Available online at www.elixirpublishers.com (Elixir International Journal)

Earth Science

Elixir Earth Science 94 (2016) 39993-39999

ISSN: 2229-712X

Comparison of Delphi and Analytic Hierarchy Process (AHP) techniques in locating flood spreading

Hamid alipor[1], Seyed Negar Hashemi Nasab[2], Amir Hosen Hatefi Ardakani[3], Mohamad Najim Cheshmidari[3] and Saeed Shojaei[4,*]

[1]Young Researchers Club, Bojnourd Branch, Islamic Azad University, Bojnourd,Iran.

[2]Student of Desertification, University of Esfahan.

[3]Student of Desertification, University of Semnan.

[4]Student of Desertification, University of yazd.

ARTICLE INFO

Article history:

Received: 14 March 2016;

Received in revised form: 29 April 2016;

Accepted: 2 May 2016;

Keywords

Flood spreading,
Management of water supplies,
Delphi technique,
AHP,
GIS.

ABSTRACT

A main part of Iran is considered as arid and semi-arid regions as well as water is one of the limited factors for these areas. Controlling the destructive floods is an important activity due to destructive floods and water shortages. In this regard, flood spreading is an effective strategy to control and use floods. To determine suitable areas for flood spreading and direct water into a permeable formation is one of the most important factors in determining the success of flood spreading projects. The present study was conducted to combine and compare the Delphi and Analytic Hierarchy Process (AHP) for flood spreading in Ivar watershed, NE Iran. For this purpose, 4 main criteria, 8 sub-criteria and 24 indices were selected. Percentage and degree of importance for criteria, sub-criteria and indices of flood spreading was determined by AHP in Expert Choice. Questionnaire forms were filled in by experts so that those which have high degree and percentage of importance are more important. After that, the maps were prepared by geographic information system (GIS). Based on the results of AHP and Expert Choice, the highest and lowest relative importance was recorded for sediment volume and Unemployment rate, respectively. According to Delphi technique, indices of soil permeability, flood quality, soil texture, slope, aqueduct, and sub-criteria of water, aquifer, topography, as well as criteria of permeability and flood are important in order in locating flood spreading for Ivar watershed. According to the results of the techniques used in this study, it is revealed that criteria, sub-criteria and indices in Delphi and AHP have approximate results. Hence, using these techniques interchangeably in location of flood spreading can be effective and practical.

Introduction

Flood spreading is a process which controls and spreads the flood by mechanical operations so that makes significant effects on plant growth and aquifer recharge (Vahabi, 1999). Controlling floods not only prevent its damages, but also appropriately use their water for various purposes (Soltani, 2002). Nowadays, flood spreading on aquifer is one of the effective techniques to control and optimal use of flood as well as groundwater recharge in arid and semi-arid regions (Ghermezcheshmeh et al., 2000). In this regard, using decision models helps GIS[1] to make useful special decisions (Mehdipour, 2007). The analytic hierarchy process (AHP) is a structured technique for organizing and analyzing complex decisions, based on mathematics and psychology. It was developed by Thomas L. Saaty in the 1970s and has been extensively studied and refined since then. It has particular application in group decision making, and is used around the world in a wide variety of decision situations, in fields such as government, business, industry, healthcare, shipbuilding and education (Ataie, 2010, Godsipour, 2009). Users of the AHP first decompose their decision problem into a hierarchy of more easily comprehended sub-problems, each of which can be analyzed independently. The elements of the hierarchy can relate to any aspect of the decision problem—tangible or intangible, carefully measured or roughly estimated, well or poorly understood—anything at all that applies to the decision at hand. AHP is based on three principles: Analysis, comparison and combination of complementing pair of consecutive values and priorities of the alternatives (Saaty, 1980). The Delphi method is a structured communication technique or method, originally developed as a systematic, interactive forecasting method which relies on a panel of experts (Adler and Ziglio, 1996). The experts answer questionnaires in two or more rounds. After each round, a facilitator or change agent provides an anonymous summary of the experts' forecasts from the previous round as well as the reasons they provided for their judgments. Thus, experts are encouraged to revise their earlier answers in light of the replies of other members of their panel. It is believed that during this process the range of the answers will decrease and the group will converge towards the "correct" answer. Finally,

