Proposed Earthquake Emergency Management Plan For Giza City, Egypt

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SUMMARY:
This paper presents a proposed earthquake emergency management plan for Giza city in Egypt. First, the paper discusses the current situation of Giza city. Then, it discusses Spatial Data Infrastructure (SDI) as a tool to develop a data base for the current situation. This paper discusses also, Geographic Information System (GIS) that has been used as a technique in which the input data can be presented and analyzed easily. Also, the GIS technique has been applied on Giza city to display the relative vulnerability between each district at the city. Finally the paper presents the proposed earthquake emergency management plan (EEMP) for the pilot city "Giza, Egypt". The proposed EEMP can be applied in all the Egyptian cities and governorates considering the current situation at each city.

Keywords: Earthquake, Emergency, Management Plan, GIS, Egypt

1. CURRENT SITUATION FOR GIZA CITY

Giza is a mega city in Egypt and it is considered one of the oldest cities in Egypt. Giza current area is 120.9 km^2 and its population is about three million. Giza is located at the west of the river Nile. Its boundaries are 6-October City at north, south and west, and Cairo city at east. Giza city is divided into eight districts (Giza E-Gate 2010): Dokki, Haram, Agouza, Warak, Omrania, Boulak, Shamal, and Ganoub. Fig.1 displays a comparison between percentages of area, population and utilities (schools, hospitals, fire stations and police) at Giza city. According to the seismic zone map (ESEE 1988), Giza City lies in zone 2 in the earthquake hazard map of Egypt. Giza city is located between the river Nile and the western desert. The nature of Giza soil has a wide variety because of its location. Some zones consist of Nile sedimentation layers (mud, clay…etc), and other zones consist of rock or sand layers.

Buildings in Giza are widely varying in type (reinforced concrete, masonry, wood and steel structures), age (hundreds of years-2012), and number of stories (varying from 1- story buildings up 40-story buildings). Giza has seen major changes over time in infrastructure terrace. Most of buildings consist of basement, ground, and typical floors. Considering the local features of the ground in Giza where the buildings are located, construction quality level of the buildings, deterioration and corrosion problems related to the age of the buildings, and population density, the earthquake risk is increasingly growing. From reviewing the current administrative organizations for Giza city and its districts (Giza E-Gate 2010), it is noticed that there is no emergency operation center or any other emergency authority. For the current administrative organization, refer to (Wahba, 2010).

2.PROPOSED TOOL AND TECHNIQUE

Earthquake disaster management is a cycle of activities (Abbas, 2010), beginning with mitigating the vulnerability, preparedness in responding to operations, responding and providing relief in emergency situations and aiding in recovery. The spatial data management and geometric engineering technologies in disaster management include Information Communication and Technology (ICT), Geographical Information Systems (GIS), Remote Sensing (RS), and Global Positioning System (GPS). The employment of recent advances in spatial data management and geometric engineering technologies in disaster management has considerably improved disaster management through facilitating data capture, integration and analysis.

The integration of such technologies with each other and with other technologies such as Decision Support Systems (DSS), the world-wide-web and simulators has created more effective disaster management. Spatial Data Infrastructure (SDI) and GIS have proven crucial in preparing for, mitigating, detecting, responding to, and recovering from natural and technological disasters. Without SDI one cannot expect effective and efficient disaster management, as SDI is the initial input for GIS and emergency response modeling and simulation systems. SDI is gathered, displayed, accessed, and distributed.

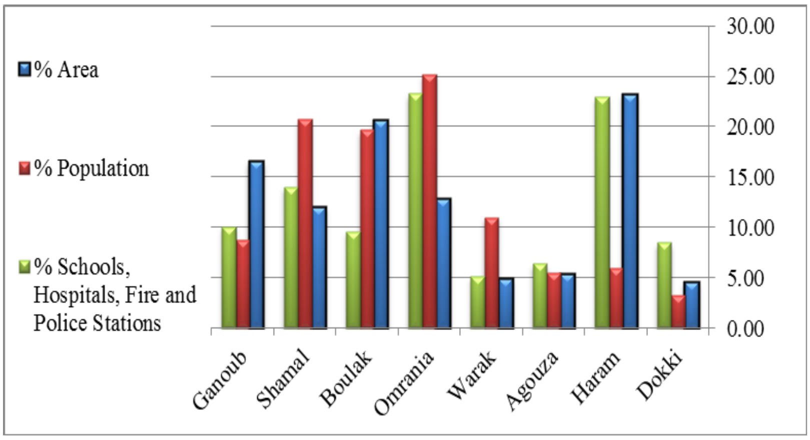

Figure 1. Comparison between percentages of area, population and utilities at Giza districts

2.1. Providing information for earthquake disaster response

The dynamic nature of earthquake emergency situation requires timely updating of a variety of required data/information from various organizations because there is no individual organization can produce and update all the required information. These organizations are logically the producer and updater of datasets during their everyday business and during an emergency situation. If the results of such data production and updating efforts are physically recorded in appropriate databases, the required data/information for disaster response is always available to the producer. If this information is shared and exchanged, then datasets are accessible to the wider emergency management community.

