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Using modern methods to determine the suitable area for rain harvesting

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ABSTRACT

In addition to the efficient use of our water resources, it is important to ensure the recycling of the water we use in order not to deplete our fresh water resources, which are decreasing today, and to leave healthy and sufficient water to future generations. The purpose of using the rainwater harvesting system is to create a reliable, low-cost, practical water obtaining system in areas where there is no water and cannot meet the desired needs. Rain harvest; It enables groundwater to be fed, increases our living standards, increases agricultural production, benefits the creatures living in nature, prevents climatic changes, floods, water pollution, and enables us to obtain drinking water. The aim of this study is to determine the area suitable for rain harvesting for the agricultural lands of Karahacılı Village in Yenişehir district of Mersin province. Specific criteria will be selected in the study to evaluate potential RWH sites. In addition, suitable and unsuitable areas will be identified and criteria will be determined for this. Both biophysical and socio-economic criteria must be considered to ensure the success of RWH techniques and to facilitate the adoption of new RWH technology by local farmers. Choosing appropriate socio-economic parameters is critical to achieve desired results.

1. INTRODUCTION

Water is the most important and basic life source of all living organisms living in the ecological system on earth. Throughout history, the birth and development regions of many civilizations have been on the waterfront. Proximity to water resources has maintained its importance from past to present and has had a direct impact on the development of societies (Aghaloo and Chiu 2020; Teston et al. 2018; Agarwal et al. 2001). Especially the ancient Egyptian civilization established around the Nile River actively used this water resource and this river has been the basis for many scientific studies. In addition, it has also contributed to the formation of activities that directly affect human life and social order (determination of the flood time, development and protection of private property, etc.). The rough and unconscious use of water harms the country's natural resources (Alwan et al. 2020; Teston et al. 2018; Akaydın Sel 2017; Al-shabeeb 2016). Due to the unconscious use of water in thousands of decares of land in the world, agriculture has become impossible and yield losses have occurred (Bashar et al. 2018; Teston et al. 2018 Campisano et al. 2017). The advantages of the rain harvesting method are that it is simple and economical, and the water transmission losses are low. In the water harvesting method, water collection areas are roofs, courtyards, streets and squares, small soil surfaces, sloping areas and large basins that feed seasonal flows (Salameh 2018). The water storage medium is divided into underground storage and storage on the soil surface (Guillaume et al. 2017; Guyassa et al. 2017; Ekinci 2015). While soil, sediment and cisterns are used for underground storage, tanks, reservoirs and pools are used as storage media on the soil surface. The rain harvesting system is limited and prone to little rainfall. Therefore, limited precipitation is among the main limiting factors of the method (Can and Yilmaz 2019; Datta 2015; Gould et al. 2014).

The aim of this study is to determine the area suitable for rain harvesting for the agricultural lands of Karahacılı Village in Yenişehir district of Mersin province. In the study, certain criteria will be selected to evaluate potential RWH sites (these are precipitation, temperature, land use, slope, aspect, soil type, soil depth and drainage density). In addition, suitable and unsuitable areas will be identified for this (agricultural

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areas, Distances to roads, urban areas, faults and drainage networks) criteria will be set. Both biophysical and socio-economic criteria need to be considered to ensure the success of RWH techniques and to facilitate the adoption of new RWH technology by local farmers. Choosing appropriate socio-economic parameters is critical to achieve desired results (Toosi et al. 2020; Velasco-Muñoz et al. 2019; Lani et al. 2018; Vema et al. 2018; Tamaddun 2018). RWH structures cannot be applied in drainage networks for environmental, technical and financial reasons. The acceptable distance from the roads should be considered to avoid any possibility of future conflict between the road development and the constructed structures. It is very important to exclude urban areas from being selected as RWH sites for safety reasons (eg conflicting with floods and land uses). In addition, agricultural land (cultivated areas) are both economically and environmentally valuable resources and should be excluded simply because they cannot be disturbed by water collection systems, but proximity to rainwater harvesting systems can be an advantage if appropriate safety measures are maintained.

2. METHOD

In this study, biophysical factors of rainfall, land use, slope, aspect, soil type, soil depth and drainage intensity were selected to assess potential RWH sites (Hajjar et al. 2020; Hafizi et al. 2018; Hassani et al. 2016). In addition, six socio-economic factors were used to identify unsuitable areas, including distances to farmland, roads, urban areas, wells, faults and drainage networks (Yeniçeri 2018; Yosef and Asmamaw 2015). The most common RWH systems that are widely used and shown to be successful will be considered. Selected socio-economic factors and common RWH systems will be conducted on the basis of similar studies. Next, optimum locations will be proposed for each type of RWH system based on the specific requirements of each system.