1 geographic information system

Tele:
E-mail address: s_shojaei@ut.ac.ir

the process is stopped after a predefined stop criterion (e.g. number of rounds, achievement of consensus, stability of results) and the mean or median scores of the final rounds determine the results (Helmer, 1997). The Delphi Method is not to be confused with a related technique for manufacturing consent in which an organizing party combines the input in a non-transparent way, giving the organizing party complete but non-obvious control over the outcome. A name often used for this deceptive use of the Delphi Method is the "Delphi Technique" (Rowe and Wright, 1999). Delphi is based on the principle that forecasts (or decisions) from a structured group of individuals are more accurate than those from unstructured groups (Wissema, 1982). The technique can also be adapted for use in face-to-face meetings, and is then called mini-Delphi or Estimate-Talk-Estimate (ETE). Delphi has been widely used for business forecasting and has certain advantages for other fields such as environmental agents. There have been conducted different studies on the application of GIS, remote sensing, and Decision Support Systems (DSS) in various fields (Ramalingam and Santhakumar, 1997; Kheirkhah Zarkesh, 2005; Ghaiomian et al., 2005). Zehtabian et al., (2001) showed fuzzy operator of gamma = 0.1 and gamma = 0.3 was the most appropriate location for Toqrood watershed in Qom province, center of Iran. GIS and remote sensing were applied to disperse flood in Zanjan province, west of Iran (Abdi, 2005). In addition, Delphi technique was used to determine the areas with high potential of flooding so that these areas were weighted and located (Majnonian, 1997; Gholami, et al. 2005). Miller and Cuff (2005) indicated that Delphi technique was determined as an appropriate technique for environmental problems. Moreover, Delphi and AHP techniques were compared to locate flooding after fire in forest (las Heras, 2007).

Material and methods

Ivar watershed with an area of 5500 ha was located in northern Khorasan, NE Iran (longitude: 56° 16´ 53″ to 56° 8´ 58″; latitude: 37° 4´ 26″ to 36° 58´ 3″; maximum and minimum a.s.l. was respectively 1603 and 1031 m) (figure1). It is in arid class based on Dumbarton classification. The mean annual temperature is 14.1 °c, which is ranging from -8.1 °c of winter to 40.1 °c of summer. The Agriculture, livestock and carpet weaving are the major occupations of local people. The location of Ivar watershed have been presented in figure 1. The watershed is covered by sedimentary and rocks from Jurassic, Cretaceous and Quaternary.

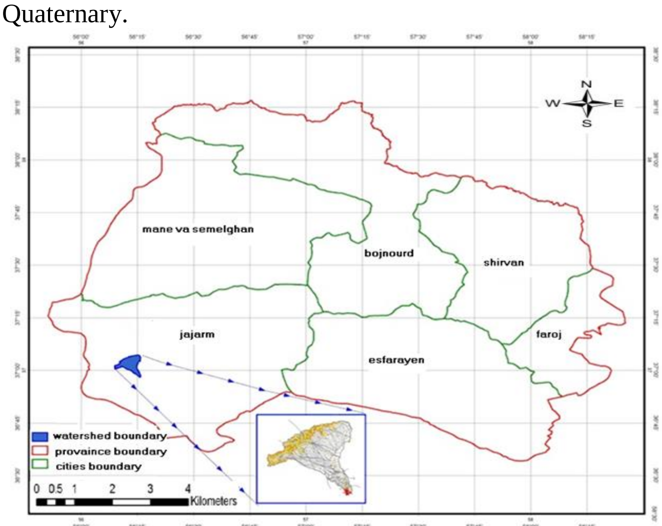


Figure 1. The location of Ivar watershed in Iran

In the present study, the map (scale of 1:25000) of elevation classes was prepared from data of National Cartographic Department, and then georeference process was done. After that, DEM was applied to create elevation and slope maps of the watershed. Slope map was classified into five classes of 0-2, 2-5, 5-8, 8-12, and more than 12. The geological map of the watershed was extracted from 1:100000 map of geological department of Iran. In addition, ETM+ of 2002, 1:50000 topographic maps, and 1:45000 aerial photographs were used in this study. Surface permeability map based on hydrological groups of soil were digitized in GIS and classified in four classes as very high, high, medium, and low. In AHP technique, a decision-maker should compare every pair criteria involved in making decision, which this comparison in first step was presented as descriptive and in next step as quantitative form from 1 to 9 (Table 1) and finally a matrix would be obtained of this comparison (Satty, 1980).

Table 1. Determining the criteria value in respect to each other by expertise in AHP.