The responsibility of maintaining information should be shared between different organizations based on appropriate and accepted policies for data production, people training to work with these datasets and accessing policies and using data/information. Fig. 2 describes the required components for developing spatial information ready for access and use. These components can aid and contribute to the development of a proper disaster response environment. There is a need for an appropriate framework which identifies the relationships between each component including the effect of the components on each other and the effect of external factors on each component.

2.1.1. SDI in earthquake emergency management

SDI is an initiative intended to make an environment that will enable a wide variety of users to access, recover and spread spatial data and information in an easy and secure way. In principle, SDIs allow the sharing of data, which is extremely useful, as it enables users to save resources, time and effort by avoiding duplication of expenses associated with generation and maintenance of data and their integration with other datasets. SDI is also an integrated, multi-leveled steps of interconnected SDIs based on collaboration and partnerships among different organizations (Abbas, 2010).

SDI includes five components as shown in Fig. 3. The relations between each of the SDI components need to be defined in order to have a better and proper disaster response environment. SDI can be an appropriate framework in bringing the disaster response components together and facilitating decision-making for disaster management to increase the efficiencies and effectiveness of all levels of disaster management phases.

Within this framework, it should be noticed that, the challenge of designing, executing, and maintaining an SDI is based on many different disciplines. Also this framework requires different factors relating to the conceptual, technical, political, institutional and financial perspectives. Therefore, the decision-makers in disaster management community should understand the significance of these factors and the importance of human and societal issues, which contribute to the success of SDI developments. Also, these factors should be considered in the long-term in order to achieve sustainable and ongoing development of SDIs for disaster management environment especially in earthquake disaster management.

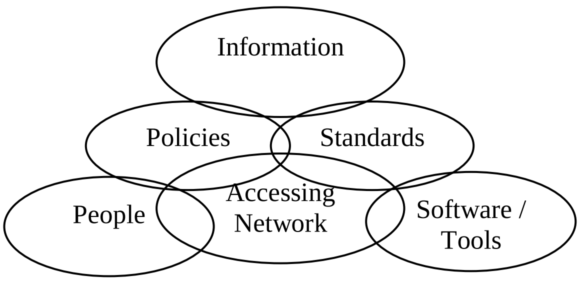

Figure 2. Required components for proper disaster response

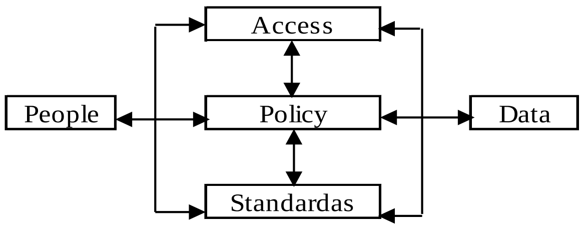

Figure 3. SDI core components

2.1.2. Proposed prototype system to facilitate earthquake disaster management

With respect to the above-mentioned environment, a research study for Giza city with an aim to propose a system based on SDI through which access to and usage of data/information and consequently EEMP can be developed. A proposed prototype system that facilitates earthquake disaster management based on data/information sharing and analysis for decision-making, coordination and control should be developed. Also, initial standards and guides describing data standards, identifying organizations for data production and updating, data production methods, and updating processes within and outside of an emergency situation should be developed.

Fig. 4 illustrates the overall structure of the proposed system. The figure shows that each of the proposed involved organizations has a database containing their required datasets for everyday business. There is also a database in the proposed Emergency Operation Center (EOC) where the representatives of involved organizations can gather to coordinate disaster response. The EOC Database contains base maps as well as fundamental required datasets for disaster management. Each of the involved organizations should be responsible for producing and updating one or more datasets within the EOC database before, during and after a disaster. Each organization can then use required datasets from the EOC database for their own use. Based on the proposed prototype, all of the organizations are connected to the EOC database using a network by which organizations can share and access their required datasets.

The developed proposed system needs to be tested with feedback used to design and develop a functioning system. This will also aid in presenting the overall advantages of utilizing the SDI concept within earthquake disaster management. The software and database model should be developed based on the concept of an Emergency Operations Centre. It is argued that the design and implementation of an SDI model can assist to develop EEMP.

