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Delineation of Groundwater Recharge Sites Using GIS Case Study: Sefied dasht

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ABSTRACT

The water crisis is harmful effects on human life. Also one of the most problems in the human society is water resources management. In this study, site selection of most suitable areas for artificial recharge using Boolean model. Criteria used to select the most suitable area for artificial recharge included: infiltration, slope, aquifer thickness, aquifer quality. The layers were produced and classified in the GIS environment. The results showed that the most suitable areas for artificial recharge using Boolean model are 7.7 percent. Land use impacted on the removal of restrictions of artificial recharge areas too. It can be said that suitable areas for artificial recharge in Boolean logic using land use filtering are 1.42% of plain.

Keywords: Boolean model, Artificial Recharge, Combining Layers, Sefieddasht Plain.

INTRODUCTION

Artificial recharge is one idea that has emerged over the past 20 years as a major water management tool for meeting water supply challenges (Eden et al., 2009). In an effort to maintain the water table condition in balance, artificial recharge shemes are being implemented in various parts of the world (Das, 2003). Artificial recharge of groundwater is achieved by putting surface water in basins, furrows, ditches, or other facilities where it infiltrates into the soil and moves downward to recharge aquifers (Bouwer, 2002). The basic requirements for recharging the ground water reservoir are: Availability of non-committed surplus monsoon run off in space and time & Identification of suitable hydrogeological environment and sites for creating sub- surface reservoir through cost effective artificial recharge techniques. The selection of sites for artificial recharge is a very important task in recharge studies (Das, 2003) and since there are many Parameters that have to be considered when determining a particular site artificial recharge (Saravi et al., 2006) Thus, it needs to be done with great care. Traditional methods of site selections are, however, time consuming and error prone (Alesheikh et al., 2008). With the advent of powerful personal computers and the advances in space technology, efficient techniques for land and water management have evolved of which RS (remote sensing) and GIS (geographic information system) are of great significance. These techniques have fundamentally changed our thoughts and ways to manage natural resources in general and water resources in particular (Jha et al., 2007).Many studies have been used GIS for locating most suitable sites for artificial recharge. As Nirmala et al (2011) used GIS to studying artificial recharge of groundwater in Sathyamangalam and Melur villages, Chennai (Nirmala et al., 2011). Kumar & Kumar (2011) and Ravi Shankar & Mohan (2005) used GIS for identification of site-specific artificial- recharge techniques in deferent parts of India. Saravi et al (2006) applied Boolean Logic among GIS techniques to determine most suitable areas for artificial groundwater recharge in a coastal aquifer in Gavbandi Drainage Basin. Sefiddasht plain have located in west of Iran country. Unfortunately, the groundwater condition in this plain is critical and its balance is negative. So, artificial recharge of groundwater will be helpful to control floods and also to rising water table in this plain. Hence this study was performed with the purpose of locating most suitable sites for artificial recharge in Sefid dasht plain using Boolean logic.

Materials and methods

Study area

Sefiddasht plain has been located in Chaharmahal va Bakhtiyari province in Iran. Coordinates of Sefid dasht plain (center of plain) in UTM coordinate system are X=513205 and Y=3562547. Its altitude is 2150m from sea level. Area of this plain is 201km2. Due to irregular use of groundwater resources in Sefid dasht plain, this plain is now barred. Figure1 show Study area and its position in Iran country.

