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FLOOD RISK MANAGEMENT BY USING FLOOD WARNING MONITORING SYSTEMS IN IRAN

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Abstract: Flood risk management seeks to reduce flood risk to communities and individuals through identification and analysis of the flood hazard, the vulnerability of communities to these hazards, and the potential resulting consequences. Increased frequency of damaging floods in most watersheds of the Iran country and Development Water resources development plan in their, the need for flood risk management and real-time flood control in this watersheds has risen more than ever before. Flood Warning Systems - Decision Support as one of the index flood management, using real-time flood forecasting tools and flood management in the Basin, have a significant role in reducing flood damages. In this regard watershed in Golestan province each year in its huge floods occurred and caused huge losses of life and property is, to establish a monitoring system of flood warning has been selected. In this study, Flood hazard zones all the rivers in Golestan Province were identified in order to extract risk and high-risk areas, and then the situation all the rain-gauge and hydrometric stations visited in the province which is active contains 55 hydrometric stations, 23 rain-gauge stations, 27 rain-gauge stations and 2 synoptic stations. In designing the optimal network of hydrometric station and rain-gauge considering the climatic conditions, geographical and hydrological basin, hydrographical network and operation of surface flow, the status of hydrological data and network status monitoring were proposed 33 rain gauges and 27 hydrometric stations. In telemetry project and River flood warning monitoring system of Golestan province that is a local flood warning system by combining the rain-gauge and hydrometric data stations, 59 original measurement station (Main Station) identified, and have read and telecommunications equipment installed at these stations and exploited, In the original plan in the original measurement stations is intended rain gauges and level meter. The project includes 74 repeater stations, 215 alarm stations and 14 control systems and monitoring stations are considered at the city center of Golestan province and the duty to collect and displaying information of all alarms stations and Main Station. The maximum length of proposed interval of river flood warning system monitoring is for the city Gonbad-e Qabus, Aghala, Bandar Turkmen and Gomishan with a Figure amounts to three billion and forty-four million Rials (8 million $).

***Keywords*:** Flood Risk Management, Flood Warning Monitoring System, Non-structural approach, Damage reduction, Golestan province.

1. INTRODUCTION

The TCFSPP believes that flood risk management seeks to reduce flood risk to communities and individuals through identification and analysis of the flood hazard, the vulnerability of communities to these hazards, and the potential resulting consequences. It also seeks to integrate and synchronize actions at various levels of government to mitigate risk.

Flood risk management provides for:

1. Effective and sustainable management of risks posed by floods to life safety, human health, economic activity, cultural heritage, and the environment;
2. Collaborative risk sharing and risk management at all levels of government and by all stakeholders;
3. Risk-informed policies and funding prioritization;
4. The use of natural processes to mitigate the consequences of flooding.

Implementing flood risk management requires:

1. A common definition of flood risk and a consistent means of assessing risk;
2. Effective collaboration, clear communications, and well-defined roles, responsibilities, and authorities at all levels of government, the private sector, nongovernmental organizations, and the public. Those affected by floods must understand and have the tools to manage their personal, household, and neighborhood risks;
3. Balanced consideration of structural and nonstructural measures to foster a sustainable resilient infrastructure. This balance includes using natural defenses to reduce risk while preserving, restoring, and enhancing ecosystems;
4. Basing land-use decisions on flood risk management principles that reflect community values, priorities, heritage, and equity;
5. Establishment of long-term, reliable funding mechanisms for flood risk reduction measures at the federal, state, and local level;
6. Adapting flood risk management strategies to meet changing conditions.

1.1. A Framework for Flood Risk Management

Globally, there has been a recent proactive shift from disaster relief to disaster risk management. A change to this type of management requires an identification of the risk, the development of strategies to reduce that risk, and a program that implements these strategies. In many cases, risk cannot be completely eliminated, but it can be lessened.

Based on guidelines set forth by the United Nations for flood risk management, it is necessary — to calculate the probability or likelihood that an extreme event will occur and to establish and estimate the social, economic and environmental implications should the event occur under existing conditions (United Nations, 2005). Flood risk management also includes helping the community to understand the potential hazards of flooding and what measures should be taken in order to protect themselves and their livelihood. Figure 1 is a visual representation of the approach the United Nations suggests should be taken in flood risk management.

