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Locating Suitable Areas for Rain Water Harvesting

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ABSTRACT

More than 75 percent of Iran is located in arid and semi-arid and faces many hydrological constraints that often are attributed to the lack of rainfall and rainfall distribution. This issue is locating suitable areas for rain water harvesting in Birjand plain however it is more importance in poor farming communities that are dependent on rain-fed cultivation. To determine the areas those are prone to runoff collection used from a Decision Support System (DSS) and Geographic Information System (GIS) to identify a logical process in relation to harvesting the rainfall and within this system utilization from Model Builder in Arc GIS 9.3 software. The process defined in this paper uses from runoff capacity for decision and some information such as runoff potential map, distances from residential areas map, irrigated cultivation map and rain-fed cultivation map is inputting in the system. With combination of these maps makes the rain water harvesting prone areas map. The result shows that more than 40 present is in medium class and 32 present is in good class.

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Introduction

Extensive exploiting of natural resources such as land, water and forests causing serious hazards and it is important for the local population in the arid and semi-arid region. These hazards makes problems including decrease in soil moisture, high rates of soil erosion, decline of groundwater levels and shortage of drinking water [6]. Arid countries faced by many constraints hydrological and this issue are consider able in poor farming communities that are dependent on rain-fed cultivation. In arid and semi-arid region rainfall patterns are not expect in terms of time and amount [7,12]. In appropriate temporal and spatial distribution of the rainfall and recurring events such problem season hydrological constraints in these areas makes the consequences of poverty in term of available water in the soil during the growing season, decrease in products yield potential and finally lead to fail products [10]. Due to ground water resource constraints, brack is hand decline in ground water level we encourage to utilization of surface water in arid and semi-arid area especially. Surface water is a potential of water resource that result of rainfall and runoff in a watershed then if properly managed can be help to meet the demand. Rainwater harvesting (RWH) is the perfect option for exclusivity and store surface run off for future usage especially during periods that have limited access to water [13]. RWH is focus to all methods that are used to collect and store runoff from rainfall.

This method can harvest runoff from the roof of houses, land and streams (both in urban and in the rural area) and then were store in hydraulic structures or in the soil profile. The water collected can improve soil moisture storage and improve groundwater aquifers and finally help to supply of domestic, agriculture, industry uses [10, 11]. Also must be considered that RWH have an impact in reducing and preventing flood damage.

It should be noted that in vast areas before addressing the choice of RWH technologies should be looking places in terms of hydrological, biophysical and socio-economic potential for these. For this purpose a decision support system (DSS) based

on GIS is providing and trying to consider the physical factors, hydrological and socio-economic risk that involved in selecting RWH structures and relying on it facility time and cost.

DSS is a management tool that helps developers in deciding strategies [8]. Jurjakakus and colleagues (2002) can be defined DSS as "An computer appropriate based graphics that with mathematical optimization and simulation models can be mixed and sometimes rules and language algorithms of basic quality are added to it and the purpose is routed to the questions and issues that are pertinent to the specific subject in particular places. In DSS, GIS as a perfect tool for storing, analyzing and managing spatial information is useful and reason able tool for decision making in choosing appropriate places to provide RWH. GIS techniques are very useful for these studies in storing, analyzing and displaying spatial data that described by the user. Gupta (1997) and John Esten and Stubby (1990) to predict runoff and the description of the drainage basin were used from GRASS GIS. Humborg and Tauer (1992) used from RS and GIS data for determine locations of RWH. White (1998) in Pennsylvania can be used from SCS model to estimate potential runoff with GIS and data including oil, land use and vegetation. Vinar (2007) suggested that the biophysical criteria are useful in choosing appropriate places RWH and these criteria included suitability of soil, slope and land use. Mwenge Kahinda et al. (2009) in South Africa used a GIS-based decision support system that deals to evaluate the RWH adoption of this measure in catchment scale. Hekmat Pour et al. (2005) Using decision support systems and GIS capabilities to locate suitable areas of artificial recharge in Varamin plain. Naseri et al. (2009) integrating multi-criteria decision systems and GIS to identify suitable locations to spreading artificial feeding. Habib Abadi et al. (2010) using GIS were locate drain water harvesting areas in Tehran province.

In this research located suitable areas to rain water harvesting based on production capacity in the region and social and economic factors are considered in this process. The most basic information that is needed to implement includes a map of

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Potential runoff in the watershed that it is the main factor and distance from residential areas and agriculture maps reflected the social and economic dimension. In order to achieve runoff potential map using hydrological models and GIS application are important.

