

# Geographic Information System (GIS) Application in Flood Crisis Management

Marjan Abdeyazdan<sup>1</sup>, and Ali Zeidi Jodaki<sup>2</sup>

**Abstract**--Nowadays, with technology information growth and its spread and effective application in Geometrics skills and sciences, more emphasis is on using non-structure methods based on geographic information system (G.I.S) in flood crisis management. Benefits like capabilities in the monitoring, modeling and the estimate of risks and the damages from flood, learning and being multidimensional of these systems, high speed and accuracy and also facilitating changes and more compatibility with the environment and low costs of these information systems cause to using more and more geographic information system in flood crisis management.

This article aims to review geographic information system in three stages of after, before, and during flood.

**Keywords**—Crisis management, Geometrics, flood, geographic information system

## I. INTRODUCTION

**N**OWADAYS due to high frequency of flood crisis and damages and human great loss and its financial loss, it seems that it is necessary to use geographic information system (G.I.S) as capable and comprehensive tools in flood crisis management issue more than before. This article tries to review this system in three main stages of flood crisis by new approach while it integrates three sciences of hydraulic, Geometrics, and crisis management.

## II. LOOKING TO GEOGRAPHIC INFORMATION SYSTEM APPLICATION IN FLOOD CRISIS MANAGEMENT

Success in all crisis management stages depends on having updated, accurate and exact information. This information should be collected and arranged logically in terms of descriptive and location information in order to be used perfectly by managers, officials and urban planners in three stages of before, after and during crisis in line with desirable objectives. In this situation, using geographic information system is a key to solve the problem that using computer provides excellent possibilities for collecting, saving, retrieval, processing, analyzing and finally producing appropriate visual outputs and including map, table, graph and the like.

## III. ANALYTICAL CAPABILITIES OF GEOGRAPHIC INFORMATION SYSTEM IN FLOOD CRISIS MANAGEMENT

Geographic information system provide data analysis possibility in the system for the user due to software and hardware type and completeness amount and information layers update and totally the more a Geographic information system has more analytic capability, the more expensive technical facilities and computer programs would be. Here, some capabilities of analyzing a geographic information system in flood crisis management are referred:

### A. Search Capability

That means finding an appropriate and reliable solution for a special problem. For example, after determining flood area in numerical map using search capability of geographic information system, we are able to find information like access routes to damaged areas, health care stations, police, fire fighters, auxiliary forces, possible places for landing helicopter and airplane, some places for reserving food and rescue devices, urban infrastructure like power plant, sewage system, communications, symmetry and the like and also risky material and places after flood crisis and cases like address, phone, email of residents and after that we need to determine some limitation for system for finding all one- floor residential houses without metal skeleton in distance of 100 m from flood range or to determine the closest health care stations that are especially for children with more than 200 hospital bed and something like that. Among another examples are finding needs (food, medicine, etc) of each temporary settlement unit or especial information required by disciplinary forces in order to establish safety for the region.

### B. Demographic

Among this system possibility is the ability to do statistical analysis in each stage of searching and researches. For example, we can estimate approximate damaged people (or event-exposed) or approximate damages in especial range and the like with this capability.

### C. preparing Combined Maps

That means geographic information system capability to combine data and information through putting information layers together and preparing combined maps. Users using this capability are able to review several factors effects on a special subject by mixing current information layers in the system (such as topography, geology, rivers and floodways, plants, land type, lands usages, assistance and healthcare centers, infrastructures and the like). For example, using this geographic information system capability, after determining flood range, we can mix two layers of route network and demographic information of all routes that are under water

<sup>1</sup>Department of Computer Engineering, College of Electricity and Computer, Mahshahr branch, Islamic Azad University, Mahshahr, Iran.

<sup>2</sup>Department of Computer Engineering, Headquarter of Port, Sarbandar Branch, Iran.

because of flood (or they could be ruined) and also flooded people and their population congestion, we can determine the best access route (by the use of other system capabilities). Or a primary guess could be achieved about region flood potential by mixing plant layers, topography and region and rivers and floodway gradient within the boundary.

Meanwhile, as there are many factors in making places like accident victims temporary settlement and assistance teams, medical center, toilets, symmetry, this system capability (together with other analytical capabilities) is very beneficial to rebuild residents life and the like.

#### IV. FLOOD ZONING USING GEOGRAPHIC INFORMATION SYSTEM

With rapid growth of hydraulic science and mixing it with Geometrics, preparing zoning maps of flood became one of the non- structure effective methods in order to reduce damages resulted from flood. Also, today, due to importance of safety and security in investment, using these maps in development and cultivation plans became one of required and necessary information sources.