2.1. Data Collection and Pre-Processing

The sources of the main factors that will be used to determine suitable sites for RWH are shown in Table 1.

Table 1. Data and sources to be used in this study

Data name	Scale	Sources
Precipitation	Data (Excel File)	Meteorology
Drainage	5m	Spatial Data Infrastructure
Road map		Spatial Data Infrastructure (open street map)
Geology	1:250000	Ministry of Agriculture National Soil and research institute
Land Use		CORINE (2018)
Slope	5 m	DEM Data
Aspect	5 m	DEM Data (Soil map)

Raw data will come from various government agencies, a field study. Monthly precipitation data will be collected from the Meteorology unit. Annual average precipitation will be calculated for each station. Maps will be created in ArcGIS environment using 5m DEM data and 3D Analyst tool. Soil map and drainage density map of the study area will be created according to slope, aspect, rainfall, soil infiltration feature and arrow. In addition, thematic layers such as existing water areas will be prepared using ArcGIS software.

2.2. Analytical Hierarchy Process (AHP)

An Analytical Hierarchy Process (AHP) method will be used to generate the potential RWH map. AHP is a method used to analyze and organize complex decisions based on professional knowledge and practice. The relative importance of each criterion will be determined by consulting experts on the importance of selected criteria for Rain harvesting using a scale from 1 to 9.

2.2.1. Layer selection:

In this study, slope, aspect, land use / cover, soil type, precipitation criteria, soil depth and drainage density criteria will be used.

Precipitation

The most influential factor for the high RWH potential is precipitation. Average annual precipitation data is one of the prerequisites for large-scale RWH structures. More rainfall in an area results in higher RWH potential. Higher precipitation values indicate higher water volume and higher potential flow and consequently higher potential for local flow capture using RWH structures (Toosi et al. 2020; Hofman-Caris et al. 2019; Nguyen and Han 2017).

Slope

Surface runoff and seepage will be greatly affected by the topography of the basin. Slope has a direct impact on runoff formation and conversion from precipitation to runoff. As the slope increases, the RWH opportunity time decreases due to increasing flow rates. Ideally, the slope of a basin should be as gentle as possible for a high RWH potential. Often areas with slopes greater than 5% are subject to more erosion; Therefore, it is necessary to consider erosion control measures in areas where the basin has a steeper slope (Toosi et al. 2020; Krois and Schulte 2014).

Soil Type

One of the main criteria for RWH planning is soil. Naturally poorly drained clay soils produce higher amounts of runoff, while sandy soils generate less runoff (Toosi et al. 2020).

Soil Depth

Soil depth is considered to be representative of water storage capacity (i.e. deeper soils have more water storage capacity). Areas with shallow soils are potentially more suitable for RWH technologies than deep ones, as they have lower infiltration (higher flow coefficient) and produce more water (Toosi et al. 2020).

Land Use

The effect of different land use and vegetation on the amount and velocity of different runoff flowing downhill. Dense vegetation, forests and closed areas increase the amount of water infiltration and water withdrawal, while urban and pasture-covered areas increase the amount of runoff. Since the infiltration effect is already explained by soil type, a lower weight has been assigned to land use (Toosi et al. 2020).

Drainage Density

Dense drainage networks can play a crucial role in collecting rainwater. The concentration time is significantly related to the drainage density, such that areas with higher drainage density are more suitable for RWH as it provides a system through which the flow can flow and harvest immediately. Drainage density is considered the least important factor (Toosi et al. 2020).

2.2.2. Socio-Economic Criteria

Both biophysical and socio-economic criteria need to be considered to ensure the success of RWH techniques and to facilitate the adoption of new RWH technology by local farmers. Choosing appropriate socio-economic parameters is critical to achieve desired results. RWH structures cannot be applied in drainage networks for environmental, technical and financial reasons. The acceptable distance from the roads should be considered to avoid any possibility of future conflict between the road development and the constructed structures. It is very important to exclude urban areas from being selected as RWH sites for safety reasons (eg conflicting with floods and land uses). In addition, agricultural land (cultivated areas) are both economically and environmentally valuable resources and should be excluded simply because they cannot be disturbed by water collection systems, but proximity to rainwater harvesting systems can be an advantage if appropriate safety measures are maintained (Toosi et al. 2020).

3. CONCLUSION

Rainwater Harvesting (RWH) is becoming one of the most promising alternative freshwater resources that can potentially be captured and used, especially in arid and semi-arid regions. This study is the preliminary information of the system to be established and its analyzes are ongoing. Using the biophysical and socio-economic factors, the appropriate RWH areas will be determined with the GIS-based AHP method and additional methods and it will be determined whether the existing areas are suitable or not.

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