Preference	Value
Totally Preference or very important	9
Very strong Preference or importance	7
Strong Preference or importance	5
Weak Preference or importance	3
Same Preference or importance	1
Preferences between above intervals	2, 4, 6, 8

All main criteria had some sub-criteria, which were assessed by experts. After extracting all sub criteria and criteria in this study, the incompatibility rate was obtained by expert's views. Controlling the incompatibility rate of decision-maker was performed based on mathematical relations and Expert Choice software. The incompatibility rate was obtained for determining the accuracy of pair-comparison matrixes in Expert Choice. The sample of this incompatibility rate has been presented in figure 2. If the incompatibility rate is less than 0.1, it can be concluded that there is an appropriate value of compatibility in pair-comparison; otherwise this indicates incompatibility (Ataie, 2010; Ghodsipour, 2009; Ishizaka & Labib, 2009; Malczewski, 2006; Saaty, 2002; Oswald, 2004) (figure 3 Making-decision tree of criteria, sub-criteria and indices for spreading flood based on AHP).

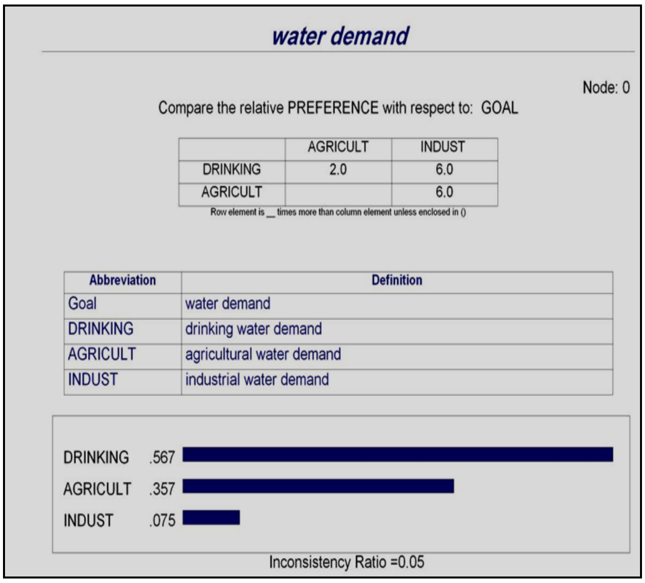


Figure 2. The sample of the incompatibility rate using Expert Choice.

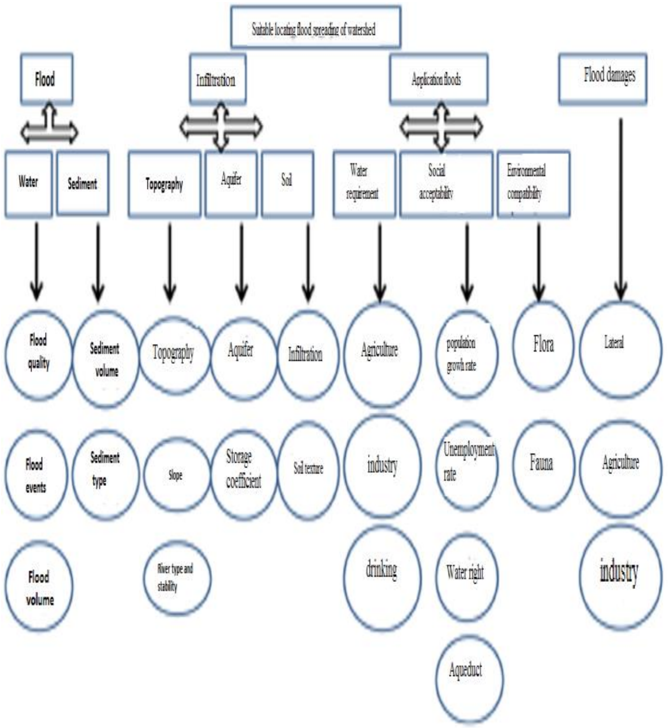


Figure 3. Making-decision tree of criteria, sub-criteria and indices for spreading flood based on AHP

The importance of criteria and sub-criteria regarding their practical aspects has been created in a new form. For this purpose, the questionnaire forms including the criteria were designed and filled by experts (table 2). After that the scores were collected and the criteria weighted.

Table 2. The degree of importance for criteria in respect to each other by expertise in Delphi technique.