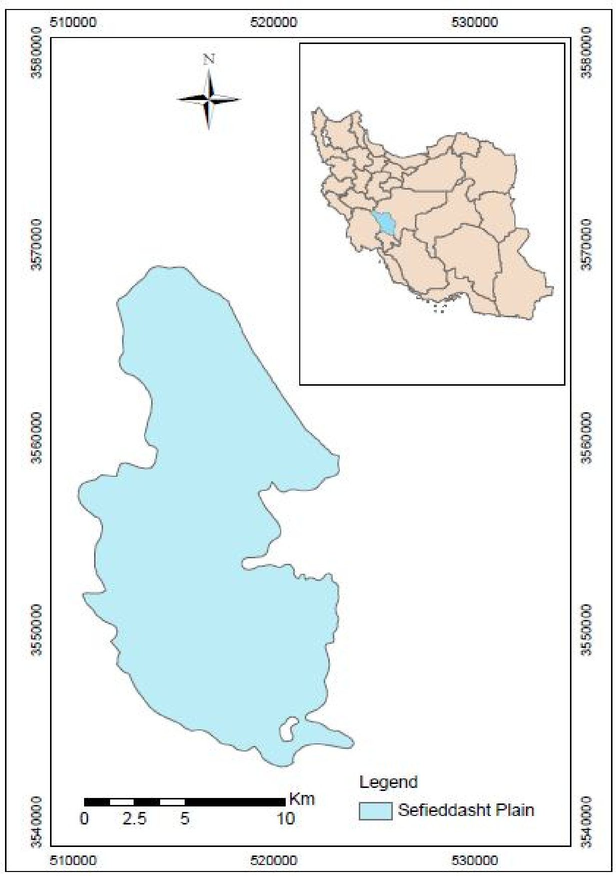

Figure1. Study area and its position in Iran country

Tematic layers

Among effective factors in locating suitable areas for artificial recharge slop, alluvial thickness, infiltration rate, Electrical Conductivity (EC) and Landuse factors were selected and examined (ASCE Standard, 2001). Among these, slop, alluvial thickness, infiltration rate, Electrical Conductivity (EC) factors were used as principle factors and land use were used as a filter. So maps based on these factors were prepared using GIS software and then Boolean Logic was used to overlay these layers.

Boolean Logic Model

The model involves logical combinations of binary maps through conditional operators, with each input map (evidence) constituting a layer (Bonham, 1996).Layers weighting in Boolean model is based on zero and one. The various layers of evidence are combined to support a hypothesis, or proposition. Only one or zero Values are assigned to each unit area, specifying whether it is satisfactory or unsatisfactory, respectively (Ghayoumian et al., 2007). The three most commonly used Boolean operators are AND, OR, and NOT. According to set theory, AND extracts commons and OR deals with subsets. In Boolean logic, an AND operator between two information layers indicates the areas that contain both conditions. An OR operator finds places that contain either of the conditions. A NOT operator negates the conditions (Brown, 2003). The AND Boolean operator is considered in this study. The thematic layers were analyzed based on Boolean logic, in table 1.

Table (1): Acceptable ranges of thematic layers in Boolean logic

Basic maps	Acceptable ranges
Slope (%)	0-4
alluvial thickness (m)	More than 20
Infiltration rate (mm/h)	More than 25
Electricity Conductivity (µmhos/cm)	Less than 1000

RESULTS AND DISCUSSION

Nowadays a lot of researches have been carried out about using Geostatistical methods in different issues related to water and soil sciences (Fiorucci et al., 2001; Goovaerts, 2000). Considering of studies of most researchers show that Ordinary Kriging Geostatistical methods have an acceptable precision (Barcae, 2008), this method have been used to preparing Alluvial thickness and Alluvial quality maps in this research. The condition to use kriging method is normality of data. With exploring two methods, data histogram and QQPLOT, was determined that data don't follow a normal distribution. So, the data was transferred to the logarithmic data. Through this, data obey the normal distribution. Histogram and QQPLOT diagrams of thickness and salinity logarithmic data have been shown in figures 2, 3, 4 and 5, respectively.

