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Flood Zoning in Rural Watersheds by GIS and HEC-GEO-RAS (Case study: North western Iran)

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Research Article

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ABSTRACTS

Rivers are Consider as the most essential resources for preparing water to human beings and other living organisms and in some cases, this source may cause non recoverable damages. Prediction of river hydraulic characteristics in contrast to probable flooding for decreasing damages to urban area, in executing establishment, fields and other uses is very important. Allocating of flooding locations in cities is one of the basic data for controlling floods in a non structural manner. In this research determination of flooding locations of some part of urban Hir water shed (Hir Chai river) is done. Mathematical model which is used in this research is named HEC-RAS which has high potentiality in simulating river hydraulic regime, evaluating steady and unsteady floods, calculation of water level profile and finding relation with Geographical Information System (GIS). Geographical information system is a profitable science in systemic evaluation of different parameters and is considered as a Support factor in decision making. In this research its relation with mathematical model of HEC-RAS and HEC-GEORAS has been evaluated. Estimation of optimum return period and flood damages due to different return period has been done. The result of this research clearly shows the relationship between HEC-RAS and GIS, also the flood location in different return period has been determined.

Keywords: *Zoning of flood, Urban Catchment, Hydrology, HEC-GEO RAS, GIS.*

INTRODUCTION

Urban areas are so vulnerable to flooding and damages directly and indirectly These damages among others includes the destruction of houses and other structures, disruption of communication lines, railways, runoff conveyance canals and roads,... which may cause loss of many human lives . Flood zoning as a managerial method when facing flood, now is widely used. Although by structural manner in flood control estimating discharge and balance of water is possible before happening flood, and by directing, deviating and controlling floods by proper structures, the damages can be decreased, These methods are in special status in flood control, its function has not been satisfactory during the recent decades and experts believe that if structural manners are combined with non-structural manners, it can minimize the flood damages.

First activation in use of Geographical Information System in flood phenomena study, returns to 1980's when first actions were done with digital elevation model analysis for hydrology uses, but the connection between hydraulic models and GIS returns to 80's and 90's. The most important actions in this field which is done basically and used all over the world, was applied by Maidment and Olivera in Texas University [Tate et al., 1990]. Correia et al. (1999) tried to zone and analyze the flood danger in flood plains along with urban development. They used Geographical Information System and hydrology and hydraulic models to evaluate flood danger decrease by controlling land use].

Johnson et al. (1999) used HEC-RAS model to estimate and determine the limits of wet lands in 10km of Wyoming River in America. By using the mentioned model, they drew the profile of the river water level, deviated water to a new basin and determined the border location with and without deviation with similar scale, then predicted in deviation period, all the area flooded with discharge of 283.3 l/s, dwindled from 167.2 Hectares to 149.7 Hectares. The researchers believe the foresaid method is a valuable one to determine the rate of deviation effects on riverside wet lands].

Islam et al. (2000) drew the flood danger map for Bangladesh by using remote sensing data taken from the flood which happened in 1988. These researchers drew the flood danger map for three revers in Bangladesh and submitted to the executive department and government to plan].

This map is classified in 5 groups: - Places with extra high flood risk, Places with high flood risk, Places with medium flood risk, Places with low flood risk and Places with extra low flood risk. Lin et al. (2000) studied the

watershed zoning in North Carolina on the basis of best management practices and introduced it as a very useful function in watershed management].

Moramarco et al. (2005) tried to model rain-flood in Tiber City of Italy and modeled the flood of 1998 by using a distributary model. Then, they used a flood 2D model for hydraulic modeling. The results showed an increase in a 50-year flood height up to 2.3m in urban areas[.,].

Yangbu et al. (2011) tried to discover the flood treatment in Touang Area in Southern China by using Liuxihe model and GIS-RS technology.

They used remote sensing data for confirming cross section. The results showed Distributary Models have better result in comparison with Lump Models. Remote sensing data also are so useful for confirming cross section and revers geometric characteristics.

Zeinivand (2001) tried to zone the flood danger of Seylakhor River in Lorestan Province by applying HEC-RAS Model. He found that this model has a high efficiency in calculating water level profile.

Safari (2002) tried to zone flood danger of Neka River in Mazandaran Province by applying HEC-RAS Model. He found that this model has a high efficiency in calculating water level profile and flood zoning].

Regarding that until now the connection between HEC-RAS model and geographical information system (here: HEC-GeoRAS) has not been used in flood danger zone and damage analyzed; and due to the importance of rivers crossing urban areas, the research takes this subject into accounts.

MATERIALS AND METHODS

In this research, first we studied the sources and researches in this field. Then collected the needed drawings (topography, roads) and the statistics of discharge (Hirchay hydrometric stations) from Ardebil Regional Water Company, Tamab and Cartography. In the last stage we tried to provide flood with different return period and site investigations (cross section control and river geometric characteristic record).