Degree of importance for criteria	Very high	High	Medium	Low	Very low
Value	9	7	5	3	1
Range of value	8-10	6-8	4-6	2-4	0-2

The results of the Delphi questionnaire were applied to calculate two numerical indices of the degree and percentage of importance. Then these two indices were graphically obtained for selecting flooding criteria. Mathematical relationships of percentage and importance are as follows (Danehkar and Hadadinia, 2009):

$$\frac{\sum(x_i \times n)}{N} = \text{Degree of importance of crite}$$

$$\frac{\sum z_i}{N} \times 100 = \text{Percentage of importance of criterion}$$

Where $(y_i) = \frac{x_i}{\sum x_i}$ is adjusted weight of $(z_i) = y_i \times n$; n = the number of people who voted to every degree of importance; N= The number of respondents; xi = initial weight.

For each criterion, the degree and percentage of importance of the criteria were calculated to create the criteria importance graph. This graph is the chart which its horizontal and vertical axes respectively show the percentage and degree of importance of criteria. Criteria entered into the sector in the right to be considered as selected criteria for flooding. According to this graph, criteria with the highest percentage of importance have the highest degree of importance. In addition, prioritization of criteria was determined based on percentage and degree of importance of criteria (Anada and Herath, 2008).

Results

In the study four main criteria viz. permeability, flooding, water application and flooding damages include 8 sub-criteria and 24 indices were extracted for selecting appropriate areas of flood spreading, which the results of AHP and Delphi technique by Expert Choice have been presented in table 3-8.

Table 3. The main indices of water, sediment and flood and their relative importance

Relative importance	Flood quality	Flood events	Flood volume	Main indices of Water
0.6	5	3	1	Flood volume
0.2	4	3	1.3	Flood events
0.09	1	1.4	1.5	Flood quality
Relative importance		Sediment type	Sediment volume	Sediment
0.7		3	1	Sediment volume
0.2		1	1.3	Sediment type
	Relative importance	Sediment	Water	Flood
	0.6	2	1	Water
	0.3	1	1.2	Sediment

Table 4. The main indices of topography, aquifer, soil and permeability and their relative importance

Relative importance	River type and stability	Slope	Topography	Main indices of topography
0.5	3	2	1	Topography
0.2	2	1	1.2	Slope
0.1	1	1.2	1.3	River type and stability
Relative importance		Aqueduct	Storage coefficient	Main index of aquifer
0.8		6	1	Storage coefficient
0.1		1	1.6	Aqueduct
Relative importance		Soil texture	Soil texture	Main indices of aquifer
0.8		4	1	Soil texture
0.2		1	1.4	Soil permeability
Relative importance	Aquifer	Soil	Topography	Main index of permeability
0.6	4	3	1	Topography
0.1	1	1	1.3	Soil
0.1	1	1	1.4	Aquifer

Table 5. The main indices of water requirement, social acceptability, environmental compatibility, sub-criteria of water application and their relative importance

	Relative importance	**Water requirement of industry**	**Water requirement of agriculture**	**Water requirement of drinking**	**Main indices of water requirement**
	0.5	6	2	1	Water requirement of drinking
	0.3	6	1	1.2	Water requirement of agriculture
	0.07	1	1.6	1.6	Water requirement of industry
Relative importance	Unemployment rate	Population growth rate	Water right	Aqueduct	Main indices of social acceptability
0.5	6	4	2	1	Aqueduct
0.2	5	2	1	1.2	Water right
0.1	3	1	1.2	1.4	Population growth rate
0.06	1	1.3	1.5	1.6	Unemployment rate
Relative importance		Fauna	Flora		Main indices of environmental compatibility
0.6		2	1		Flora
0.3		1	1		Fauna
Relative importance	Environmental compatibility	Water requirement	Social acceptability	Main indices of water application	
0.5	2	2	1	Social acceptability	
0.2	1	1	1.2	Water requirement	
0.2	1	1	1.2	Environmental compatibility	

Table 6. flood damages: Main indices and their relative importance

Relative importance	**Industrial damage**	**Agricultural damage**	**Body damage**	**Main index**
0.7	9	8	1	Body damage
0.1	3	1	1.8	Agricultural damage
0.06	1	1.3	1.9	Industrial damage

The maximum relative importance was belonged to sub-criterion of water and indices of flood and sediment volume (table 3), sub-criterion of topography and indices of topography, storage coefficient, and soil texture (table 4), sub-criterion of social acceptability, indices of ware requirement of drinking, aqueduct, and flora (table 5), index of body damages (table 6).

Table 7. The results of Delphi technique for criteria and sub-criteria of locating flood spreading of Ivar watershed.

