Design of Expert system for Catastrophe response-Case Study: Northern Tehran Flash Flood

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1-introduction

On July, 1987, a devastating flash flood occurred on northern Tehran the capital of Iran. The addressed basin catchment (named Golabdareh&darband) discharged about 250m3/s runoff (excluded mud flow) in 30Km2 watershed area that caused more than 300 casualties and a large amount of losses to public and individual properties. A huge amount of mud, boulders and stones were deposited on the streets in an urban area. Many houses and other proprieties were also buried under sediments (Kuritkara Co.2006). Flash floods happen in a very suddenly gesture that cause huge amount of damages to urban facilities, foundations and human lives in no time taking into consideration the main reasons as decreased human-basin interface which leads vast modifications in hydrological characterizations of basin. The management of emergencies, resulting from natural or man-made disasters, requires enough information as well as experienced responders both in technical and co-ordination matters (Hernandez&Serrano,2001). Information requirements may be partially satisfied with the development of telematics systems which make it feasible to build up applications integrating sensors, communications and real-time data bases to provide raw information about the state of a natural or artificial installation such as a chemical plant or a watershed. In this way, a great amount of information is available that should be used to improve the management of the emergency, which generally means making the best decision at the right moment. In order to support the decision-makers in the evaluation of this raw information, knowledge-based systems (KBS) are good candidates, as they are able to integrate both theoretical and common sense knowledge directly taken from the expert decision-makers. Furthermore, KBS are able to provide explanations of their recommendations; this is of fundamental importance in any emergency domain, as the responsible personnel cannot adopt a decision and response to the event without fully understands it (Hernandez&Serrano, 2001).

1-1-Flash flood in brief

It is generally agreed that flash floods have the following characteristics:

1. They occur suddenly, with little lead time for warning;
2. They are fast-moving and generally violent, resulting in a high threat to life and severe damage to property and infrastructure;
3. They are generally small in scale with regard to area of impact;
4. They are frequently associated with other events, such as riverine floods on larger streams and mudslides; and
5. They are rare (Burrell and Gruntfest, 2002)

Several important factors arise as a result of these characteristics. First, areas prone to flash flood need to be prepared, since such events usually come as surprises, warning and preparation are essential; however, because they are rare, the motivation to invest time and resources into such activities is low. Because flash floods usually affect relatively small areas, losses resulting from them do not always generate much long-term response, unless there is high loss of life; however, losses per unit (acre, square mile, or kilometer) of area affected tend to be high compared to other events like riverine floods or hurricanes. Finally, it is sometimes very difficult to attribute specific losses to flash flood events, particularly when they occur in combination with other events. Thus, losses may be underestimated in many instances.

2-Flood response operation

A flood response operation consists of managing and executing a range of activities during the development, passage and recession of a flood. These activities are aimed at protecting the community, minimizing property damage and reducing the disruption to community activities. A flood response operation starts at the first indication of flooding. This may coincide with the issue of a formal flood warning or prediction by the responsible agencies. In many cases, though, it will coincide with a local recognition of conditions which could lead to flooding including heavy or sustained rainfall or actual stream rises. Recognizable start points exist and should be utilized by the combat agency to declare operations commenced.(EMA, 1999). Flood response activity is one of the elements of the crises

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management cycle PPRR where described in order P=prevention, P=preparedness, R=response, R=recovery. In addition, it covers a range of activities as declared in table bellow:

Table1-typical measures covered by flood response.(EMA, 1999).

Implementation of plans	Issuing of warnings
Notification of public authorities	Providing immediate relief
Implementation of emergency	Activation of operations centers
legislation/declarations	Conducting search and rescue
Keeping the public informed	Mobilization of resources
Providing medical assistance	Carrying out evacuation

2-1-Flood operation management

One of the most difficult tasks confronting a flood operations manager can be to establish effective control over a flood response operation. During a flood which develops slowly, control measures may be established progressively as the water rises. In comparison, in the case of flash flooding, control may have to be established quickly to minimize loss of life, injury or damage to property. Flood response operations may be controlled from:

- a combat agency operations centre; or
- an emergency operations centre.

Floods are managed from an operations centre, the function of which is to assist the flood operations manager conduct flood response operations. It will also:

- monitor operations;
- coordinate support;
- liaise with all agencies involved in the flood operations; and
- pass information to other agencies and the community (EMA, 1999).

Apart from the flood operations manager, the key appointment in a flood Operations centre is that of Operations Centre Manager. Whenever possible, flood expert staff should be included in the staff of the flood operations centre.

Thus the expertise plays a very important role in handling the flood operation center.

3-The essential role of information technology in disaster management

Information is one of the prime resources in the planning and management of disasters. Its quantity, quality, flow and utilization can effectively determine the level of success achieved in mitigating catastrophes or dealing with emergencies (Alexander. D, 2002). In the modern world, an information revolution is in progress with profound technological, social and cultural implications. It is hardly surprising that this is spreading to the field of civil protection. This opens up a potentially vast array of new opportunities, and it also throws out a challenge to the disaster planner to make use – good intelligent use – of the emerging technologies. (Alexander. D, 2002)

Flooding occurs within a few hours of the occurrence of heavy precipitation, which is often too short a time to take preparatory measures. For flash flood event the case is much more critical in the view that it happens harshly. Thus a few minutes lost in any phase (pre-event, during and post-event) can lead to catastrophic results(Burrell and Gruntfest, 2002).

The growth of information technology simultaneously with the development of flood warning system, data gathering and transmission, data processing and forecasting is globally on the increase. Upgrading any management related application are mostly dependant on the information flow. In other word, information is a very important resource which is necessary to development of other resources.