Computer usage during two recent decades and mixing geographic information system with mathematics, hydrologic and hydraulic models causes to abolish traditional methods and hand calculations and facilitating flood zone drawing operation. These systems are able to determine floodplain or flood zoning with high accuracy and speed and spending lower costs for human and financial resources; and they can determine floodway and rivers margin water logging extent by considering flood desired return periods. And finally, with the possibility of mixing and integrating different layers of geographic information system (such as topography, lands usage, route network, etc), while they can determine flood balance and transfer water level numbers into topography maps, they can show possible damages (and going under water) of residential regions, route network, infrastructure facilities (and the like) that are around river and/or floodway, and they can release output as flood zoning map (that show water logging height of every point of each region). (Images relating to this section in association with detailed descriptions will be offered during article oral offering.)

##### *A. Advantages and Usage Capabilities of Geographic Information System in Preparing Flood Zoning Maps*

In addition to mentioned capabilities and advantages, some other advantages for using this system for flood zoning are as follows:

- A. Ease of making change and required reform in flood zoning maps by changing statistical period and by different return periods of flood.
- B. The ability to change geographic features and flood plain in flood zoning maps that are happened based on new construction and/or flood plain topography changes.
- C. The possibility of showing and comparing deep water surface by flood with different return periods
- D. Simple reforming and archiving and releasing for flood zoning maps

##### *B. Flood Zoning Maps Usage*

- a. Determining rivers bed and limits: determining rivers bed and limits is considered complicated in terms of legal and technical issues in our country. One of the most important applications of flood zoning maps is logically determining floodway and rivers margin lands floodplain, so that by using an appropriate return period of flood, vulnerable regions are determined against river overflowing, and optimal bounds will be defined for river and in this way, maximized usage possibility will be provide for fertile lands beside river.
- b. Study and economic justification for flood management plans
- c. Flood insurance: insurance companies need to use these maps in order to determine risk rate of different regions of river margin and giving an appropriate insurance fee. At the moment, in our country, insurance fee is determined with mere attention to lands extension or/and investment value because there is not such maps for all river neighborhood lands regardless their risky amount. It should be considered that due to effective role of insurance covers in reducing and compensating damages in stages of after flood crisis, making flood insurance fee logical and fair will lead to extend flood insurance coverage.
- d. Preparing and distributing comprehensive flood zoning maps and also determining lands insurance fee in floodways and rivers neighborhood, due to their risk amount, will gradually reduce risk and construction in regions with high vulnerability by people and investment institutions and through which prevention will be achieved in the regions before crisis.
- e. These maps can be produced due to water closet statistics and by different return periods and by which identifying weaknesses and using necessary measures would be possible against flood in a stage of before crisis. Also, during crisis, due to hydraulic information and flood current that is sent on- line to the flood simulator system based on G.I.S; flood situation will be simulated and its expansion will be predicted in future hours of crisis.
- f. Identifying vulnerable points and meeting and reducing vulnerability resulted from flood by doing structural and non- structural methods of flood crisis management.
- g. Preparing flood risk maps: it will be discussed in next section in detail due to its importance.

#### V. FLOOD HAZARD MAP

These maps are one of the most important outputs of flood zoning that are produced by Geographic information system and generally by mixing different layers of Geographic information system.

Flood hazard maps are prepared with the aim of identifying vulnerability of a region against determined flood in order to predict and choosing arrangements and necessary decision-making before, during and after crisis by officials and also identifying it to region residents. Therefore, information about water logging deep of each region, vulnerability about of each region (as it is demonstrated with different colors in terms of

vulnerability amount), damaged settlement area, access routes to damaged people settlement area and the like are included in these maps with simple language and understandably (especially maps that are produced for residents usage).

#### A. *Usages and Advantages of Preparing Flood Hazard Maps*

Produced maps for local residents usage

- a. Local residents can receive different information about flood hazard potential and they can be prepared before crisis.
- b. Considering an appropriate usage pattern and resistance construction against flood in vulnerable regions by residents and their encouragement in order to non-construction in high risky regions
- c. People will evacuate the place when flood possible warn is heard or during crisis.

#### B. *Prepared Maps for Officials, Crisis Managers and Assistance Teams*

- a. Flood hazard maps help crisis committees to consider and conduct simulation maneuvers for urgent situation of flood.
- b. Flood hazard maps help crisis managers and assistance teams to do assistance operation and rescue and evacuation during flood as best as possible. Meanwhile, assistance teams that are sent to the region are able to use these maps to determine risky routes and drowned by flood and to choose the most secure and short route to reach region. And due to their flood hazard map that have more accurate information than prepared flood hazard map (for residents), they can approximately calculate damaged people number in order to choose arrangements.
- c. These maps help officials and urban managers to confront flood before occurrence due to vulnerability of each region and possible scenarios of flood crisis with prediction programs. They will determine current shortages (hospitals, police stations, fire fighting, etc) and they will build them in low- risk and with high access availability locations.
- d. Helping to identify structures and important usages under threat of flood (like power plants, hospitals, etc) and low resistance structure against flood and assisting legislatures and urban manager in order to determine high risk regions and preventing construction or forcing secure construction in these regions.