Materials and methods

Case study

Birjand plain in South Khorasan province of Iran is very important as agriculture, industry, military and urbanization. The plain is located in the northern part of the highlands bagheran with coordinate of 32°34' until 33°8' North latitude and 58°41' until 59°44' East longitude and study area have 3435 square kilometers that 980 square kilometers is formed by plains and other is highlands. Maximum basin elevation from sea level is 2720 meters in Bagheran and minimum is 1180 meters at the output of plain. Birjand plains with average annual rainfall of 140 mm and an average temperature of 16.5°C locate in arid area.

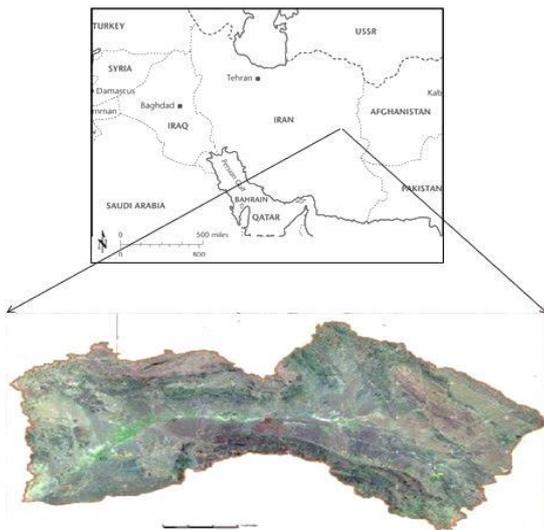


Fig 1. Map of study area

Methodology

In order to determine the capacity of runoff has been used the following data. Topographic map of 1:25000 scale, slope map of the area based on digital elevation model with a resolution of 100m, land use map were attained according to satellite images and field visits. Soil texture map has been prepared according to experts and sampling the soil. Hydrologic soil group map is obtained based on soil condition and slope of the area. Rainfall map created based on an average of 20 years.

To determine locations potential is defined a decision support system to rain water harvesting in Arc GIS 9.3 software. Input data including rainfall, soil texture, soil samples, and the ground points that have length, width and height and used from the satellite image and topographic maps. The data collected will be entered into GIS. Preprocessing step is for providing runoff potential maps that using some data and maps from residential areas and agriculture. For this purpose is made with help of topographic maps, digital elevation model and slope map of the area. With the combination of slope and soil texture maps, soil hydrological group map achieved the status of soil classification of infiltration capacity.

Field visits and satellite imagery to assist us in providing the land use map. Combine this map with the map of soil hydrological groups and tables SCS, produce runoff curve number map. Runoff curve number (CN) is important in the calculation of the characteristics of the runoff. Rainfall precipitation data can be used for map and it can be used in the final calculations.

Results and Discussion

Researcher shows that Land Use is within eight classes and they are rivers, woodlands and shrubbery, rocky, forests and irrigated agriculture, dry land farming, rangeland, residential areas (Fig 2).

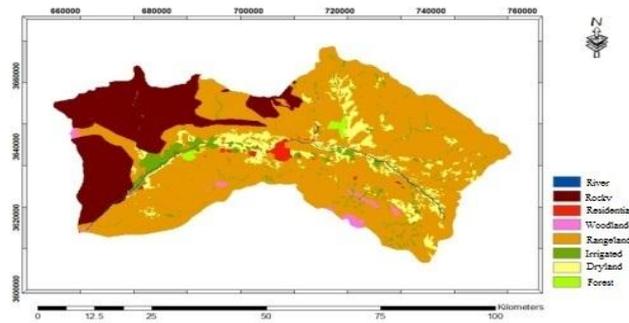


Fig 2. Land Use map of area

Combine of this map with the map of soil hydrological groups (Fig 3) and use of SCS table can generate runoff curve number map (Fig 4).

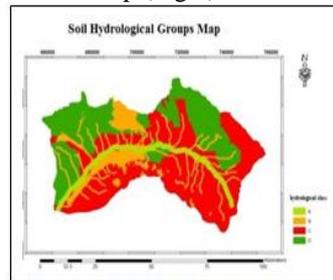


Fig 3. Soilhydrologicalgroupsmap of area

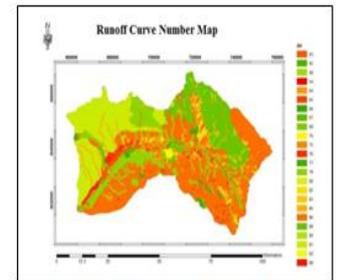


Fig 4. Runoffcurvenumbermap of area

Then with use of long time data in region and with some laboratory research we can make soil map (Fig 5) and finally we make slope map (Fig 6) in this area.

