wide range. After centralized database, distributed database was applied. In this case, software and hardware technologies and facilities removed the need of deployment of all centralized data in a database and specific geographical space. As can be seen in figure 4, each custodian and organization could maintain the relevant database in its organization and support data sharing operation using mentioned facilities. Organizations that had not server could use a common and public server. In this type of database, each organization can remove its own sever, which is physically placed in organization, from sharing path without requesting from other organizations.

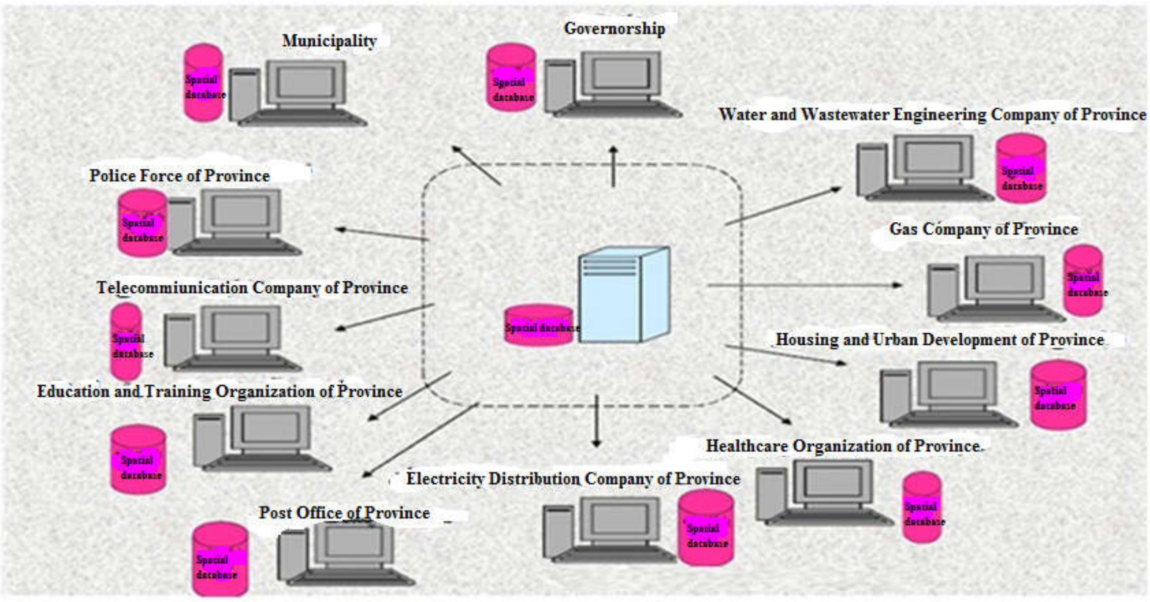

Fig.4. Non-Centralized or Distributed Database

Although structure of distributed database is prior to concentrated database, the problem of data sharing still exists (SDI Development Document, 2015).

A set of prerequisites and infrastructures is required to create, and maintain spatial data to actualize implementation of executive processes for integration of spatial data in Tehran, Iran and the final goal of TSDI is reaching to powerful position in order to use spatial data and make relationship between all governmental and private sectors in Tehran. TSDI presents some properties for database management:

- Administrative and legal arrangements to produce and develop spatial data
- Identifying requirements to produce, retain, and maintain spatial data in Tehran
- Required mechanisms for sharing spatial data in Tehran Municipality, and technology development strategies and their applications.

Proposed Project of Comprehensive Database of Crisis Management

Creation of a comprehensive database not only reduces costs caused by parallel tasks and interfering measurements of involved organizations in crisis but also makes the process of coping with crisis more effective and minimizes damages and consequences of crisis. This database is web-based and those provinces that are connected to government internet network are also connected to system through this specific network available in other parts of country through internet. Central server is deployed in central headquarter of crisis management and secondary servers are installed in each of ministries so that every organization can enter the data related to their own operational scope then system can generate applied reports related to natural tasks of each organization. Clearly, reports obtained from input data processing are integrated in all aspects. Data can be received and processed in different frameworks such as text, figures, digital data, images, and spatial data using diverse equipment (Yoosefi, 2012).

