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GIS-BASED AHP-OWA APPROACH FOR LOCATING SUITA SITES FOR WATER HARVESTING DAM IN QASSIM REGI SAUDI ARABIA

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ع سدود حصاد المياه هو عملية اتخاذ قرار معقدة. حيث إن إيجاد الموقع الأفضل يتطلب دمج تقنية المعايير
نظم المعلومات الجغرافية. في هذا البحث تم استخدام نظم المعلومات الجغرافية بالاعتماد على تقنية -AHP
جاد أفضل مواقع لبناء السدود في منطقة القصيم في السعودية. تم اعتماد انحدار الحوض، استخدامات
نوع التربة، جيولوجية السطح، توزع الأمطار، المسافة إلى الطرق، والمسافة للمناطق المخدمة كمعايير لاتخاذ
رت النتائج أهمية هذه الطريقة في إيجاد أفضل مواقع لبناء سدود حصاد المياه، مع السماح لمتخذ القرار أن
عتبار سيناريوهات مختلفة بين المتفائلة والمتشائمة.

ABSTRACT

Selection of a water harvesting dam site involves a complex array of decision crit may have conflicting values. Finding the optimum location requires integratio capacities of Geographic Information Systems (GIS) and Multi-criteria Decision- (MCDM). In this paper, a GIS-based multi-criteria decision analysis approach is used this problem. The approach is based on the extension of Analytical Hierarchy Proce fuzzy quantifiers-guided Ordered Weighted Averaging operators (GIS-based AHI This approach is applied to determine the optimal site of a water harvest dam in region, Saudi Arabia. Several factors affect the selection of the best location of t water harvesting dam such as: slope, landuse, soil type, geology, rainfall, drainage distance from the road, and distance from the cities, are used. The results showed tha combination of GIS-based AHP–OWA is proper approach for optimal water harves selection, where this approach provides a generic powerful decision-making tool th decision-makers to define a decision strategy on a continuum between pessimist averse) and optimistic (risk-taking) strategies.

KEYWORDS: Water harvesting site selection, Geographic Information Sy

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(GIS), Analytical Hierarchy Process (AHP), Ordered Weigh Averaging (OWA).

1. INTRODUCTION

Increasing demand of water due to growing population, with the difficulty of exploi some cases, cause intense pressure on available water resources. So it becomes nec harvest rainfall as the primary source of water, maximizing storage and minimizing of rainwater. Rainwater harvesting techniques have received growing attention, espe arid and semi-arid regions like Saudi Arabia. Rainwater harvesting and conservati activity of direct collection of rain. The collected water could be stored for direc recharged into the groundwater. It is the best means to get water when other water so not available.

One of the most important and complex problems in different countries is the selectio water harvesting site. A large amount of information should be gathered, combi analyzed to develop correct criteria which will affect the final decision. The problem i combine the criterion maps according to the attribute values and decision maker's pre using a set of decision rules. Geographic Information Systems (GIS) and Multicriteria Making (MCDM) techniques are the most common tools employed to solve these probl each suffers from serious shortcomings. While GIS is a great tool for handling suitability analysis, but it has limited capabilities of incorporating the decision preferences into the problem solving process. On the other hand, MCDM is the proper analyzing decision problems and evaluating alternatives based on decision maker's va preferences. However, MCDM lacks the capability of handling spatial data (e.g., buffe overlay) that are crucial to spatial analysis. The need for combining the strengths techniques has prompted researchers to seek integration of GIS and MCDM.