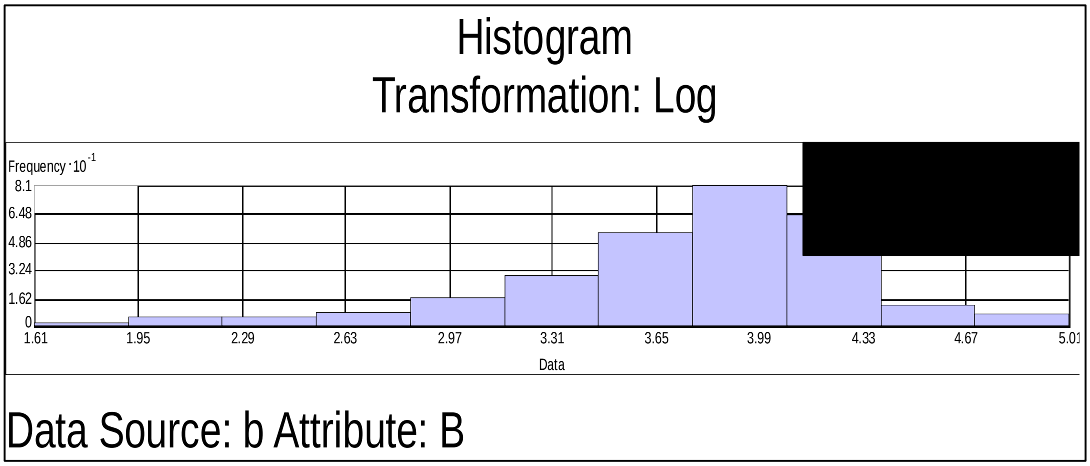

Figure2. Histogram of alluvial thickness logarithmic

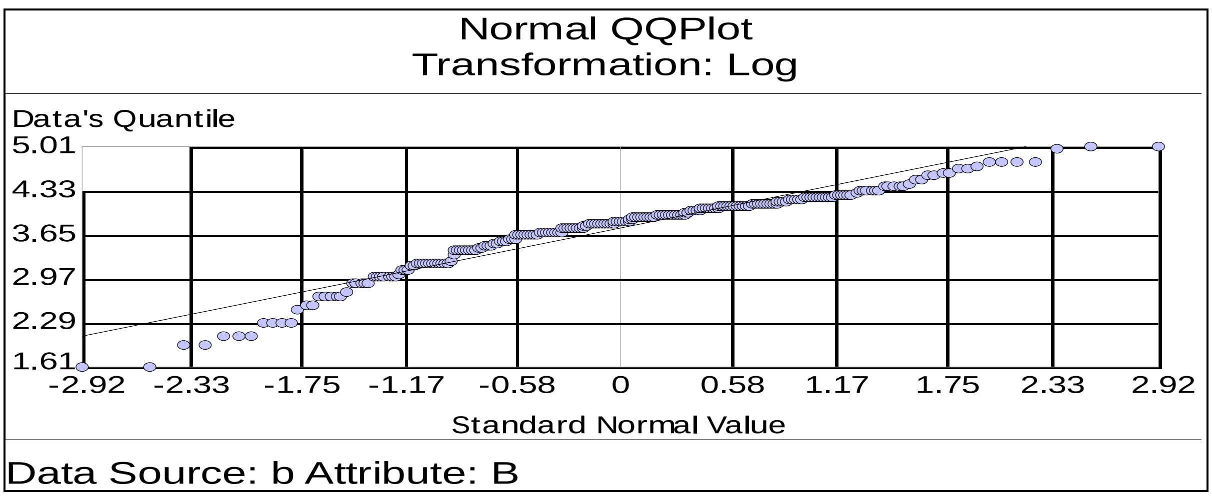

Figure3. QQPLOT of alluvial thickness logarithmic

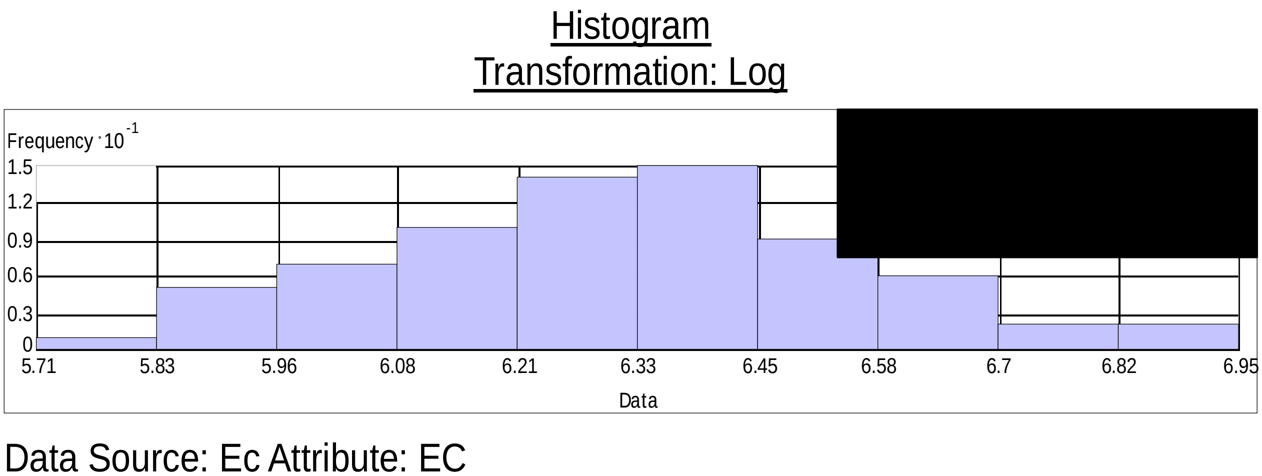

Figure4. Histogram of EC logarithmic

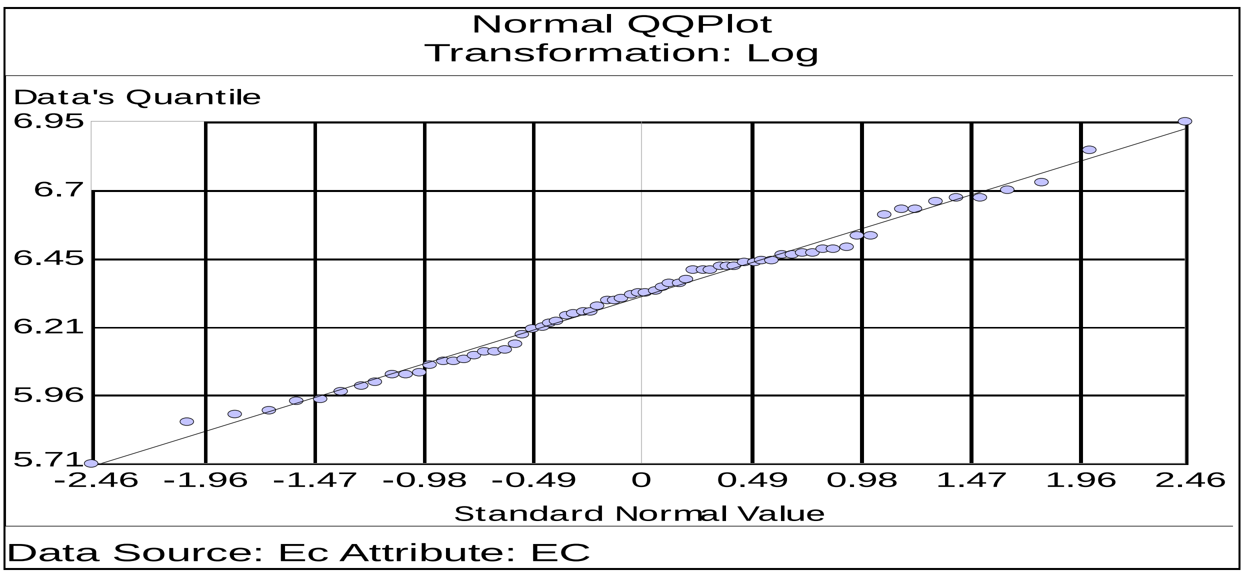

Figure5. QQPLOT of EC logarithmic

As Histogram of logarithmic data in Figure2 shows, Mean and Median of Alluvial thickness data are very close (Median-3.87 and Mean-3.75). Also mean and median of salinity data is 6.32 and 6.31 respectively. Therefore, according to low difference between median and mean (Moradi et al., 2011) data have been changed to normal distribution by converting to logarithm and thereby the condition of normality for distribution of data to use the geo statistical methods was provided. Using Boolean logic model to overlay thematic layers, maps of most suitable areas for artificial recharge was developed (Figure 6).

Figure (6): Suitable Areas for Artifitial Recharge in Sefieddasht plain based on Boolean model

Also table (2) shows suitable and unsuitable areas of artificial recharge in sefiddasht plain based on Boolean logic model. It can be observed that suitable areas for artificial recharge in Boolean logic are 7.7% of plain (Table 2).

Table (2): areas of suitable and unsuitable sites for artificial recharge based on Boolean logic

Value	Area(km2)	Area (%)
Unsuitable	185.52	92.3
Suitable	15.47	7.7

According to deferent types of land-use, only rangelands are appropriate for artificial recharge. Therefore, rangelands and non-rangelands regions are distinguished on the land-use map and coded as one and zero, respectively. This classification is applied to the map of suitable areas for artificial recharge, as a filter. Table (3) shows suitable and unsuitable areas of artificial recharge using land use filtering.