2.2. GIS in earthquake emergency management

Earthquake emergency management covers a wide range of activities. Government at all levels has primary responsibility for emergency management. Mapping and GIS is excellently suited to the needs for integrating EEMP. Also, GIS helps the needs for integrating local awareness, sharing needs assessment and problem analysis, identifying local priorities, understanding responses and managing strategies. There are many factors influencing the increased use of GIS like more spatial data, free spatial data, low cost GIS servers/data, and open source GIS

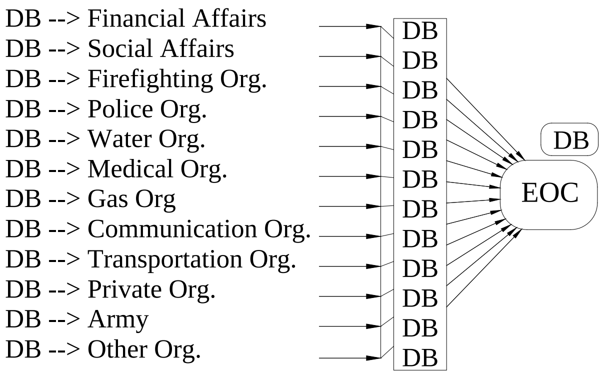

Figure 4. A proposed communication system to facilitate earthquake disaster management using SDI environment

2.2.1. Hazard, vulnerability and risk in GIS

Hazard is a pre-disaster situation where some risk of disaster exists, mainly because of human population has made itself vulnerable in some way. Risk is a combination of hazard and vulnerability. So, risk is simplified as a function of elements at risk, the hazard, and the vulnerability to that particular hazard. This is appearing from GIS as the elements at risk can be viewed as spatial information layers (e.g. population, properties, and infrastructure) and these layers can be combined through spatial modeling procedures to produce an effective estimate of hazard, vulnerability, and risk (Cova, 1999).

2.2.2. GIS roles in emergency management

GIS has many roles in emergency management phases. Emergency management programs begin with locating and identifying potential emergency problems. Using a GIS, officials can pinpoint hazards and begin to evaluate the consequences of potential emergencies or disasters. Analysis and planning must be done before an effective emergency management program can be applied. GIS facilitates this process by allowing planners to view the appropriate combinations of spatial data through computer-generated maps. When hazards (earthquake, fire, etc.) are viewed with other map data (streets, pipelines, residential areas, etc.), emergency management officials can begin to formulate mitigation, preparedness, response, and possible recovery needs.

GIS helps civil safety and defense people to focus on where mitigation efforts will be necessary, where preparedness efforts must be focused, where response efforts must be strengthened, and the type of recovery efforts that may be necessary. Analysis and planning must be done before an effective emergency management program can be applied. Fig. 5 shows one way in which the concepts of risk, hazard, and vulnerability are frequently related in a GIS framework. GIS task is developing spatial models of hazards and their associated vulnerability.

Finally, an organized GIS database is essential to EEMP. Time spent to create and re-create data for analysis reduces time to reach people in need. Critical infrastructure data that should be ready in advance includes transportation, political boundaries, telecommunications, etc. Communicating with the media is also important. Coordination is a big issue that would enable solutions to many time problems in earthquake emergency matters.

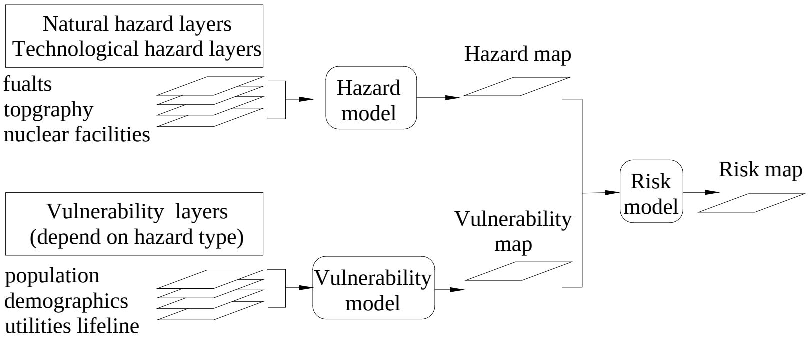

Figure 5. One approach to model the concepts of hazard, vulnerability, and risk in a GIS framework

3. APPLICATION OF GIS TECHNIQUE ON GIZA CITY

This part will focus on the application of the GIS at Giza City. It is well known that, the GIS output will give the result as a map and the program displays all what the user's need as it makes all the elements like layers and it is easy to show or hide any layer at the GIS program. Therefore, all the available data obtained from Giza city authorities are used to develop different GIS maps. For EEMP it is important to compromise the vulnerability of each district and to find out the relative vulnerability to evaluate the current situation and to develop the appropriate EEMP for each district and for the whole city.

