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A GIS-based Approach for Assessing Water Harvesting Suitability in a Badia Benchmark Watershed in Jordan

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Résumé
Dans les environnements les plus secs de l'Asie de l'ouest et de l'Afrique du nord (badia), la précipitation n'est pas suffisante pour la production de cultures, et la végétation naturelle a souvent été dégradée par surpâturage. Des techniques de collecte et de conservation des eaux de ruissellement peuvent améliorer la productivité d'eau. Pour développer une intégration réussite et fiable des techniques de conservation des eaux dans les systèmes agro-pastoraux existants, un bassin versant de référence a été établi dans la badia en Jordanie. Un système pour vérifier l'aptitude des différentes techniques de conservation des eaux au niveau du basin versant a été développé. Les critères physiques principaux pour l'aptitude de la collecte des eaux de ruissellement dans cet environnement étaient la pente, la profondeur du sol, la texture du sol, et le pourcentage de la surface couverte de pierres. Les critères ont été intégrés et une carte d'aptitude a été préparée dans un environnement SIG. Les investigations au champ ont révélé que l'approche appliquée est très promettant.

Introduction

In arid and semi-arid areas water harvesting techniques can be used to capture and efficiently utilize rainwater runoff to maintain productive and sustainable agro-pastoral systems. With water resources being depleted by growing populations and increasing development, water harvesting emerges as a crucial means for water management and conservation in the water-scarce environments of West Asia and North Africa. Successful performance of water-harvesting systems in the arid steppe (*badia*) of Jordan has been documented by Oweis and Taimeh (1996); Abu-Awwad and Shatanawi (1997); and Taimeh and Hattar (2001). However, the adoption of water harvesting techniques by the *badia* communities is still limited. The International Center for Agricultural Research in the Dry Areas (ICARDA) has established in cooperation with the agricultural research organizations in Jordan a Badia Benchmark Watershed to develop and test water-harvesting systems with the participation of rural communities.

The main objective of this study was to develop a methodology to assess in a systematic, practical, and informed manner the potential for water harvesting in watersheds in arid and semi-arid regions. The watershed was characterized to provide data for the selection of sites that are suitable for various water harvesting interventions. A suitability analysis, based on biophysical criteria, was carried out using GIS. The suitability analysis provided all potential interventions for each land unit; the socio-economic aspects were then incorporated to select the optimum intervention.

Materials and Methods

The benchmark watershed, named Muhareb, is located in the eastern part of Amman district in Jordan. It has an area of approximately 60 km^2. The area lies within the xeric-aridic transitional moisture regime where the annual rainfall ranges between 100 and 150 mm. The

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major land formation is very finely dissected limestone, chert and marl. The watershed has rounded hills and crests, with steep upper slopes. Alluvial and colluvial fans merge down slope to fill the valleys. Active wadis have gravelly channels. The watershed is characterized by steppe grassland vegetation, while barley is grown in the valley bottom alluvium where the moisture from the limited rainfall is augmented by run-off from the hillslopes. Land use mapping using on-screen digitizing of Landsat TM imagery showed that barley cultivation is practiced on 19% of the land, while about 81% of the area is not cultivated (Al-Bakri, 2004). The dominant natural species are *Anabasis* and *Poa*. The steppe grassland produces a tough *turf,* which protects the soil surface from wind and water erosion. The area is degraded due to over-grazing, which keeps vegetation growth close to the soil surface.

The suitability analysis consisted of the following three steps:

1. Determination of the biophysical requirements for each water-harvesting intervention.
2. Characterization of the biophysical conditions of each land unit, with respect to the requirements.
3. Matching the water-harvesting intervention requirements with the land conditions to identify areas suitable for water harvesting interventions.

The criteria that determine the requirements for various water harvesting techniques were taken from Oweis et al. (2001). The criteria were modified to include two priority classes (Ziadat et al., 2005). This will give more flexibility for determining suitable interventions, and at the same time leave some freedom for the final selection based on socio-economic factors. The main biophysical criteria for water harvesting suitability in this environment were slope, soil depth, soil texture, and stoniness.

The data required for the physical characterization of the watershed were derived partly from available data and partly from a field survey. Topographic information was provided by the Royal Jordanian Geographic Center. A Digital Elevation Model (DEM) with 20-m resolution was generated from the contour lines (20 meter interval) and the natural drainage system was extracted from topographic maps with a scale of 1:50,000.

