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Identification of suitable areas for artificial groundwater recharge using integrated ANP and pair wise comparison methods in GIS environment, (case study: Garbaygan Plain of Fasa)

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Extended abstract

1- Introduction

Groundwater is the single water resource in many regions of Iran. This is considered to be a major historical limitation in the social and economical development of the country. Recent studies on the management of water resources in Iran have shown that out of the 430 billion m3 of the annual precipitation in the country, 20% is lost during sudden floods which flow into the playas, lakes and seas (Foltz, 2002; Mohammadnia and Kowsar, 2003). The climate of the country is mainly classified as arid and semi-arid.

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In addition to the small amount and unbalanced distribution of precipitation (both spatially and temporally), high intensity rainfalls which result in destructive floods bring about serious damages to downstream towns, roads, and agriculture, and sometimes even cause casualties (Hayati and Karimi, 2005). Flood spreading on aquifers, thereby artificially recharging of the aquifers, is an efficient strategy for controlling floods and managing water shortage and water resources (ASCE, 2001).

Selecting optimal sites for flood spreading involves integrating several complicated parameters, which necessitates the use of GIS (geographic information systems) in combination with MCDM (multi criteria decision making).

The groundwater-based agricultural activities in the Garabaygan Plain and the location of the region in the arid zone of Iran have highlighted the significance of water in this area. Considering these conditions, the present study aims to prevent the wasting of water in the region by determining suitable flood spreading sites and using the floodwater optimally. To this purpose, using the ANP and Pair wise comparison methods in combination with GIS, the suitable flood spreading areas were located.

2- Methodology

The Garabaygan Plain (28° 30' to 28° 45' N and 53° 45' to 54° 01' E) is located in the south part of Fars province of Iran (Fig. 2).The mean elevation of the area is 1476 meters above mean sea level. According to the De Martonne climate classification, the area represents a dry climate type with the average annual rainfall of 259 mm, the average annual potential evaporation rate of 2934 mm, and the average annual temperature of 20.6 C. Garabaygan is an area located in the folded Zagros Mountains stretching like a folded belt from the northeast to the southwest of the country.

2-1- Pair wise comparison

In the present research the Pair wise comparison was used to determine the weights of the sub-criteria. The Pair wise comparison was first proposed by the renowned mathematician Thomas L. Saaty (1980) as an appropriate decision-making approach to handle complex problems with numerous factors involved. This process is used to assess the intangible qualitative criteria and the objective quantitative criteria (Ghodsipour, 2005). To assign weight, a pair wise comparison matrix is formed to make a pair wise comparison between the classes of any criterion. In the pair wise comparison, each of the classes was assigned a weight ranging from 1 to 9. For this, the local conditions of the region, the relevant literature and the specialist expertise were considered and finally the relative weight of each class was determined using the Eigen Vector method in the environment of the Expert Choice software. Tables of 2 and 3 presents the pair wise comparison matrix along with the weights of the sub-criteria extracted via the software.

2-2- Analytic Network processes (ANP)

In this study, ANP method was employed to determine criteria weights. ANP is one of the most recent MCDM techniques which have been proposed by Saaty (2001). In fact, ANP can be considered as a more recent extension of AHP for decision making with dependence and feedback that can handle a more complex decision structure (Saaty, 2001) such as food spreading siting which is a complex network of various factors. AHP is limited to relatively static and unidirectional interactions with little feedback among decision components and alternatives (Sarkis, 2002). ANP consists of three parts: the first part is the control hierarchy for the network of the criteria and sub-criteria; the second part is a network of influences among the elements and clusters; and the third is the feedback between the various clusters and elements within a cluster (khan and Faisal, 2008).

For the case under study, four groups of connoisseur experts, namely environmentalists, hydrologists, geologists and GIS specialists contributed to establish the ANP based network model with the support of Super Decisions software. To calculate criteria weights by the use of ANP method, some questionnaires consisting of pair wise questions for the comparison analysis were designed. The experts participating in the survey completed the questionnaires. Then, through Super Decision software, criteria weights were calculated using information derived out of the questionnaires.

3- Discussion

The overall process of the flood spreading site selection has been schematically presented in Fig. 1. The

collected data related to the eight parameters (slope, water quality, geology, alluvium thickness, land use,

transmissivity, geomorphology, and the drainage density) was analyzed in the present work. Having collected the information layers according to the flowchart, Pair wise comparison and ANP were used to determine the weights of the criteria and sub-criteria respectively.

After obtaining the normal weights of all eight thematic layers and the features of individual thematic layers, all the thematic layers were integrated with one another in order to demarcate artificial recharge zones in the study area. The Final map was classified in five equally scored classes from the least suitable to the most suitable areas. The final land suitability map is presented in Fig.9.

The results of the study show that the majority of the areas considered most suitable and suitable for flood spreading are located in alluvial and pediment geomorphological units, and quaternary Qg , Qb and Qgsc geological units.This can be due to the location of the units on the margins of the streams and on the low slopes, the formation of these units from lime, silt, sand and gravel, and the good permeability of the units.

4- Conclusion

Soil erosion and the flood-proneness of Iran have followed growing trends in recent decades. Planning to use floods not only can reduce their destructive effects but also provides new water resources for various uses. Flood spreading is one of the methods which set the ground for efficient utilization of floods. In this study, the integrated MCDM-GIS approach was used in order to determine the suitable areas for flood spreading and artificial recharge of aquifers. To this purpose, the most important and effective factors in selecting suitable flood spreading areas were employed.

The results of the study indicated the efficiency of the MCDM in flood spreading site selection and the effectiveness of ANP in the rapid assessment of large areas. The present work proposes a method for flood spreading site selection and can help policy and decision-makers to approach water management issues with a deeper understanding of environmental factors.

Key words: ANP, Flood Spreading, Garbaygan, GIS, Pair-wise Comparison, Water Resource Management.

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