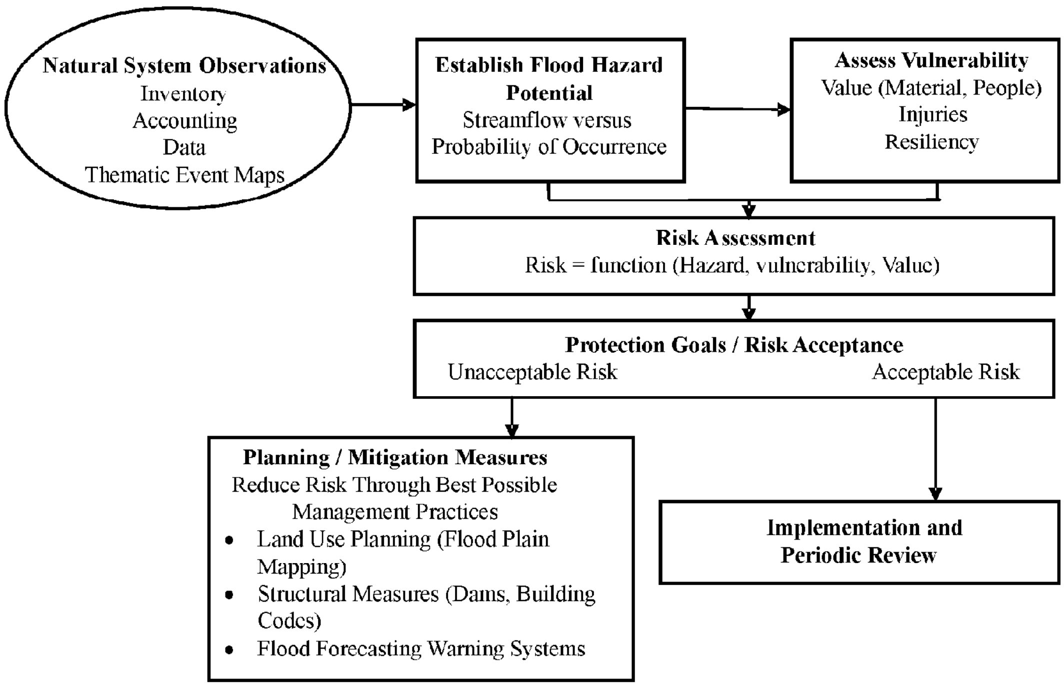

Figure 1: Framework for flood risk assessment and risk management (United Nations, 2005)

A comprehensive, numerical, community-based disaster risk index was piloted in three districts in Indonesia. This risk index is unique because it measures risk on a much smaller scale, focusing on the specific situations of the local communities. It involves the scoring and weighting of disaster risk indicators, which are separated into four main factors: hazard, exposure, vulnerability, and capacity and measures (Figure 2).

Flood warning systems are forms of non-structural flood control and management, which are measures of coping with flood and recently have been applied seriously (Chiang, *et al.* 2010). (Eslamian *et al.* 2002, Eslamian *et al.* 1995, Kaluza *et al.* 2014, Rahman *et al.* 2014, Dalezios *et al.* 2016, Talchabhadel *et al.* 2015, Yousefi *et al.* 2015). According to the flooding of Golestan province as well as massive floods occurring in rivers, studies about flood warning system with the following objectives will be necessary (Deiminiat and Eslamian, 2014).

- Timely announcement of the flood that is coming.
- Pre-designed plan to evacuate the areas that are most vulnerable.
- Providing evacuation instructions for vulnerable areas.
- determining safe areas

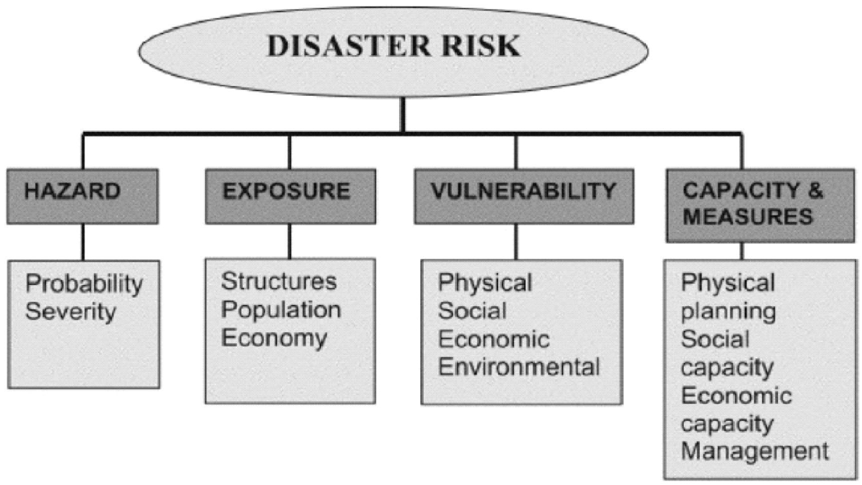

Figure 2: The conceptual framework to identify disaster risk (Birkmann, 2006)

In a study by Zhijia *et al.* (2008), in Lutaizi gauging station upstream on Huai River In order to simulate nonlinear wave propagation mode, the combination module of rainfall-Xin'anjiang model and Muskingum routing model was used (Zhao, Liu;1984, 1992, 1995) Galoie *et al.* 2014, Ajigoh *et al.* 2013, Galoie *at al.* 2013, Bazrkar *et al.* 2013, Alaghmand *et al.* 2012, Galoie *et al.* 2012, Gholami *et al.* 2012, Alipour *et al.* 2011, Ghasemizade *et al.* 2011, Dhital *et al.* 2011).

In this study for prediction of flood discharge, upstream hydrograph using Muskingum method became routed. The results showed that the main channel flood discharge to the surrounding area is directly proportional to the volume of the discharge channel and the model was able to predict floods and flood diversion measures can be taken in critical areas (Zhijia, *et al.* 2008). Alfieri *et al.* (2015) attempted to assess the long-term flood risk under climate scenarios in Europe. This study proposes a new method for assessing the flood risk in the future under global warming's changes. In this study they attempted to assess flood risk until 2080 given the projected population growth and social and economic impact of the floods on their predictions were considered (Alfieri *et al.* 2015) Ostad-Ali-Askari *et al.* 2016, Eslamian *et al.* 2017, Eslamian *et al.* 2016, Eslamian *et al.* 2015).