Because of the absence of detailed soil data, a field survey was designed to provide information about the relevant biophysical factors in the watersheds. The sampling procedure was based on grid sampling. A uniform 500-m grid was used with one field observation taken from each grid. The total number of sampling sites was 138. Samples for texture analysis were taken at nine of the 138 sites, representing the dominant slope classes of the watershed. Observations available from the Ministry of Agriculture were added, resulting in a total of 160 observations. The following parameters were recorded for each field observation:

1. GPS coordinates: easting, northing
2. Surface cover of the land (stoniness percent)
3. Vegetation type and coverage (percent, for some sites)
4. Texture of the surface horizon, estimated by feeling
5. Soil depth, depth to limiting layer (cm).

The Arc/Info standard command (SLOPE) was used to derive a slope grid from the DEM. A 5x5 average (smoothing) filter was applied to clean the layer from small (suspicious) units. The grid was then converted to polygons to make it ready for subsequent analyses. Slope units derived from this step where used as a basic mapping units for the suitability analysis. Slope steepness is also an important criterion for the selection and implementation of water harvesting interventions. The Inverse Distance Weighted (IDW) interpolator of ArcView Spatial Analyst 3.2 was used to produce a continuous surface (grid file) of slope steepness, soil depth, and stone percentage. The soil texture of the whole watershed was silty clay loam or clay loam.

The interpolated grids (soil depth, stoniness and soil texture) were intersected with each others (using the INTERSECT command in ArcView 3.2) and with the slope unit map to produce new mapping units having a unique combination of all variables. The value of each variable in each slope unit was defined accordingly, providing a physical characterization of each slope unit. The previously mentioned criteria were subsequently applied for each mapping unit in the GIS environment using conditioned selection to satisfy the value of each criterion.

Results

The result of the data collection and GIS analysis is summarized in a table (linked to the map) with each mapping unit occupying one row and for each row there were 56 columns. The 56 columns represent the 16 different water harvesting interventions, including macro- and micro- catchment interventions, each with different crop types (trees, field crops and range crops), and with two priorities for each combination. In each column, the mapping units that are suitable for the intervention, based on the above mentioned criteria, were given the symbol (S1: Suitable), and the mapping units that are not suitable for the intervention were given the symbol (NS: Not Suitable). The table was further manipulated to produce a list of interventions that are potentially suitable for each mapping unit. Figure 1 shows these options for all mapping units within the watershed. The legend is explained in Table 1. This map represents a final output of the watershed characterization process.