This system is designed and used at three different levels including upper (governing), middle (province), operational (city). Data are not entered at upper level, but this level has the most excellent possibility for reporting and data processing in which, all data fields are available. This level is established in headquarter of crisis management in Ministry or Central Organization. At middle level, this system is deployed in governorship in all provinces and provincial organizations input relevant data to the system within certain time intervals through their communicational ports then these data feed holistic data tables. These data are recorded in specific pages and can be observed or controlled by central headquarter of each organization or ministry. This level has the highest interaction level with system; hence relevant experts in organizational structure of crisis staff should be selected to input data and perform other affairs of system. At provincial level, there is a relationship between user and data input pages to system in each of offices in province so that data should be continuously entered into system. These data are inputted into a mediating database that is at higher level in each office in each province to be confirmed by Province Department then these data are inputted into the main database of system. Reporting and observing system data are not possible in province. Properties and capabilities expected from this system can be determined based on crisis management cycle and each stage.

- Before crisis: data collection and organization- data analysis and process for planning and modeling based on collected data- protection from infrastructures- risk detection and alarm- providing prognosis- monitoring accident-prone places- purposeful reporting- interaction with other applied systems- planning and preparing to cope with disasters.
- During crisis: identification of crisis signs- immediate and smart recall- planning for proper distribution of forces and facilities- sending alarm to relevant organizations- arrangement of operational teams- emergency response team- navigation and providing optimal path for logistic, management and optimization of transportation- notifying at different levels- reducing secondary consequences of crisis- monitoring and controlling rescue operations.
    - After crisis: gathering relevant data to encounter with crisis- management of evacuation and accommodation- arrangement to support damaged area- determining evacuation paths.

To develop and strengthen this system, there should be a proper relation between ministries and organizations involved in crisis so that this system is the only field for relationship between organizations in the context of crisis management. On the other hand, a part of output of this national portal should be available to public; in this case, as a number (110) is available to contact with police, a communicational channel should be anticipated for this database in field of crisis. These measurements make interaction between national database and society; in this regard, public opinions can be used to remove possible problems in system. The success story of social databases in field of crisis management in the world indicates the importance of mentioned interaction. For instance, some websites in this field can be named such as Ushahidi.com in Africa and mixi.com in Japan that has 20 million active members.

CONCLUSION

Crisis management is a complicated and intersectional issue. In crisis management process, information is the most important part after human. Crisis management should be integrated due to involvement of different sectors in it besides various data sources to improve the process. There are numerous organizations and informational sources involved in crisis management process; hence, information should be integrated in this process. According to relevant Iranian resources, some implemented programs in Iran have been conducted to integrate crisis management data; in this regard, various systems can play role in this process. INDMP is one of the mentioned systems that its goal is organizing informational and communicational systems during crisis. The other system is National Disaster Risk Management Portal that was designed to prepare a public field to create simple relationship between organizations and to publish knowledge.

In general, some properties can be named for relevant systems and tools examining current systems and experiences:

- Majority of studied systems were designed and used to integrate crisis management;
- Majority of these systems were web-based and now they are designing to be used on cellphone;
- These systems are designed based on a service-oriented architecture considering current standards;
- Majority of these systems have been applied in all stages of crisis management process;
- Organizing information in framework of a database plays a vital role in these systems as the main component of these systems;
- It is important in these systems to share information between organizations and centers involved in crisis management centers;

- Some of these systems have specifically considered data infrastructure as a main component.

Despite the mentioned advantages, it can be stated that data collection and integration of software have been emphasized in majority of designed systems and plans either in Iran or in foreign countries.

It is required to identify effective data, role and function of each data and their relationship, and recognize involved organizations and their ruling process in order to have a correct and efficient crisis management. Required infrastructures for an integrated system are designed and implemented based on mentioned factors. The conducted surveys on designed systems showed that integrated data system is not that much considered by designers of these systems while such factors can help managers of crisis management process to use human and data resources better regarding simulation and decision-making before crisis to be ready and at the time of crisis to make arrangements. However, some of these systems and projects such as NIMS, FIMA, CRISMA and DFNAK are matched with an integrated crisis management system providing a proper architecture for an integrated data system. For instance, architecture of holistic data infrastructure in DFNK that is based on the model of FEMA has been designed based on four major parts including work processes, data systems and software, integrated database, and technology infrastructure so that it can be a suitable model to design an integrated data system for crisis management. According to the success stories and experiences, those systems and infrastructures have had an effective role in crisis management that have been supported by governments and centers such as UN, US Federal Agency and European Union; hence, all-out support of governments and relevant organizations is an essential factor to provide an efficient infrastructure for crisis management.

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