Pappenberger *et al.* (2015) referred in a study to the financial interests of flood warning systems in Europe. After the 2015 United Nations provided a framework for disaster risk reduction in order to save money and lives and reduces the impact of severe accidents by warning systems to strengthen disaster risk management. They stated that flood forecasting systems on a global scale could be appropriate flood warning information to national authorities to be prepared on how to cope with flooding in the future. Implementation of these warning systems on a continental scale has an effective role in improving the face of natural hazards such as floods (Pappenberger *et al.* 2015). Ran and Nedovic (2016) offered a new conceptual framework for integrated flood risk management programs. They discussed about three dimensional planning mergers (land, policies and institutions) with flood risk management as an effective approach to reduce the risks of flooding. The lack of easy access to information and the right tools to use are barriers of achieving to this approach. To facilitate the effective integration of flood risk management in these three parts there is a need to define infrastructures which contains data and information, systems, decision support, analysis tools and annexed protocols (Ran and Nedovic, 2016).

1.2. Decision support system components - flood warning

Flood warning systems - decision support, as one of the flood management methods, by means of real-time flood forecasting and flood management in the catchment area, have a significant role in reducing flood damages (Bolshakov, 2013). Eslamian *et al.* 2010, Ghazavi *et al.* 2010, Shayannejad *et al.* 2015,Ostad-Ali-Askari *et al.* 2015, Ostad-Ali-Askari *et al.* 2017). The data collection technology, transmission and processing of real-time hydrological data and forecasts through modeling have been significantly improved and raised the possibility to use more advanced systems (Alfieri *et al.* 2015; Marfai, 2003). Flood warning system - support the decision has various subsystems as follows (Dumas *et al.* 2013):

1. ***Identification the system and flood forecasting:*** It includes the collection, transmission, receiving, organizes and process information, modeling, simulation and flood forecasting systems (Buganova *et al.* 2013).
2. ***Flood warning subsystem:*** It includes the determination of flooding areas and dividing these areas in terms of the kind of flood's danger and preparation and submission of alert massages to each area (Campolo *et al.* 2003). Flood warning system is used for review after analyzing the predictions made by the model and is based on hydraulic and hydrologic simulation results obtained from the meteorological model matrix or the results of other systems such as radar technology (Demeritt *et al.* 2013).
3. ***Subsystems of emergency response:*** It includes temporary evacuation flood areas before the flood, to determine the real-time operation of flood control structures, search and rescue flood victims after flood, organizing outreach centers, to deal with floods, protection of vital services, supplies to help etc. (Parker, 2003).
4. ***Subsystem database:*** In decision support systems, collecting data is conducted by telemetry network to collect real-time data, which helps to communicate with the database. These subsystems are used for flood warning system internally, and for collection daily decisions of decision support systems in a standard database. Thus assessments conducted by experts from the flood events of the past and the degree of flood would be stored in the database (Irimescu *et al.* 2010).
5. ***The communications subsystems:*** It is used in order to facilitate the issuance of flood warnings, flood and other phrases. This communication subsystem uses e-

mail and File Transfer Protocol (FTP). E-mail is used to send expressions relating to flood from the command center. File Transfer Protocol (FTP) serves to send and receive data between the command center and other FTP servers (Gouweleeuw *et al.* 2011).

Decision Support System INPUT:

Intervention Strategy constraints:

- Length of intervention strategy (e.g. 10yrs, 15yrs, 20yrs…)
- Number of time steps (e.g. 1, 2, 3…)
- Length of time steps (e.g. 5yrs, 10yrs …)
- Types of intervention measures (e.g. Structural interventions, flood proofing)
- Constraints between time steps (e.g. Account for previous epochs)
- Constraints to ensure realistic measures (e.g. max height increase)

Selection of Objective Functions

- Single objective (e.g. NPV, BCR)
- Multi objective (e.g. Benefit, Cost, Loss of life …)

In Figure 3 is shown decision support system inputs.