It should be mentioned that today, hazard maps are put in Internet world network in updated version and by considering the latest changes by management official institutions for easily access of people due to high efficacy of flood hazard maps for rapid and in time exit of residents and increasing assistance speed and also expansion usage of Internet.

#### VI. GEOGRAPHIC INFORMATION SYSTEM APPLICATION IN TOPOLOGY FOR URGENT SETTLEMENT PLACES FOR FLOOD CRISIS DAMAGED PEOPLE

One of important issues in crisis management in natural unpredicted events is optimal topology for optimal settlement points for damaged people during and after crisis. Desired points should meet two conditions of safety (during and after

crisis) and appropriate access (access ease for damaged people and assistance people and also appropriate access to hospital, assistance centers and like that).

Regarding numerous factors involved in optimal topology, using Geographic information system is necessary. For this reason, we identify low risk regions with an appropriate access using Geographic information system and by mixing layers and information (such as topography, routs network, usage, fire fighting station and health care centers, etc) and capabilities of this system. As an example in mechanical modeling, urgent settlement possibility in flood crisis, roofed saloons with suitable height and away from flood, with logical distance from health care centers, fire fighting and the like and away from dangerous places and materials are among candidates for more review in order to find optimal points. After determining low risk regions and considering some points using geographic information system analysis capabilities through distance calculations of these points to health care and assistance centers and like that are factors with positive weight and distance from gas station, power pressure reduction stations, gas and dangerous materials and the like are considered factors with negative weight and by considering other factors we selected the most optimum point(s) and released optimal access route maps to this point(s) with the help of Geographic information system. It should be mentioned that topology specialized software for temporary settlement possibility are produced based on G.I.S, nowadays.

#### VII. GEOGRAPHIC INFORMATION SYSTEM APPLICATION IN MANAGING DEBRIS REMOVAL AFTER FLOOD CRISIS

Current experiments and studies show exactly that process of picking debris and their evacuation of damaged regions is a very important section and meanwhile critical, expensive and long- term in preparation stage in region in order to begin restoration operation after crisis. Geographic information system, by its capabilities and tools, can help managers and planners to speed debris removal and it can reduce costs and environmental issues.

If updated information is prepared with high accuracy, these systems are able to determine land usage kind and its produced debris kind (dangerous and non- dangerous); they help us to estimate debris volume, weight and combination after crisis and its distribution in desired range. (Consequently, officials will be able to determine number and kind of instruments and debris removal possibilities). Also Geographic information system will help planners in dividing damaged regions (for assigning to debris removal team and by determining tasks), prioritizing debris removal, determining transport range routes and transferring debris with delivering related map and suitable topology for temporary and permanent accumulation of debris.

Meanwhile, by formulating damages estimation models resulted from natural accidents based on geographic information system in recent years, these systems evaluation and accuracy developed for damages and its volume, for example HAZUS software could be referred for different natural accidents that are released by crisis management organization of US.

#### VIII. GEOGRAPHIC INFORMATION SYSTEM APPLICATION IN MANAGING DISEASES IN FLOODED REGIONS

Flood may lead to different diseases such as blood flux, typhoid fever, skin contagious infection and infectious diseases in damaged region. So, if enough attention is paid to the way how disease is distributed geographically, health officials can predict disease distribution and time of its occurrence in different places. As public health issues and diseases distribution have location dimension and have a direct relation with region geography, Geographic information system can play a major role in management and health issues planning (like determining medicines needs and/or drinking water in each region and choosing appropriate measure in order to prevent disease extension) in direction of monitoring because of reducing and stopping disease expansion.

#### IX. GEOGRAPHIC INFORMATION SYSTEM APPLICATION IN DAMAGED REGIONS RESTORATION

In restoration stage after crisis, using geographic information system will give extended possibilities in debates like topology, studies, planning, prioritizing construction and measuring and reviewing operation development faced by managers and actors of this problem that are avoided because of this discussion expansion.

#### X. CONCLUSION

In this article, some Geographic information system applications are mentioned in flood crisis management. Effective and extended applications of these systems in administrative process, decision making and formulating flood crisis management strategies made a widespread application for these systems in flood prone countries around the world that unfortunately they are not used in our country because we did not know their capability and advantages and also lack of necessary infrastructure for using Geographic information system in flood crisis management. According to the topic, authors of this writing consider it necessary to support comparative researches and based on laws and local characteristics in this field (in different majors of water, mapping and natural accidents management) and they believe that desirable flood crisis management will be created if an appropriate bed is created and country Geographic information system layers is completed and researches are operated.

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