Table (3): areas of suitable and unsuitable sites for artificial recharge based on Boolean logic using land use filtering

VALUE	Area(km2)	Area (%)
Unsuitable	198.14	98.58
Suitable	2.85	1.42

Comparing of suitable areas and unsuitable sites for artificial recharge based on Boolean logic using land use filtering table (2) with table (3) can be said that using land use map as a filter, suitable areas for artificial recharge have decreased. Based on table (10), only 1.42 percent of plain is suitable areas for artificial recharge in Boolean model using land use filtering.

Conclusion

Water consumption was estimated 2200 m3 per person in 1990 in Iran, while it is predicted that in 2025 there will be 726 to 860 m3 (Alesheikh et al., 2008). Due to negative balance of ground water in Sefiddasht plain, artificial recharge in this plain will be very helpful to increase water table in this region. One factor that is very important to successful recharge of ground water is determining most suitable areas for artificial recharge. So this research has been carried out to determine the most suitable areas for artificial recharge of groundwater in Sefid dasht plain. Hence slop, infiltration rate, electrical conductivity (EC), alluvial thickness and land use factors used as thematic layers. To overlay these thematic layers Boolean model was used. Results showed that based on Boolean model 1.42% of this region is suitable for artificial recharge. Considering that only range lands are suitable for artificial recharge, so land use map used as a filter to produced maps and ultimate maps have been produced. It can be said that suitable areas after using land use filter have decreased.

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