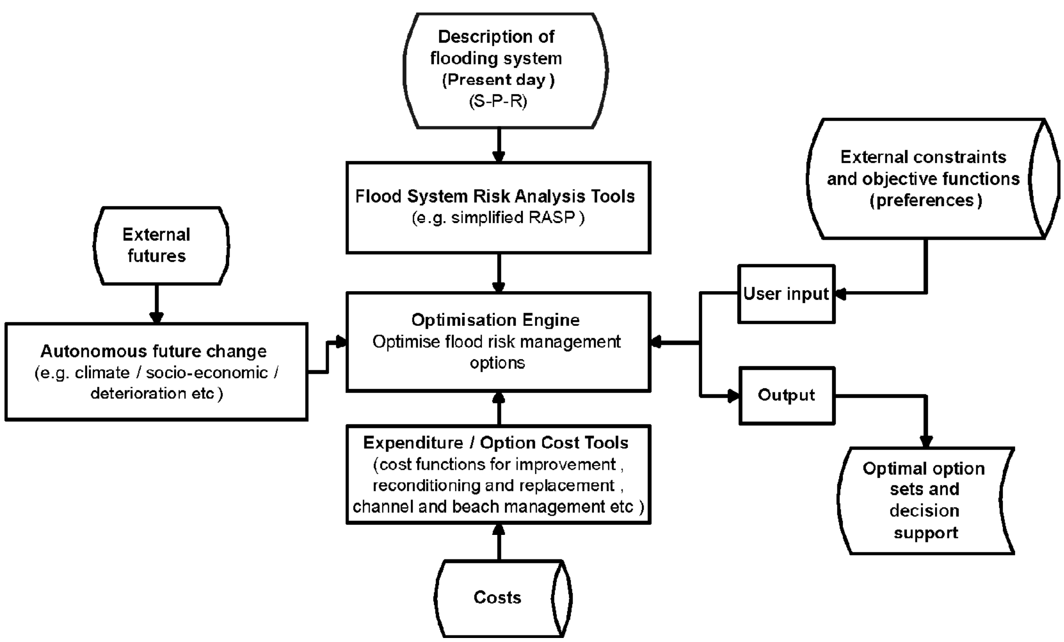

Figure 3: Decision support system inputs

2. MATERIALS AND METHODS

2.1. The intensity and frequency of floods in the area under study

The Study area is the province of Golestan in Iran. Natural causes of floods in the province are the intensity, the extent and continuity of rainfall, soil type, slope of the land and natural cover. Floods factors include the destruction of forest vegetation and pasture, non-normative construction of houses and roads in the bed of river, and lack of training to deal with flood warning system. More floods in the province in terms of timing occur in the summer and spring; such as floods related to the years 2000-2005 in Atrak and Gorganroud. More big floods occurred mainly in eastern Region; such as Persian date 11 August 2011 at an area of 100,000 hectares in the municipalities Minoodasht, Galikesh, Kalaleh, and Gonbad, that caused a great deal of damages to the urban facilities, rural infrastructure, agricultural, residential, commercial and forest lands and introduced pasture. The study area is the following situation in Iran with Flood Zones show in all rivers in Golestan province (Figure 4).

Figure 5 shows the information about the frequency of floods in Golestan province during 23 years. The total fatality during this period is 406 people and the total amount of financial damage caused by the floods is estimated 175,257.9 billion $. In the Figure (6) the frequency of flooding in the Golestan province city is shown.

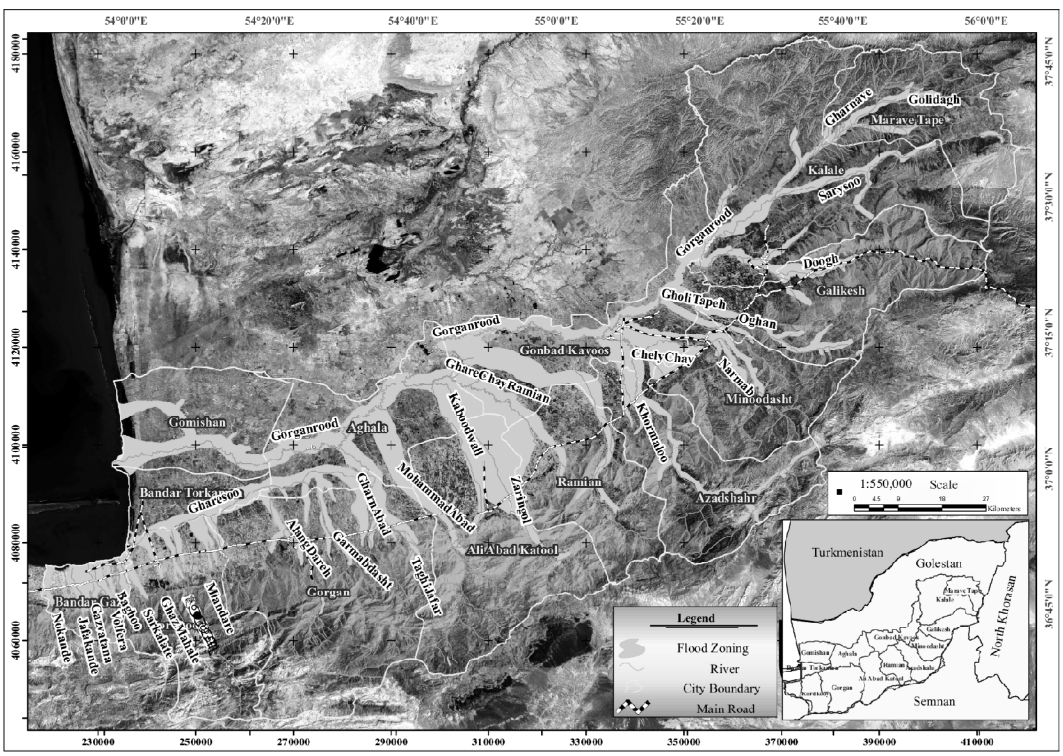

Figure 4: Study area in Iran with flood Zones show in all rivers in Golestan province