Fig. 6 displays the population distribution in Giza city. It is clear that El Omrania district has the largest population and El Haram district has the largest area in the city. Actually one should take into consideration that El Warak district has the largest population density since it has the smallest area in Giza city. Fig. 7 displays the distribution of fire and police stations at Giza city. Fig. 8 displays the distribution of schools at Giza city. It is noticed that El Agouza and El Haram districts have the largest fire and police station distribution, however, El Haram district has the largest schools and hospitals distribution. Also it is noticed that El Warak district has the smallest distribution of utilities at Giza although it has the largest population density. Giza has seven main bridges, as shown in Fig. 9, which are connecting Giza and Cairo. Also Giza City has eight main tunnels and the most important tunnel is the metro. These bridges and tunnels are crossing the city. So it is recommended to use a rapid seismic screening and risk assessment method for bridges and tunnels at Giza city to evaluate such important structures. By having such maps for any city, it will be easy to judge, compare and to analyze the relative vulnerability for each district. Giza construction development map which considers the most important GIS map in vulnerability evaluation couldn't be achieved till now because it requires more data and more time to survey all the building and to make an appropriate classification for the construction development. So, it is recommended to use a rapid seismic screening and risk assessment method for structures at Giza city to evaluate its vulnerability.

4. PROPOSED EARTHQUAKE EMERGENCY MANAGEMENT PLAN FOR GIZA CITY

This paper displays some proposed definitions for Emergency Operation Condition (OPCON), and then displays the proposed EEMP for Giza city. Finally, some recommendations are presented to apply the proposed plan.

4.1. Emergency operation conditions (OPCONs)

OPCOs are the levels of emergency. The proposed EEMP divides OPCONs to five levels. These levels are numbered from 1 to 5 where level 1 describes the smallest case of emergency and level 5 describes the worst case of emergency These OPCONs are as follows:

- OPCON 1 describes a little or moderate damage at the district and can be controlled by the district.
- OPCON 2 describes moderate or massive damage in one or more districts at the city, and can be controlled by the city.
- OPCON 3 describes massive damage in one or more districts at the city, and can not be controlled by the city and it is required to get help from the nearest city.
- OPCON 4 describes a great damage in one or more cities, and can not be controlled by the city and it is required to get a governmental effort from the country (National Level).
- OPCON 5 describes a great damage in one or more cities, and can not be controlled nationally and it is required to get an international help to control the damage.