After digitalizing maps with scales of 1:2000 and 1:25000 from Surveying Organization using HEC-GeoRAS software and showing cross sections, border locations and other river and flood plain characteristics in HEC-RAS model, for different return period; water level profile was provided. In the next stage, the data taken from hydraulic model was entered to HEC-GeoRAS software.

First step in flood plain management study is flood plain zoning and flood plain surveying. In this step, HEC-RAS model was used to survey flood zoning. By using the output of this software including flood discharge balance digits for different return periods and inputting them to geographical information system, flood zones and flood plains were determined. In this research, the following stages were applied to prepare flood zoning maps:

- Confirming geometric characteristic
- Introducing river canal
- Entering sections geometric data
- Introducing discharge rate and border location in GIS
- Calculating hydraulic of model
- Considering output results
- Preparing first report in order to enter into geographical information system

After calculating water level profile for different return periods and other needed parameters such as cross sections table, geometric data, etc. the data was entered into GIS to provide flood zoning maps and after analysis, the maps were prepared. So in order to prepare and show cross section in GIS, first the needed outputs were provided from HEC-RAS model inputs. In the prepared report, data were from a number of measured cross sections in Hirchay River path, waterway central line location, flood plain zone location, main canal edge location, the distance of edges from river central line and water level digital elevation.

In each cross section, elevation of all points which were determined during topography, were entered into ArcGIS. They are used to provide the location of flood plains border and show the site of each point and read from the left terminal point to the right one.

In order to prepare flood plain map, the detailed topography data is needed. In geographical information system, TIN Model is known as the best model to present the earth surface characteristics in large scale. After fixing the cross sections as the ground, the points converse to 3D map which have length, width and height. In this case we can provide the TIN Model from the main canal and flood plain. Since the resulted TIN only contains the main canal and flood plain, but not the surroundings, so it cannot be reliable enough to have a perfect view of under study area. Therefore, in order to have a better view of the area and use it for flood zoning, DEM (Digital Elevation Model) was applied. The following stages were done automatically in

HEC-GeoRAS software:

- Exchanging the digital elevation model to elevation points
- Boundaries of cross sections terminal point in Polygon form

- Elimination of points out of polygon in digital elevation model
- Confirmation of central and lateral points in order to form a 3D model from central and lateral lines of river in each cross sections
- Providing TIN model by point data of digital-linear elevation model and waterways central and lateral lines
- Providing water level TIN model by water 3D model and bordered polygon of cross sections

RESULTS

After stimulating the flow in HEC-RAS Model, its many characteristics such as longitudinal profile can be observed and according to them the organizing plans of river and flood control can be provided. A model output in one section is shown below as an example.

Fig.1: Water cross profiles for different return periods

Fig.2: Longitudinal profile

Fig.3: Discharge rating curves

Fig.4 : Flood retention zones for different return periods

After preparing the floodgate zones in GIS, it is tried to transfer the mentioned zones to HEC-GeoHMS software. These zones shows the level and depth of floodgate zones.

Fig.5: Flood retention areas, each with different return periods

CONCLUSIONS

- 1- Combination of GIS and HEC-GeoRAS model is efficient, due to the accuracy in providing inputs and observing outputs.
- 2- In this research, TIN Model was used to analyze the elevation characteristics and the result was satisfactory. The accuracy of provided triangles depends on inputs and as the topography information in this research is within the scale of 1:20000, so, the grid resolution is high.
- 3- Presenting flood management model in the under study area includes approving and amending the Hirschay River path, land management and control, study and watershed management in upstream zone, river limits protection, integrated and coordinated management between the relevant organizations, determination of the relevant type of activations by municipality with supervision of Ministry of Energy before transferring the building license in flood plain areas, developing a flood prediction and warning system in Hirschay River upstream. So, we can conclude that the limitations in developing activations and government aids to people and dispatching them to other residential places may have great effects in an attempt to decrease flood danger.
- 4- The flood happening in watershed areas may influence whole or part of the area, in this case, the lands influenced by flood are wider than urban areas. So, it is necessary to provide an integrated emergency management system for the under danger areas.
- 5- It is suggested to use this research for the future planning of the under study area such as inserting a flood warning system, flood insurance, and construction of bridges, drainages and fountains.
- 6- Regarding that in this research the Statistical methods are used to estimate discharges with different return periods, it is better to use rain-flood models such as HEC-HMS to prepare hydrograph of floods with different return periods.
- 7- In this research, because of the sensitivity of Hirschay downstream urban area, HEC-GeoRAS model was used to confirm sections.

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