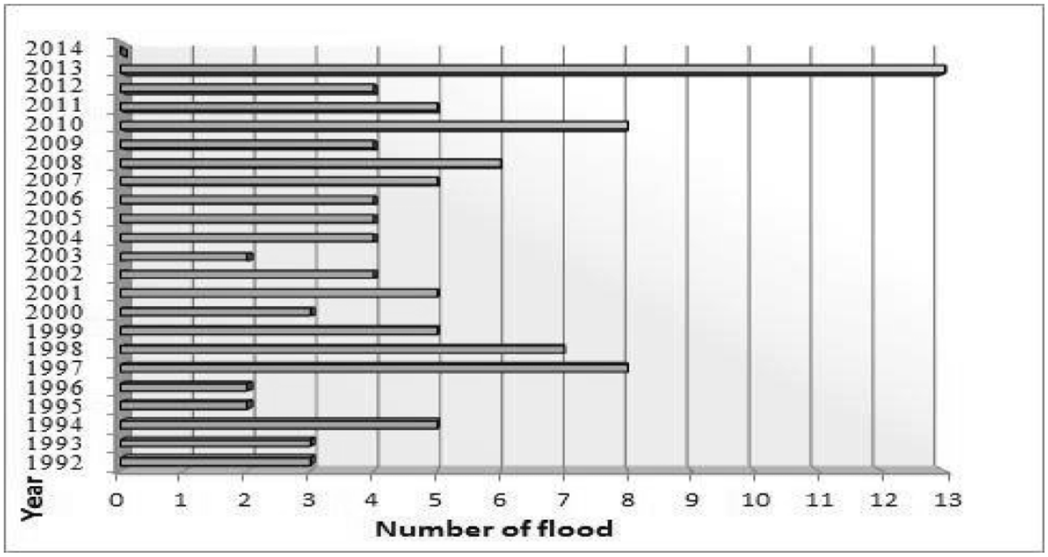

Figure 5: Information about the frequency of floods in Golestan province during 23 years

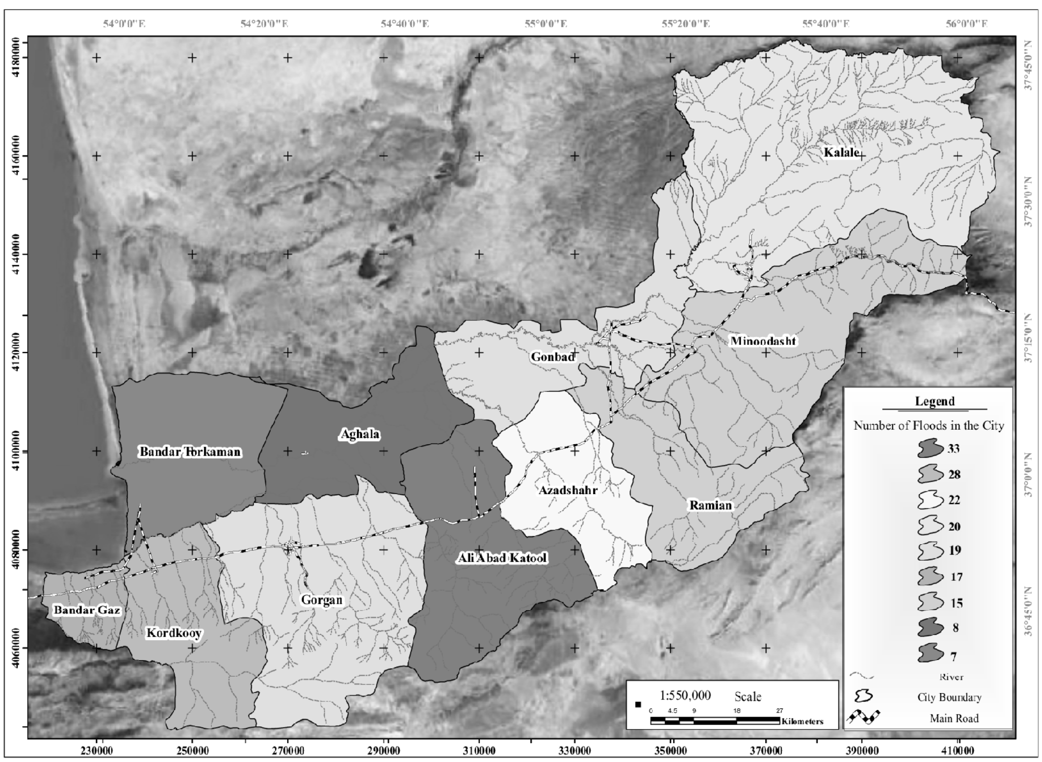

Figure 6: Frequency of flooding in the Golestan province

3. RESULTS

3.1. Determining the number and location of flood warning stations in the province

Flood Warning Decision Support System has a critical role to mitigate damages during flood events (Winsemius *et al.* 2013). Because of the kind of software system needed as a warning system, that can be helpful in predicting critical situations and informing in decision making and investigating the possible hazards of the flood has a critical role, its susceptibility is doubled (ICPDR Report, 2010). The flood warning system should have the following qualifications (Dale *et al.* 2013):