Percentage of importance	Degree of importance	Criteria	
29.6	7.4	Permeability	1
18.4	4.6	Water application	2
23.2	5.8	Flood	3
16.8	4.2	Flood damages	4
Percentage of importance	Degree of importance	Sub-criteria	
29.6	7.4	Topography	1
30.4	7.4	Aquifer	2
27.2	6.6	Soil	3
18.4	4.6	Water requirement	4
12.8	3.2	Social acceptability	5
12.8	3.2	Environmental compatibility	6
33.6	8.2	Water	7
28.8	7	Sediment	8

Table 8. The results of Delphi technique for indices of locating flood spreading of Ivar watershed

Degree of importance	**Degree of importance**	**Index**		**Degree of importance**	**Degree of importance**	**Index**	
10.4	2.6	Population growth rate	13	16.8	4.2	Topography	1
8..8	2.2	Unemployment rate	14	29.6	7.4	Slope	2
11.2	2.8	Flora	15	15.2	3.8	River type and stability	3
9.6	2.4	Fauna	16	23.2	5.8	Storage coefficient	4
24.8	6	Flood volume	17	24	6	Aqueduct	5
16	4	Flood events	18	31.2	7.8	Soil texture	6
32	8	Flood quality	19	33.6	8.4	Soil permeability	7
20.8	5.2	Sediment volume	20	12.8	3.2	Water requirement of drinking	8
20	5	Sediment type	21	11.2	2.8	Water requirement of agriculture	9
12.8	3.2	Body damages	21	10.4	2.6	Water requirement of industry	10
13.6	3.4	Agricultural damages	23	26.4	6.6	Aqueduct	11
12.8	3.2	Industrial damages	24	20	5	Water right	12

As is shown in tables 7 and 8, the highest degree and percentage of importance based on expertise was belonged to criteria of permeability and flooding and sub-criteria of water, aquifer, topography, as well as indices of soil permeability, flood quality, soil texture, and slope.

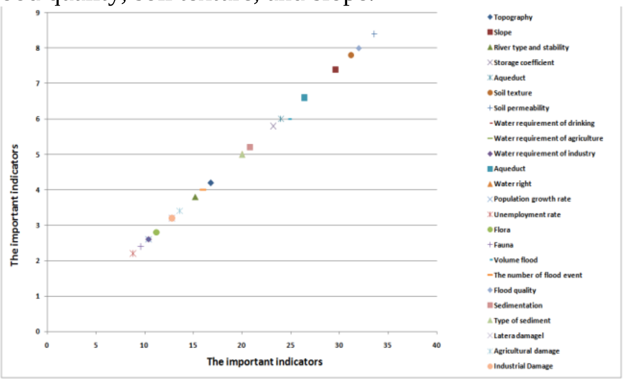


Figure4. The graph of degree and percentage of indices for locating flood spreading of Ivar watershed.

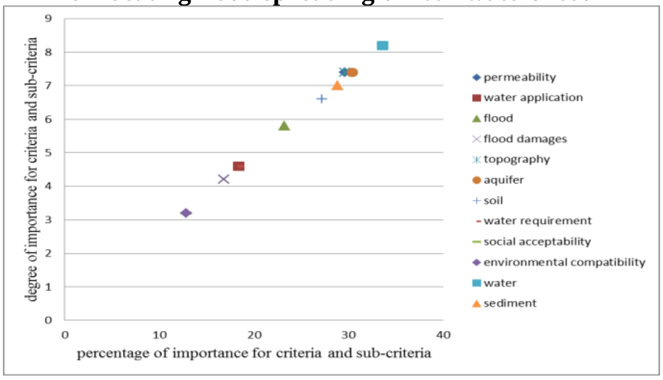


Figure 5. The graph of percentage and degree of importance for criteria and sub-criteria in locating flood spreading.

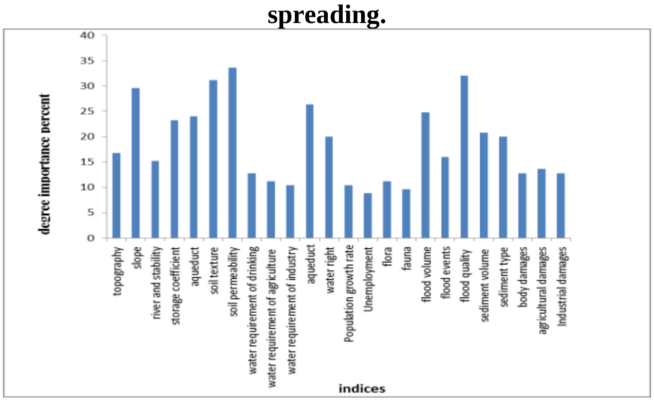


Figure 6. The graph of degree importance percent for indices.