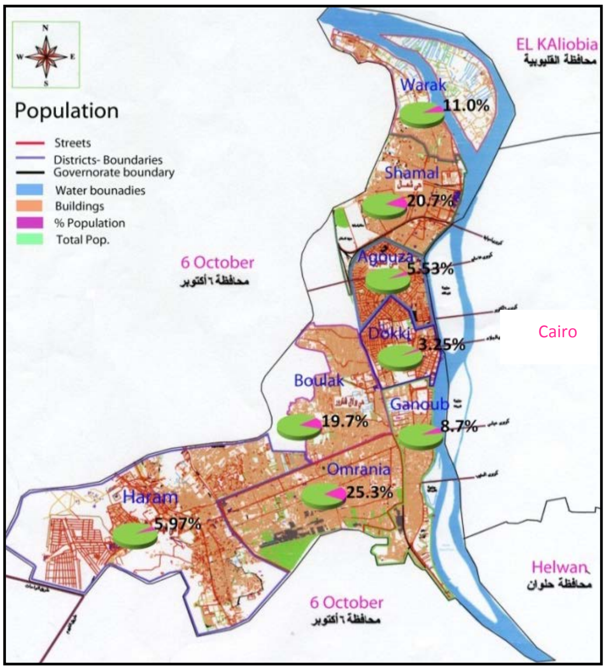

Figure 6. Population distribution

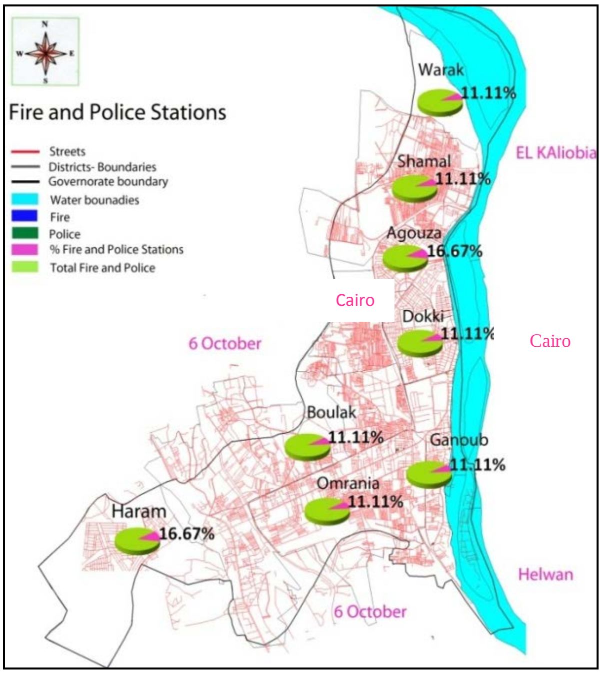

Figure 7. Fire and Police stations distribution

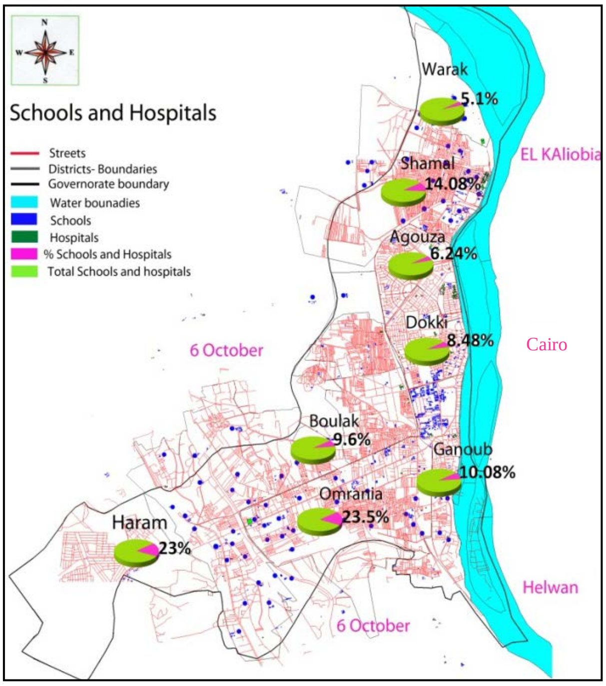

Figure 8. Schools and Hospitals distribution

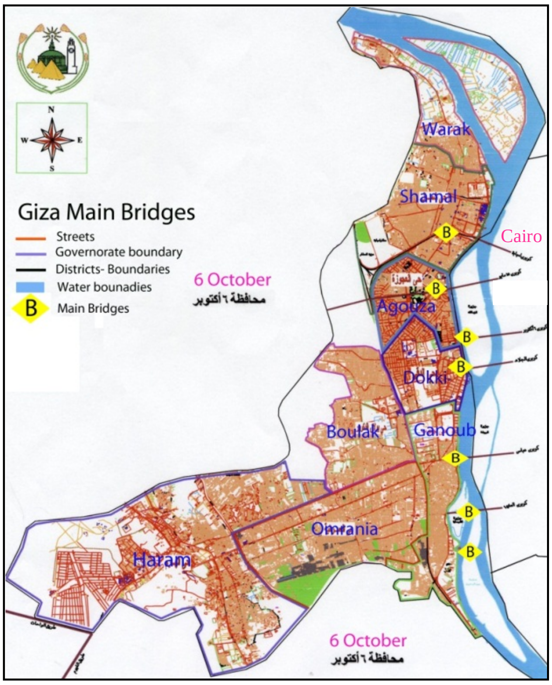

Figure 9. Bridges distribution

4.2. Proposed earthquake emergency management plan

After studying the current situation and the structure organization in Giza city, it is proposed to construct an Emergency Operation Center (EOC) to produce appropriate EEMP. Three levels of EOC should be implemented as follows:

- District Emergency Operation Center (DEOC).
- City Emergency Operation Center (CEOC).
- National Emergency Operation Center (NEOC).

NEOC is out of the scope of this paper. This paper will focus on both DEOC and CEOC. Also, it is important to clarify that; the role of each center will be according to the OPCONs and also will be classified to before, during (at the first few hours after earthquake occurs) and after earthquake happen.