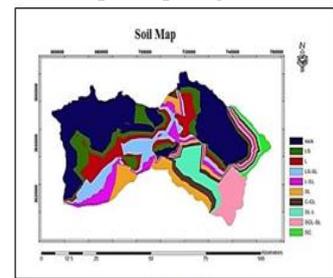


Fig 5. Soilmap of area

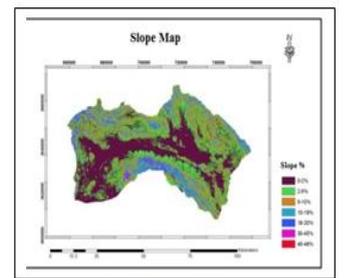


Fig 6. Slope map of area

Finally, with combine of rainfall map and runoff curve number map and base on hydrological relationships that defined in this field could make classification the region in terms of runoff map. This classification is based on three classes that are expressed in 13-30 mm, 30-100 mm and 100-172 mm in this region.

As mentioned above, in order to contribute to socio-economic conditions in deciding used from distance of the residential area and agriculture which to be collected in terms of distance maps and GIS capabilities. These maps are operating based on that in residential areas do not allow aquifer projects. Also at distances more than 5km from the project is recommended less than other distances. Views of agricultural if being closes the site of project will economic because with stored of moisture in residual improve soil moisture conditions in these areas. After the above steps is begins the most important component of DSS. This step does with using of Model Builder program. After the initial maps of this study in Raster are classified base on class which are effective in decision making.

The basic operation that is performed in this phase is WOP¹ (Tab 1).

Tab 1. Weight of each layer

Factors	Runoff Potential	Distance from residential areas	Distance from rain fed lands	Distance from irrigated lands
Weight	39%	22%	19%	20%

Following maps that shows are making in preprocessing steps and the final result of these had classified and have become in raster formats. After weighting the data layers that used in the Model Builder and WOP, the final map is obtained.

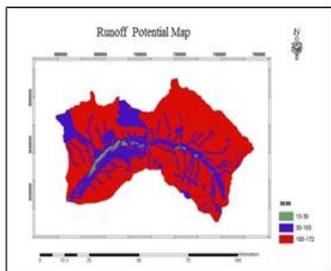


Fig 7. Classification map of runoff potential

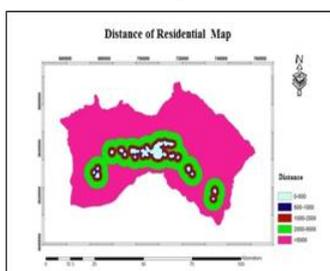


Fig 8. Classification map of residential distance

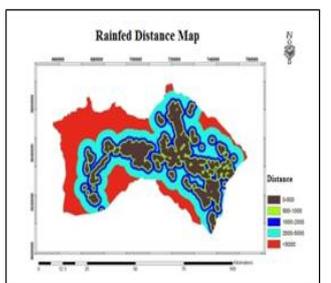


Fig 9. Classification map of rainfed distance

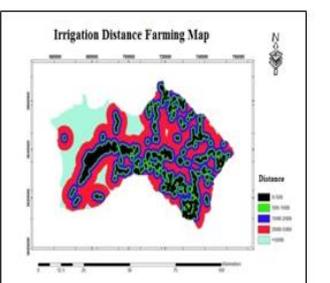


Fig 10. Classification map of irrigation distance farming

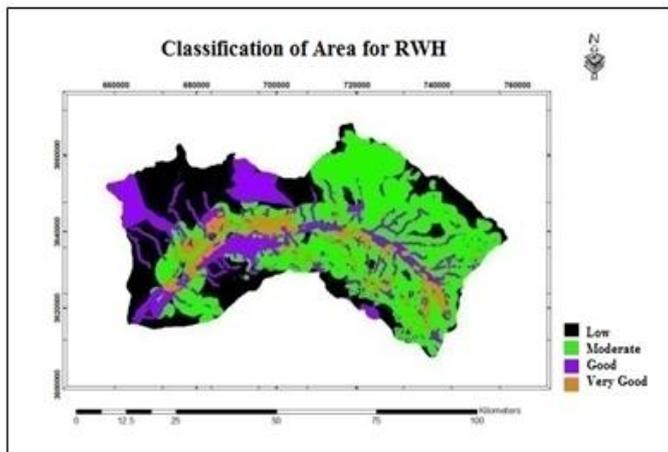


Fig 11. Classification of area for RWH

Conclusion

Because water resources and ground water is Limited and then we are forced to use from RWH to help in this issue. Mainly, in the Northwest and West regions, as well as a small area in the North and South due to poor soil and high slope although is made a large proportion of runoff but is not suitable for RWH and finally this part is in low potential that is 28.38 present of this case study. Areas with are in moderate class can be seen in the central and eastern of the area and have 43.9 present of this region. In this case shows good and very good class in the central of plains which has a less slope and has more

suitable from the soil. In this classification drain age paths and places of them is suitable for implementation of the plan.

Finally must mention that the use of GIS and DSS area new approach for locating of suitable areas in terms of planning these systems.

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¹Weighted Overlay Process

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