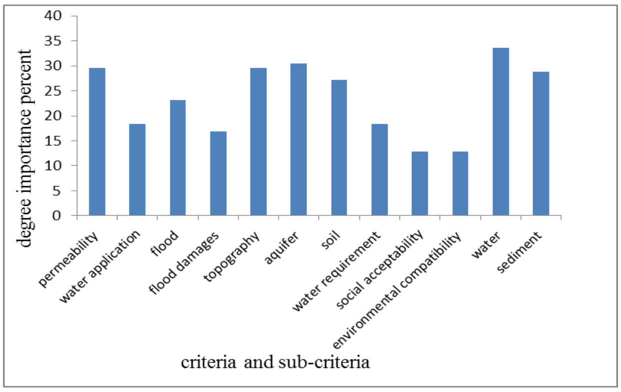
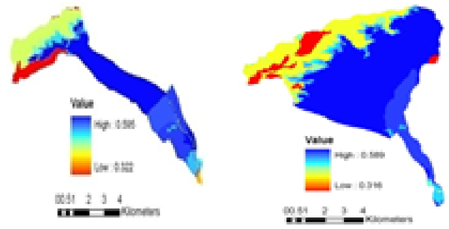


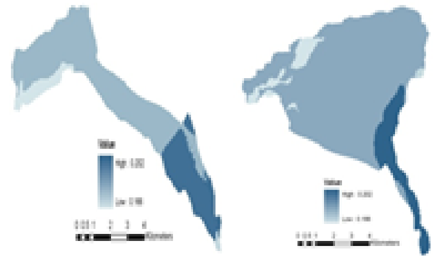
Figure 7. The graph of degree importance percent for criteria and sub-criteria.

Figures 4 and 5 indicate the graph of percentage and degree of importance for criteria and sub-criteria, and figures 6 and 7 show the degree importance percent of locating flood spreading iIvar watershed. Based on these figures, the highest percentage and degree of importance and also the maximum degree importance percent were belonged to indices of soil permeability, flood quality, soil texture, slope and aqueduct, and sub-criteria of water, aquifer, and topography as well as criteria of permeability and flood (figure 8, 9, 10 and 11 Respectively The priority map of Permeability, Food damages, Flood and Water application).



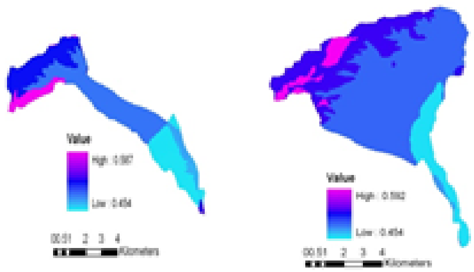
Sub-Watershed 2 Sub-Watershed 1

Figure 8. The priority map of Permeability.



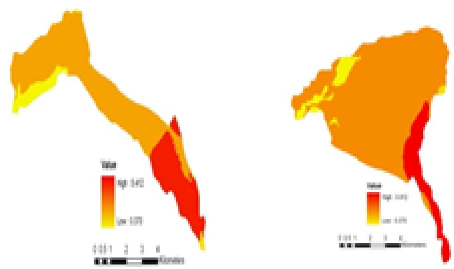
Sub-Watershed 2 Sub-Watershed 1

Figure 9. The priority map of Food damages.



Sub-Watershed 2 Sub-Watershed 1

Figure 10. The priority map of Flood.



Sub-Watershed 2 Sub-Watershed 1

Figure 11. The priority map of Water application.