1. Always be active and provide updated information to the correct authorities and the users of the system.
   - Input data stored in a database for later use.
   - Ability to view and identify the misinformation, lack of information and the right information sent from the stations and hydrometric stations on specified location and areas.
   - Ability to view any definite connection between stations and problems in communication with a base station be there.
2. The possibility for future system development.
3. Flexibility in providing service to all applicants.
   - Ability to compare and evaluate the rainfall and runoff from the rainfall provided at different times.
   - Obtaining data build reports and create different graphs during and after the rainfall.
4. The maximum speed and accuracy in processing.
5. Uses the top layer of security for the transmission of information access.
6. To increase awareness is not limited to a specific geographic location or region.
7. Not limited to the physical presence of users to launch the system in processing information.
   - In case of flood risk, does generate alarms and alerts to users automatically.
8. Not limited to computer users accesses to alert and inform.
9. Can have the most notification in the shortest time.
10. Be able to processing operations at maximum speed and precision support.
11. Be able to offer the ability to view and access to relevant information through the Web and awareness and provide alerts on Online Access.

In these studies, to survey the flood warning, stations and rain-gauge data alone or in combination, are used in some places. Location and number of such stations is intended to meet the objectives of the present study as follows:

– Upstream catchment of sample stations be a good index for the entire basin.

– Time interval between notices of the threat of flooding to send messages and for appropriate security measures be appropriately.

– The distance of flood warning stations from venture areas be sufficient to venture areas have enough time to escape from the area.

– The ability to transmit data from the stations and assessing the level of flood warning stations be there.

Suggested rain-gauge stations should be equipped with instruments and limn graph. The water level is measured frequently and if the rainfall degree controller measure more than standard level, an alarm will be submitted to a downstream station by a modem and rotter in site and through telephone lines, so that the residents of the village will be notified of the possibility of flooding. The proposed survey stations should be equipped with sensors to measure the water level and rainfall and water level should be measured periodically. If the height measured at these stations be exceeded the limit, the alarm panel will be active. Also through frequency band and the corresponding antenna a signal will be submitted to the downstream station and the alarm system will be activated on this station.

The overall view shows that in the study area the villages and residential areas in riverside in the province are the most important issues that should be attended to. In addition, joining multiple branches to the river increases the flooding in the region and intensifies the flood damages. Therefore, the study and identification of vulnerable areas to establish flood warning systems to reduce flood damage is essential. To obtain system information, the related instrumentation used and the goal is to transmission information, so instrumentation should be used with electrical output (voltage or current, or frequency, etc.). The output signals of instruments are in the form of standard signals and they are analogue or digital signals (4-20mA DC).

Instruments used in this study include the measurement of water level and rainfall measurements. The output signal from the controller entered Instrumentation and analysis is done on it. After estimating the risk of flooding by software in the controller, and the sirens installed in place turn on. These actions are done in a short time therefore, residents have enough time to save their lives from the natural disaster and the flood warning using a communication platform (UHF) will be sent to the control center.

Telemetry and monitoring flood warning system in the province Golestan which is in the form of local flood warning system by combining survey data and are the stations, has 59 stations for the main measure (Main Station) and read and telecommunications equipment should be installed at these stations and exploited. In this original plan in the original measurement stations, rain gauges and level meter are intended. The project includes 74 iterative stations and 215 stations are alarming. It is worth mentioning that the control and monitoring center of Kalaleh, city Maravetappe Water Affairs, Water Affairs Galikesh city, city Minoodasht Water Affairs, Water Affairs Azadshahr city, water affairs of Ramian, Water Affairs of Aliabad, Golestan Regional Water , the Kordkoy city water, city water affairs Bandar Gaz, the Turkmen port city water, city water affairs Gomishan, Aghala city water, city water affairs Gonbad-e Qabus, are considered whose mission it is intended to collect and display data from all stations. The Figure below gives an overview of the monitoring plan flood warning system in Golestan province.