The hiring of information management systems is considered an advanced phenomenon in dealing with situations these days which leads to more appropriate results in planning, designing and decision making. With respect to numerous problems seen in natural disaster management as unstructured issues, there is a need to have an essential contribution to information flow. In this regard, with the advances of the information technology and information management systems, there have been seen a dramatic

change in disaster management and response. Natural disasters are categorized as unstructured problems where there is not any specific approach to deal with that causes complexity in situational decision making.

3-1- incorporating information management systems in emergency response

As it was mentioned earlier, emergency management requires enough information as well as Expert activists on the area of response. Information requirements may be partially satisfied with the development of telemetric systems, which make it feasible to build up applications integrating sensors, communications and real-time data bases to provide raw information about the state of a natural or artificial installation such as a chemical plant or a watershed. In this way, a great amount of information is available that should be used to improve the Management of the emergency, which generally means making the best decision at the right moment. In order to Support the decision-makers in the evaluation of this raw information, expert systems (ES) are good options, as they are capable of gathering the expertise from the expert decision-makers. Furthermore, KBSs are able to present reasoning for their recommended choice. Totally, an expert system would provide the user with the full track and process of any decision made.

3-2-Expert system concept

An expert system is a system that employs human knowledge captured in a computer to solve problems that ordinarily require human expertise (Xiaoshan.P,2000). Well-designed systems emulate the reasoning processes used by experts to solve problems, and are popularly used in medicine, business management, design, and searching for natural resources.

Rule-based programming is commonly utilized to develop expert systems. Rules are used to represent heuristics, which specify

Rule-based expert systems are popular for a number of reasons:

- Modular nature. This makes it easy to encapsulate knowledge and expand the expert system by incremental development.
- Explanation facilities. By keeping track of which rules have fired, an explanation facility can present the chain of reasoning that led to a certain conclusion.
- Similarity to the human cognitive process. Rules appear to be a natural way of modeling how humans solve problems. (Xiaoshan.P, 2000)

On the basis of the above, an expert system assists a crises manager in decision making process using if-then rules. The architecture of such an expert system consists of three major components: an inference engine; a knowledge base; and user interface which has been displayed in figure 1.

4-A framework for the design of expert system for flash flood response operation

As discussed earlier, an expert system using if-then rules mimics the human expert's process in decision making. A scenario based expert system makes use of knowledge stored in knowledge-base through scenarios. In other word, scenarios are concerned as essential tools by which the expertise can be simulated and transferred to the decision maker.

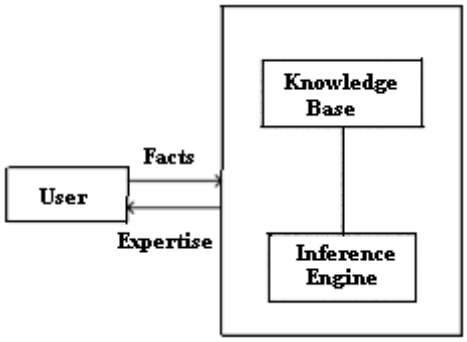

Figure 1: User -Expert System interface (ghazanfari and Kazemi, 2002)

A typical scenario for flash flood is as followings:

Expert system: what time is this? **User:** 9 mornings
Expert system: How much is the predicted rate of rain? **User:** 45 mm/hr
Expert system: what month is this? **User:** spring

Expert system thinking

Expert system: The flood degree is medium, *Flood description*: intense flow in river, course sediment transport, inundation of foot paths and carriage ways, Expected *impacts:* mud flow to resident areas and shops, interrupting recreational activities and traffic flow.

Expert system: How much is the lead time? **User:**6 hr

Expert system: *what to do*; inspecting the waterways, making preparation in man powers related to operative organizations, issuing warning message to the people who are active in the hazard zone And so on.

The above scenario is very general in the sense that it does not cover the more detailed actions.

5-Case study

The Golabdare & Darband catchment placed on northern Tehran with the total area of 30 km^2 is exposed to heavy rainfalls especially during spring. The mentioned basin is mountainous lacking enough vegetation cover to detain the run-off flow. this small area has been subjected to sever land use changes over years so that is under harsh modifications in hydrologic characteristics such as concentration time which has been estimated almost1 hour. (kuritkara Co, 2006)

Having in mind the above factors, the basin is faced with high rate of flow discharge plus a very short time for flood respons by individuals and relevant organizations. Otherwise there have been developed some structural measures in the area still it lacks safety. Data gathering in the study area has been of traditional approach that is replacing with the modern equipments of sensor based. The severity of the flood incidents and the need for immediate response provide the necessity for meteorological predictions.

6-Conclusions and recommendations

Flash floods can lead to important environmental emergency situations affecting the integrity of large infrastructures and the life of many human beings. There is a need for efficient systems to assist public administrators and emergency services in responding to floods based on different emergency scenarios in the prone to flooded areas. Delivery of any action against flood especially in a very short time needs enough knowledge and expertise. It could be of advantage to use expert system simultaneously with human experts in a decision making situation; since in disastrous situations, human would face disability in decision making. In addition, human–expert system interference would empower decision making process due to some expert system's features such as: increasing in certainty, decreasing errors related to decision making, presenting reasoning for decisions and some other advantages. On top of them, an expert system has the ability to learn and to hire the knowledge of a couple of experts in problem solving.

In order to implement an operational expert system in the study area; there should be made a more detailed study on

the basin parameters, requirements for providing an action plan**,** the organizational setup and scope of work relevant to flood response. Thus it could be made more realistic scenarios to be used by mentioned expert system.

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