Discussion

In determining the appropriate area for spreading flood, there are layers which are less important than others in terms of total information but they have a significant role on limiting the area. So these layers are considered as important as main layers. GIS is able to show the value of each layer and determines the portion of each layer in combination forms (Soltani, 2002). In addition, AHP reflexes the natural action and thought of human. This technique investigates the complex issues based on their interactions and simplifies them. AHP is used when the decision are faced to some competitors, while Delphi technique is used for issues which don't need more accurate processes and when the real data are not available. Lack of sampling, uncertainty of future events and lack of clearly defined procedures for conducting Delphi studies, is only one of the factors that distinguish Delphi from other controlled scientific methods. According to the results obtained by GIS and Delphi technique, the maximum percentage and degree of importance and also the maximum degree importance percent were belonged to indices of soil permeability, flood quality, soil texture, slope and aqueduct, and sub-criteria of water, aquifer, and topography as well as criteria of permeability and flood. In addition, based on the results of Expert Choice, the highest and lowest relative importance was recorded for sediment volume and Unemployment rate, respectively. The results indicate that GIS, Delphi technique, and AHP are approximately able to cover same areas in flood spreading. This issue is supported by Mehrvarzmoqanlo et al. (2005); Alshaikh et al. (2002) who reported that applying GIS with conceptual models results in significant accuracy. In the present study, most areas of flood spreading were in quaternary areas of Qa1, Qt1, Qt2, and Qf1 due to locating these units on the margins of the main rivers, their formation of clay, silt, sand and gravel and be located at lower altitudes and low slopes. These findings are in accordance with Abdi (2005) who reported that 40 percent of appropriate areas of flood spreading were found in quaternary areas. Most areas are located in low slope (less than 3 %), which shows the effective impact of this factor in flood spreading and are in accordance with findings obtained by Ghermezcheshmeh et al. (2000) and Abdi et al. (2000). They mentioned that areas with slope of less than 3% are appropriate for flood spreading. Sub-watershed 1 is more preferred than Sub-watershed 2 and selected as more suitable one due to its high water requirement, large flood area, flood controlling, land uses, deposits, low slope, and available to main ways and larger areas. These results are similar to those obtained by Kheirkhah Zarkesh (2005) which after weighting, flood volume, soil texture, and water requirement of drinking are the significant factors on determining high potential areas. According to the results of the techniques used in this study, it is revealed that criteria, sub-criteria and indices in Delphi and AHP have approximate results. Hence, using these techniques interchangeably in location of flood spreading can be effective and practical.

Suggestion

- To investigate the efficiency of different models in location of flood spreading, the adaptive models with GIS will be applied to select the most appropriate model.
- To increase the accuracy of model, more indices will be applied so that provides the economic and time justification.
- Further studies are needed in regard to weighting, because this part is significant on flood spreading.

References

[1] Adamat R.A., Diabat A., Shatnawi G., 2010. Combining GIS With multicriteria decision making for siting water harvesting ponds in northern Jordan. Journal of arid environments.Vol74:1471-1477.

[2] Adler, M., Ziglio, E., 1996. Gazing into the Oracle: The Delphi method and its application to social policy and public health. London: Kingsley Publishers,829P.

[3] Anada, J., Herath, G., 2008. Multi-attribute preference modelling and regional land-use planning, Ecological economics 65: 325–335.

[4] Abdi, P. and Qaiomian, J. 2000. To determine the appropriate areas of flood spreading in Zanjan plain (Iran) using geophysical data and GIS, the symposium of aquifer achievements, 86-99.

[5] Abdi, P., 2005. The mapping of quaternary deposits of Zanjan province in Iran using RS-GIS. Journal of Surveying Engineering. Remote sensing and geographical sciences. 14 (54): 41-36

[6] Alshaikh, A. A., Soltani, M.J., and Helali, H., 2002. GIS application in locating the flood spreading areas, Geographical Research, 17 (4): 22-38.

[7] Ataie, M., (2010), Multi-criteria decision, Shahrood University Press, 333 p.

[8] Danehkar, A. and Hadadiniar, S., 2009. Weighting and ranking ecotourism for planning in desert and semi-desert ecosystems with Delphi. Journal of Natural Resources Development and Management, 2 (2): 21-32.

[9] Ghermezcheshmeh, B., Giomian, J. and Mehdian, M.H., 2010., determining the suitable indices in locating of flood spreading, (Case Study: Meymeh watershed of Isfahan, Iran), the symposium of aquifer achievements, 39-50.

[10] Ghodsipour, H., 2009. AHP technique, Amir Kabir University Press, 236 p.

[11] Gholami, M.H., Farhoosh, T. and Ariani, J., 2005. An application of Delphi technique in determining the strategic goals of oil, gas and petrochemical management. First National Conference on Safety Engineering and Management of HSE. Iran.

[12] Giomian, J., Ghermezsheshmeh, B., Faiznia, S. and Norozi, A.A., 2005. Integration of GIS and DSS to identify potential areas of artificial recharge (Case Study: Meymeh watershed of Isfahan, Iran). Geology of Environment. 47 (4): 493-500.