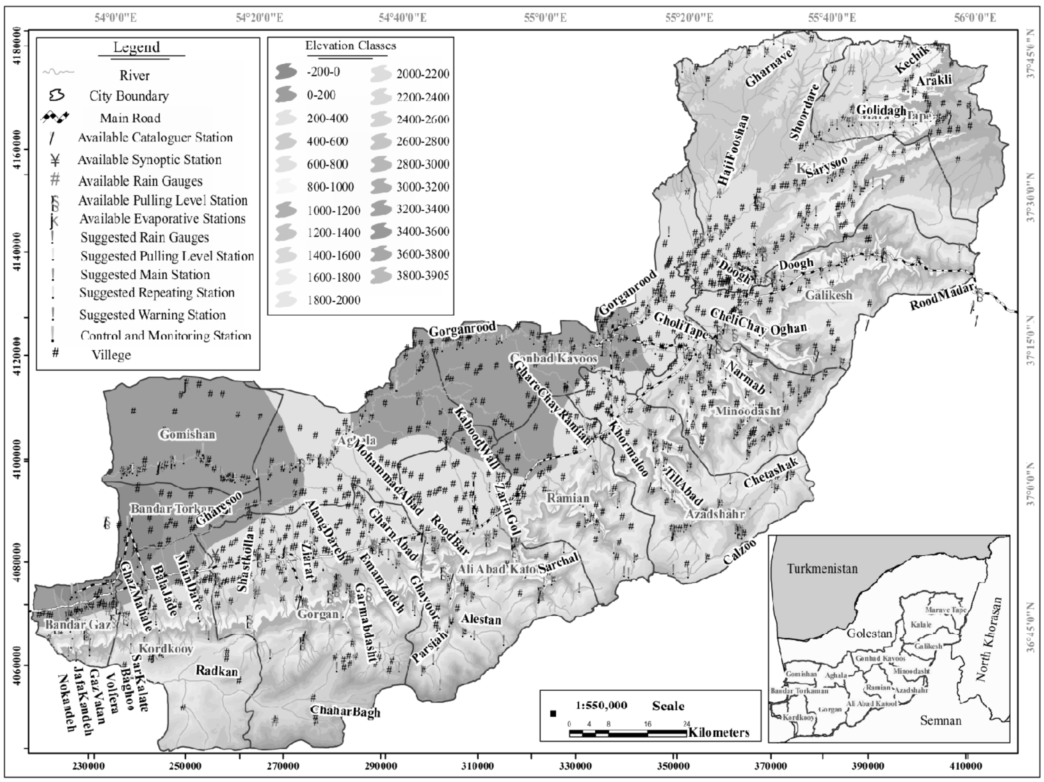

Figure 7: Monitoring plan flood warning system in Golestan province

3.2. Economic analysis of projects to establish flood warning system

In order to determine the economic situation in contact with flood alarm systems level approach, damages before and after the implementation of flood warning systems (Priest *et al.* 2011), river basins and river basin Qarnaveh pilgrimage were selected as pilot area (Meyer *et al.* 2012). In Golestan province, flood warning system in the Ziarat, Doogh, Sary Soo, and Qarnaveh were installed. In order to analysis of economic situations of the warning system implementation in Ziarat river, water level for each of the flooding occurred in different dates with the amount of damages to property and land in the floodplain were extracted, and the reduction factor by implementing a warning system for flood damages from 2010 onwards were calculated. The coefficient for the Ziarat River and for Qarnaveh River was 45.1 and 58.2, respectively. This ratio reflects the reduction in losses after the implementation of flood warning system in the regions. Economic analysis of projects in terms of balance - loss in this area is shown in the Figure below. In this diagram the amount of damage in the region from 1991 to 2010, before running flood warning and flood forecasting system is a continuous line and the amount of damage in the region from 2010 onwards, and after the flood warning and flood forecasting system run are shown as dotted line in two rivers of Ziarat and Qarnaveh.

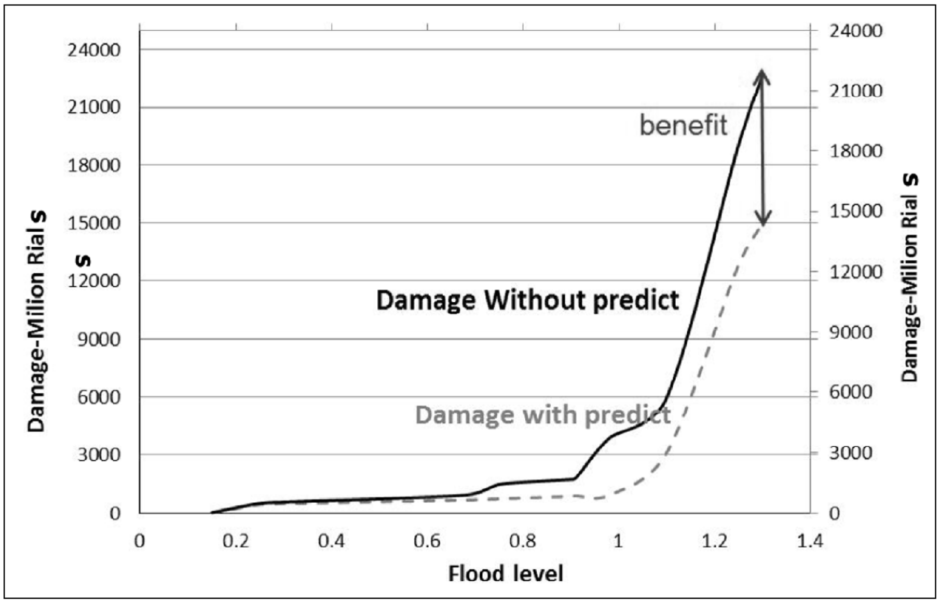

Figure 8: Terms of balance – loss after the flood warning and flood forecasting system in Ziarat river