4.2.1. District emergency operation center (DEOC)

DEOC is the main emergency operation center at the district. This DEOC will have the authority to produce EEMP at its district, collect data, evaluate the operation condition stage at its district and recover its district from earthquake disaster. DEOC is connected mainly with many organizations and branches at the district like hospitals, schools, police, fire station, communication center,…etc. Also, the DEOC is connected with CEOC. The communication between DEOC and other organizations is based on SDI tool. Also, this communication and data exchange facilitate the DEOC role. DEOC will have a role in Disaster Management Activity Cycle (DMAC). For more details refer to (Wahba, 2010). Fig. 10 to Fig. 13 display collaboration between DEOC and other organizations during DMAC.

4.2.2. City emergency operation center (CEOC)

CEOC is the main emergency operation center at the city and it is the chief of the DEOCs. This CEOC will have the authority to produce EEMP at its city, collect data, evaluate the operation condition stages at its city, follow up DEOC for its EEMP and recover its city from earthquake disaster. CEOC communicates mainly with many organizations and branches at the city like DEOCs, hospitals, schools, police, fire station, communication center,…etc. Also, CEOC is communicated with NEOC. The communication between CEOC and other organizations is based on SDI, also, this communication and data exchange facilitate CEOC role. CEOC will have a role in DMAC. For collaboration between CEOC and other organizations during DMAC refer to (Wahba, 2010).

4.3. PROPOSED ADMINISTRATIVE ORGANIZATION

4.3.1. Proposed district administrative organization

After reviewing the administrative organization for Giza districts, the proposed DEOC location should be one of the main items at the administrative organization for the district. Fig. 14 displays the general brief administrative organization for the district including the proposed DEOC.

4.3.2. Proposed DEOC administrative organization

Fig. 15 displays the proposed DEOC administrative organization for Giza districts. All the proposed staff in the administrative organization for DEOC Giza districts are the heads of existing districts departments or their designees except the Incident Commander (IC) and the representative of the GIS center.

4.3.3. Proposed city administrative organization

After reviewing the administrative organization for Giza city, the proposed CEOC location should be one of the main items at the administrative organization for the city. Fig. 16 displays the general brief administrative organization for the city including the proposed CEOC.

4.3.4. Proposed CEOC administrative organization

Fig. 17 displays the proposed CEOC administrative organization for Giza city. All the proposed staff at the administrative organization for CEOC at Giza are the heads of existing city departments or their designees except the Incident Commander, the Emergency and the Rescue Officer. DEOCs managers or their designees should be represented in the proposed CEOC administrative organization.

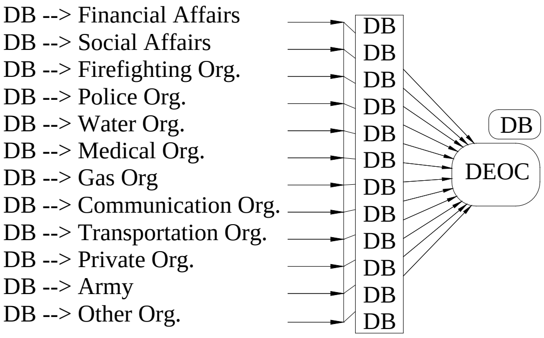

Figure 10. Collaboration of DEOC with different organizations before earthquake disaster

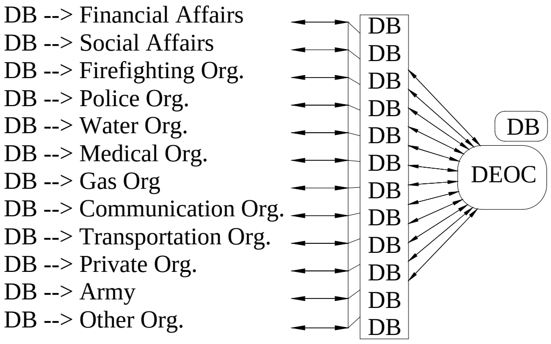

Figure 11. Collaboration of DEOC with different organizations during earthquake disaster at OPCON1 and at OPCON2

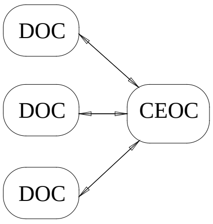

Figure 12. Collaboration of DEOC with CEOCs during earthquake disaster at OPCON 3

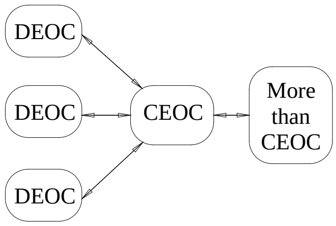

Figure 13. Collaboration of DEOC with different organizations after earthquake disaster

4.4. Proposed responsibilities

The proposed EEMP consists of some proposed responsibilities that enhance the current situation and the performance of the proposed EOC. First, proposed responsibilities and tasks for EOC staff are presented, and then proposed additional responsibilities for the current city officials are presented. According to the proposed EEMP, collaboration should be between EOC and other organizations. The heads of organizations and districts department are proposed to be responsible for emergency action within their departments before, during and after earthquake. More details about the proposed responsibilities may be found in (Wahba, 2010).