[13] Gokhale, A., 2004. Environmental Initiative Prioritization with a Delphi Approach: A Case Study, Environmental Management Journal, 28(2):187-193.

[14] Hatzichristos, T., Giaoutzi, M., 2006. Landfill siting using GIS, fuzzy logic and the Delphi Method, Int. J. Environmental Technology and Management, Vol. 6, Nos. ½, pp.218–231.

[15] Hekmatpour, M., Faiznia, S., Ahmadi, H. and Khalilpour, A. 2007. zoning the appropriate areas for artificial recharge in Varamin plain using GIS and DSS, Journal of Environmental Studies, 33 (42): 1-8.

[16] Helmer, O., 1997. Problems in futures research: Delphi and causal cross-impact analysis. Futures, 17-31.

[17] Ishizaka, A & Labib, A.(2009). Analytic Hierarchy Process and Expert Choice: Benefits and Limitations, ORInsight, 22(4): 201–220.

[18] Kheirkhah Zarkesh, M., 2005. DSS for floodwater site selection in Iran, PhD Thesis. Wageningen University. 273.

[19] Kheirkhah Zarkesh, M., Meijernk, A.M.J., Goodarzi, M., 2008. Decision Support System (DSS) for site selection floodwater spreading schemes using Remote Sensing (RS) and Geographical Information Systems (GIS). Desert. 12 (2): 99-197.
[20] Klosterman, R.E., 1997. Planning support system: a new perspective on computer-aided planning. Journal of Planning Education and Research (17): 45-54.
[21] las Heras., 2007. Wildfire motivation survey through theDelphi Method.p:1-10 .
[22] Leskinen, P., Kangas, J. A., pasanen, M., 2003. Assessing Ecological Values with Dependent Explanatory Variables in Multi-criteria Forest Ecosystem Management. Ecological Modelling, (170)1-12.
[23] Majnonian, H. 1997. Environmental evaluation of regions to determine national park. Ecology journal, 19: 11-27.
[24] Mehdipour, F., 2007, the model for locating based on AHP and GIS, Mapping journal, 87, 20-29.
[25] Mehrvarzmoqanlo, K., Faiznia, S., Giomian, J. and Ahmadi, H. 2005. Studying quaternary deposits to determine potential areas of flood spreading using RS and GIS, Journal of Iranian rangeland and desert researches, 12 (4): 437-467.
[26] Miller, A., Cuff, W., 2005. The Delphi approach to the mediation of environmental disputes, Environmental Management Journal, 10(3): 321-330.
[27] Malczewski, J. (2006). GIS-based multicriteria decision analysis: a survey of the literature. International Journal of Geographical Information Science, 20(7): 703–726.
[28] Oswald, M. (2004). Implementation of the analytical hierarchy process with VBA in ArcGIS. Computers and Geosciences, 30: 637–646.
[29] Ramalingam, M., Santhakumar, A.R., 1997. Case study on artificial recharge using Remote Sensing and GIS. GISdevelopment.221p.
[30] Saaty, T. L. (1980). The Analytical Hierarchy Process. McGraw Hill, New York. 350 pp.
[31] Saaty, T. L. (2000). Fundamentals of Decision Making and Priority Theory. 2nd ed. Pittsburgh, PA: RWS Publications, p.11.
[32] Saaty, T. L. (2002). Decision-making with the AHP: Why is the principal eigenvector necessary. European Journal of Operational Research, 145: 85–91.
[33] Shamsaie, A., 2002. Hydraulic flow of water in porous areas, 2nd vol. of groundwater engineering, Amir Kabir University Press (Tehran Polytechnic). 2nd edition. 559.
[34] Soltani, M. J., 20002. GIS application in locating areas of flood spreading, Geographical Research, Iran, 17 (4): 22-38.
[35] Vahabi, J., 2009. Principles, criteria, goals, and research needs of flood spreading, the first workshop on research management and operation of the flood. Research Center of Soil Conservation and Watershed Management, 78.
[36] Wissema, J.G., 1982. Trends in technology forecasting. R & D Management, 12(1), pp. 27-36.
[37] Zehtabian, Q.R., Alavipanah, S.K. and Hamedpanah, R., 2001. Determining the appropriate areas for flood spreading using GIS and satellite images in Toqrood watershed of Qom province, Iran, international symposium of mapping, Seoul. Korea. 1-6.