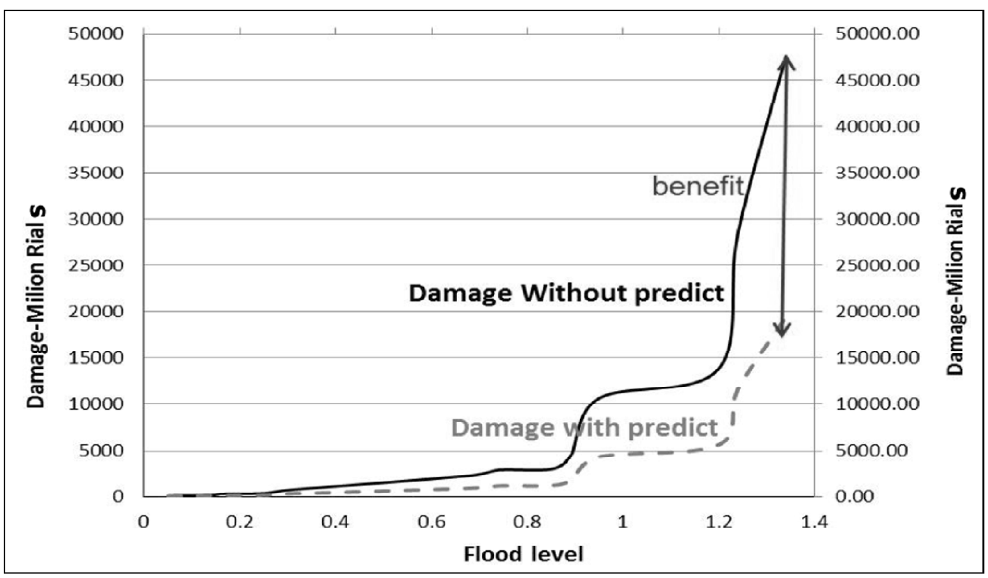

Figure 9: Terms of balance – loss after the flood warning and flood forecasting system in Qarnaveh river

4. CONCLUSIONS

According to studies, the maximum length of proposed interval of river flood warning system monitoring is for the city Gonbad-e Qabus, Aghala, Bandar Turkmen and Gomishan with a Figure amounts to three billion and forty-four million Rials (8 million $).

The following chart shows Golestan province in terms of the cost required for studies for each of the city's flood warning system. In terms of cost required for the study, among the 14 cities in Golestan province, the followings are the highest to the lowest costs order.

Gonbad-e Qabus city, the port of Torkaman, Gomishan and Aghala at a cost of 8 million $, Kalaleh with a cost of 6 million $, Gorgan city at a cost of 4 million $, Aliabad city at a cost of 4 million $, Minoodasht city at a cost of 4 million $, Bandar Gaz port city at a cost of 4 million $, Azadshahr city at a cost of 2 million $, Galikesh city at a cost of 2 million $, Kordkooy city at a cost of 2 million $, Ramian city at a cost of 2 million $ are estimated price range for the proposed studies in each of the city's rivers.

This study, as well as other activities carried out by researchers to establish flood warning monitoring system in the whole province are possible in order to reducing

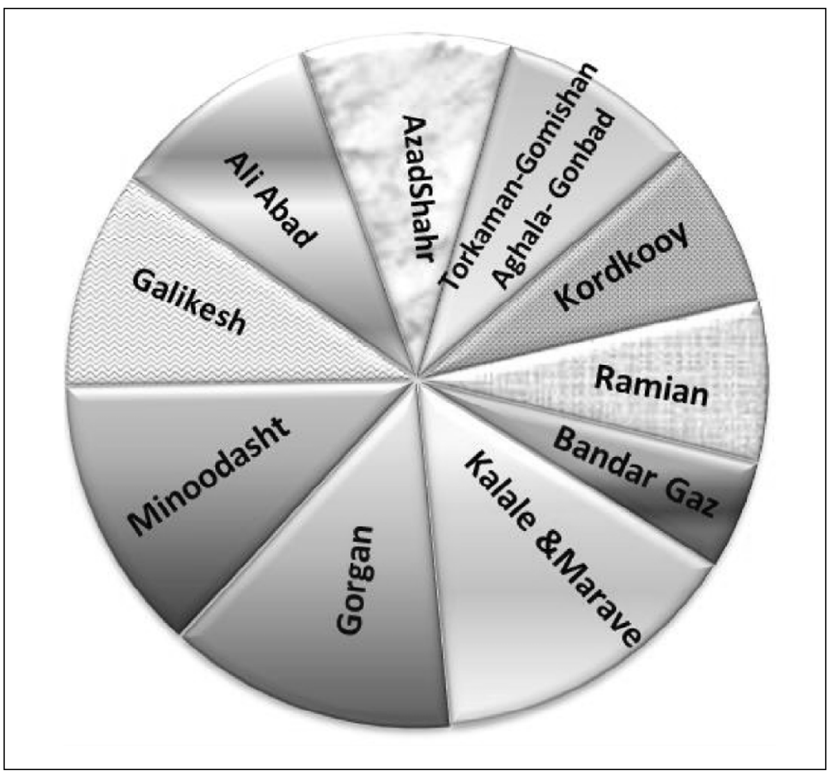

Figure 10: Golestan province in terms of the cost required for studies for each of the city's flood warning system

probability human and financial losses. In this study it was found that the establishment of flood warning systems could have an important role in improving economic conditions of flooding prone areas before and after the crisis. In research conducted by Priest *et al.* (2011), Pappenberger *et al.* (2015) and Ran and Nedovic (2016) also observed this result.

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