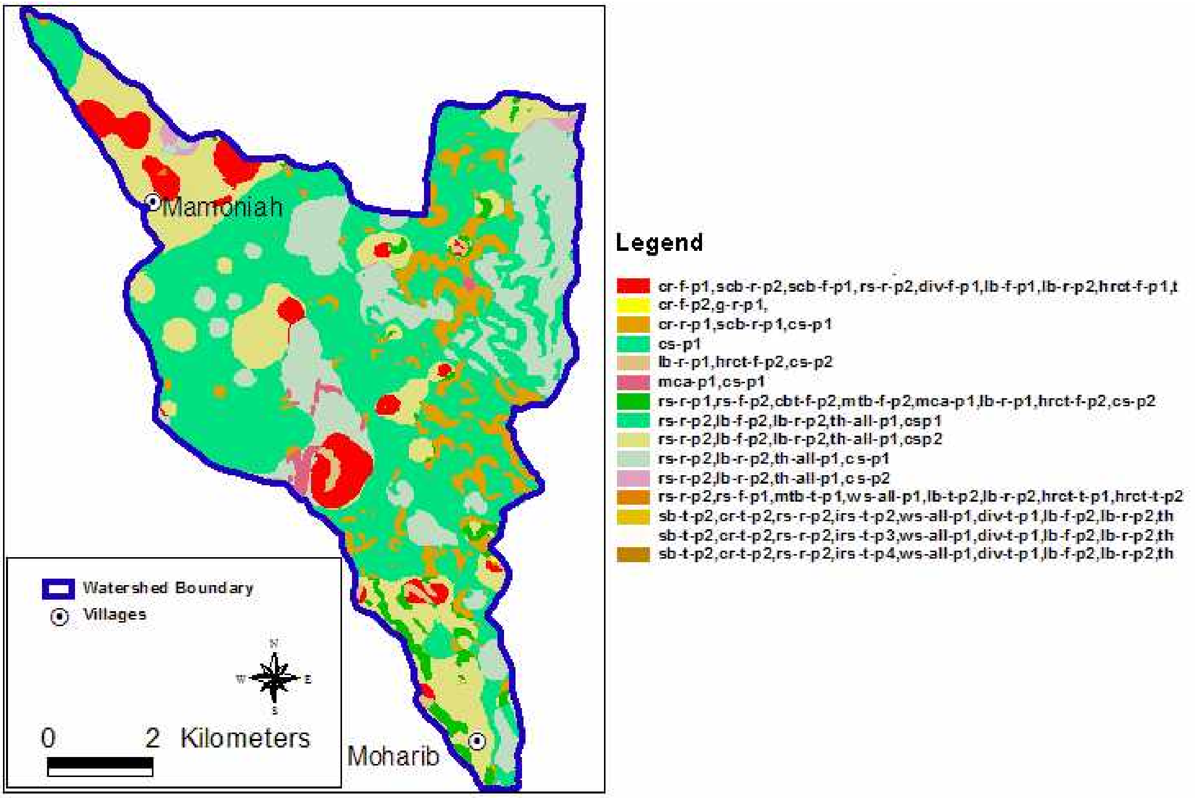

Figure 1. Potential water harvesting option(s) suitable for each mapping unit.

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Table 1. Index for water harvesting techniques.

Code	Water-harvesting technique	Code	Crop/priority
CR	Contour ridges	r	Range crops
SCB	Semi circular bund	F	Field crops
SB	Small basins	T	Trees
RS	Runoff strips	All	All crops
IRS	Inter row system	P1	First priority
CBT	Contour bench terraces	P2	Second priority
G	Gradoni		
MTB	Meskat trapezoidal bunds (cultivated area)		
MCA	Meskat catchment area		
WS	Water spreading		
J	Jessour		
DiDiv	Water spreading (diversion)		
LB	Large bunds		
HRCT	Hillside runoff systems (cultivated)		
Hcat	Catchment (hillside catchment)		
TH	Tanks & Hafirs		
CS	Cisterns		

Discussion and Conclusions

A system for identifying the potential suitability of the land for different types of water harvesting techniques at the watershed-level was developed. The approach matched water harvesting requirements with land physical conditions. GIS proved to be a powerful tool for water-harvesting site selection studies due to its excellent capabilities in storing, analyzing and displaying spatially distributed data. The applied methodology was effective for identifying appropriate water harvesting techniques, including micro-catchments, contour ridges, collection and storage of rainfall water in cisterns, pits and others.

The applied approach for assessing water harvesting suitability was found to be very promising when evaluated during field investigations. Water harvesting is site-specific and assessing the suitability of the land requires quantitative data and involves interaction between specific criteria. Therefore, the capacity of GIS to integrate different types of information facilitates and speeds up the process. Given that basic information is available, the approach could be applied for other suitability analyses for introducing water harvesting techniques in arid and semi-arid areas. GIS facilitated the integration of bio-physical and socio-economic aspects to undertake the selection process.

Literature Cited

Abu-Awwad, A.M. and M. R. Shatanawi. 1997. Water harvesting and infiltration in arid areas affected by surface crust: examples from Jordan. J. Arid Environ. 37(3): 443-452.

El-Bakri, J. 2004. Rapid environmental impact assessment. Badia Water Benchmark Site: Jordan. National Center for Agricultural Research and Technology Transfer, Jordan.

Oweis T., D. Prinz, and A. Hachum. 2001. Water harvesting: Indigenous knowledge for the future of the drier environments. ICARDA, Aleppo, Syria.

Oweis, T. and A. Taimeh. 1994. Evaluation of a small basin water-harvesting system in the arid region of Jordan. Water Resour. Manage., 10:21-34.

Taimeh, A.Y. and B.I. Hattar (ed.). 2001. Improvement of agricultural productivity in the arid and semi-arid zones of Jordan (JAZZP). A cooperative project between the Ministry of Agriculture and the European Union. Vol. 1. Main report. University of Jordan.

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Proceedings

Ziadat, F. et al. 2005. Badia Benchmark: Jordan. In: T. Oweis et al. (ed.) Water Benchmarks of CWANA. Site selection and characterization. ICARDA, Aleppo, Syria.