5. CONCLUSIONS

This paper presents the proposed EEMP for Giza city for the first time in Egypt. First it discusses the current situation for the city then discusses the proposed tool and technique by which decision makers can identify relative vulnerability and apply the appropriate EEMP. This plan should be adopted by the city and should be the official EEMP as there is no earthquake EEMP in all cities of Egypt. This plan should be activated automatically every five year to match social and economic requirements. Finally the proposed EEMP can be applied at all Egyptian cities but one should take into consideration the current situation of each city.

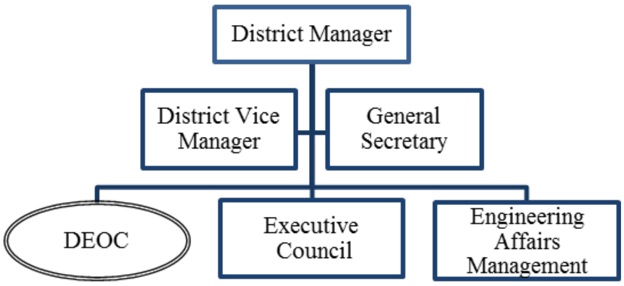

Figure 14. DEOC's proposed location at the general administrative organization for the district

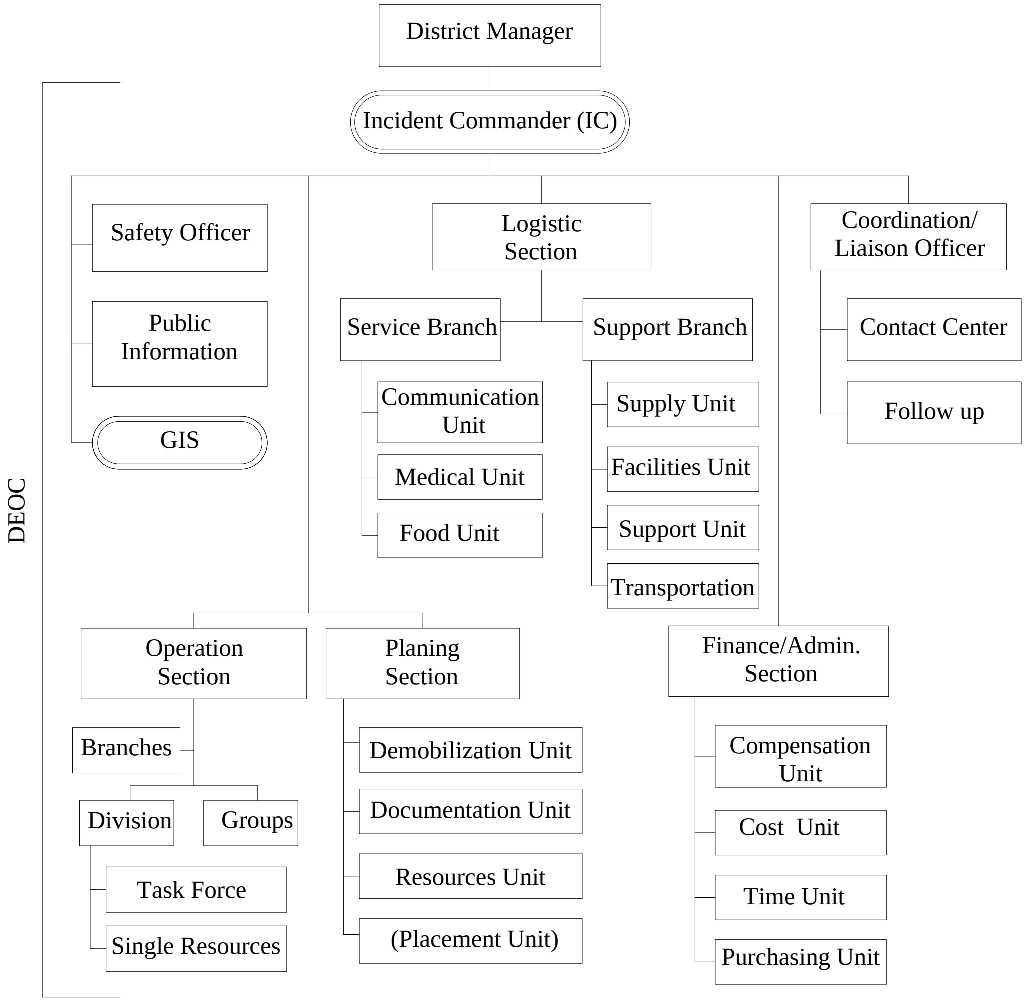

Figure 15. Proposed DEOC administrative organization

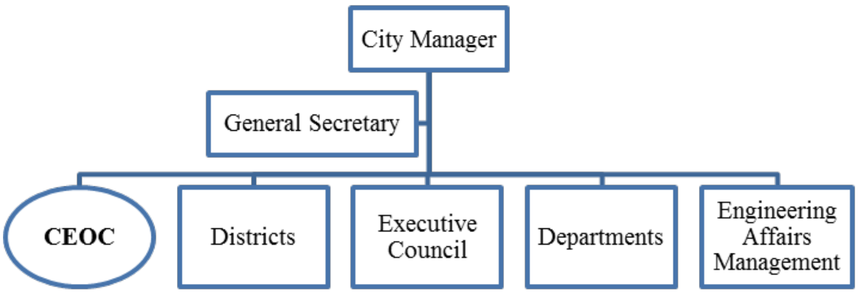

Figure 16. CEOC's proposed location at the general administrative organization for the city

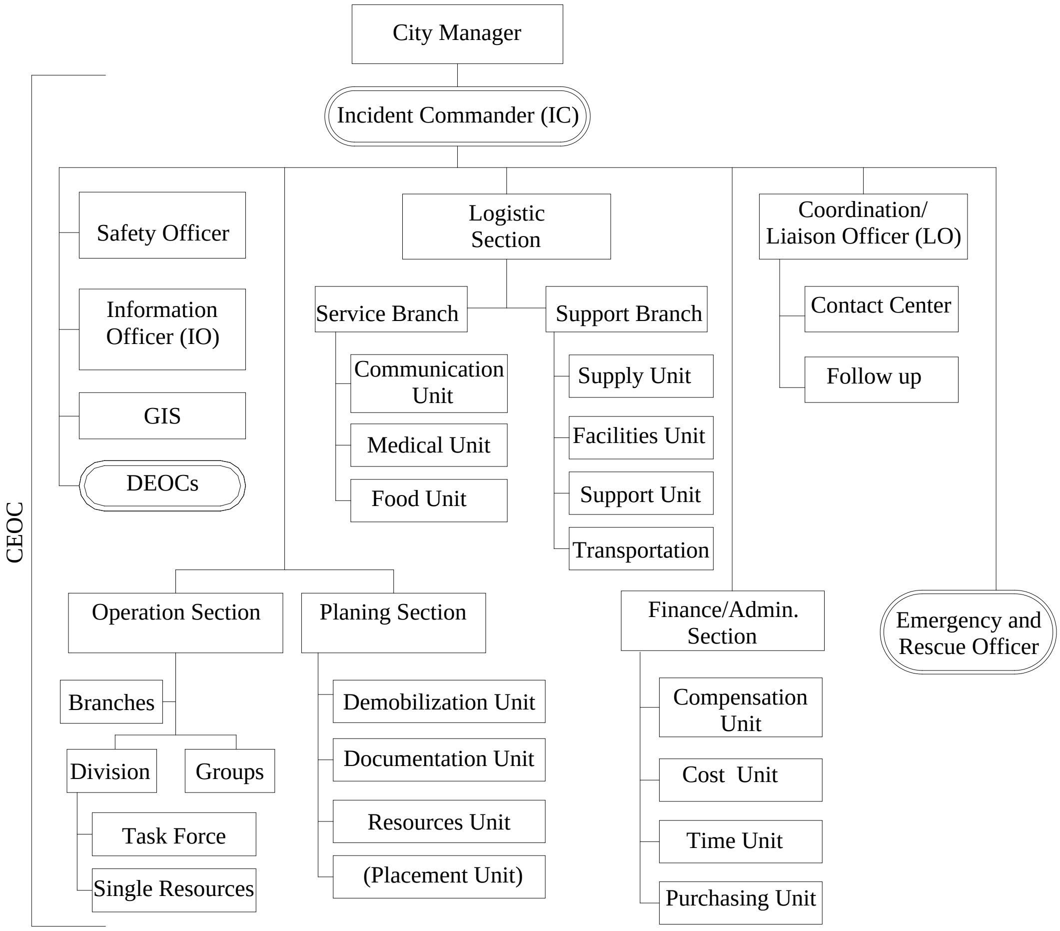

Figure 17. Proposed CEOC administrative organization for Giza City

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