A number of attempts had been implemented in the GIS environment over the last de identifying the most appropriate sites for Water Harvesting Structures (WHS). For exar site suitability for different water harvesting structures was determined by considering varying parameters like runoff potential, soil type, slope, drainage network and land u the overlay and decision tree concepts in GIS [1]. Runoff coefficient, land use, soi drainage and stream order, soil permeability were considered in site selection o harvesting/recharging structures in [2] using Overlay in Analysis tools of GIS Ma suitable of water harvest in Qassim region was done, through the overlay method of the soil, slope, rainfall, landuse, distance to roads, distance to cities criteria using raster c operation in GIS, adopting equal weight approach [3]. GIS and AHP was used for site s analysis of water harvesting Structures in Pisangan, different layers were taken into acc multi criteria evaluation are Soil texture, slope, rainfall data, land use/cover, geomor lithology, lineaments, drainage network [4]. In general, previous studies show the us overlapping, or GIS-based AHP for choosing suitable sites for a rain water harvest. B and OWA procedures have been employed individually in GIS environments, each limitations. AHP used the pairwise comparison to calculate the weight of criteria, but it g scenario, while OWA uses the fuzzy linguistic quantifier to gives several scenarios and rank method to evaluate the weight of criteria. Combining the strength of each method, OWA can provide a more powerful multicriteria decision-making tool for structu solving spatial decision problems. In this paper, an efficient decision-making framework site selection is developed by integrating the strengths of GIS-based AHP-OWA (the e of Analytical Hierarchy Process using fuzzy quantifiers-guided ordered weighted av This will allow decision-makers to define a decision strategy on a continuum pessimistic (risk-averse) and optimistic (risk-taking) strategies. By changing the l quantifiers, the GIS-based AHP–OWA approach provides a generic powerful decisior tool that allows decision-makers to generate a wide range of decision strategies.

2. PROPOSED GIS-BASED MULTICRITERIA EVALUATION FRAMEW FOR SOLVING HARVEST DAM SITE SELECTION PROBLEMS:

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GIS-based Multi criteria Evaluation (GIS-MCE) can be defined as a process that integ transforms geographic data (map criteria) and value judgments (decision maker's prefer obtain overall assessment of the decision alternatives.

Four procedural steps of the proposed framework will be followed. (1) Defining selection Criteria, (2) Preparing criterion map, (3) Data standardization, and (4) Mul evaluation using AHP-OWA method. Figure (1) shows the steps of GIS-based MCE.

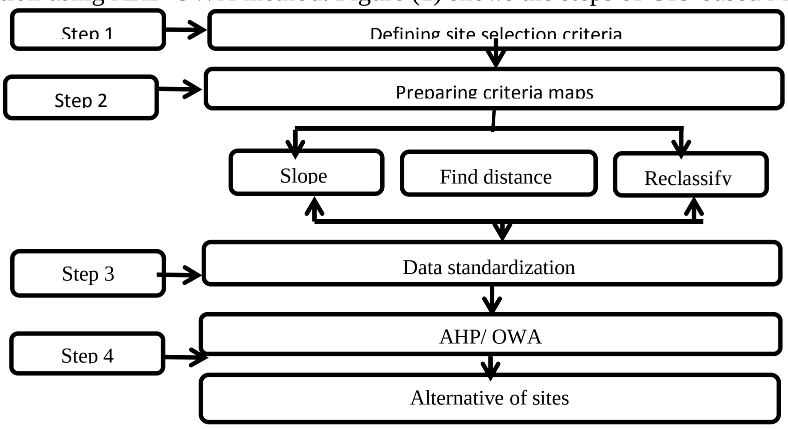

Fig.1.GIS-based MCE approach

To implement the proposed GIS-based MCE approach for dam site selection, a resear modified an present tool [5] to be used for dam site selection, using Visual Studio 2 Programming Language), as a toolbar within ArcGIS desktop to help the GIS an solve complex dam site selection problems. As shown in Figure (2) a dam Site S Toolbar is comprised of three main menus (data preparation, data standardization, a Tools)

Fig.2. Dam Site selection using GIS-based MCE toolbar.

The steps of getting the suitability map of water harvesting dam using the tool are:

2.1 Data Preparation:

The first step after selecting the main criteria and sub-criteria of water harvesting generate their maps based on different GIS functions (slope, distance, etc..), and mak result maps have same pixel size and number.

2.2 Standardized Criterion Maps:

After preparing the criteria maps, and before aggregating the input layers in an process, they must be on the same scale. The maps are created using raster format and ea layer contains the attribute values assigned to the alternatives, and each alternative related to the higher-level elements (i.e., attributes). For decision analysis, the values c in the various criterion map layers are standardized to a common scale to reduce dimens The outcome of the function is always a value between 0 and 1.

2.3 MCE tool:

After preparing the standardized criteria maps, the next step is using one of the MCE methods to identify the most suitable locations for rain water harvest (Analytical H Process (AHP), Order Weighted Averaging (OWA), and the extension of AHP usin operators.

3. Literature of the AHP and OWA methods:

3.1 Analytical Hierarchy Process (AHP)

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The AHP is a powerful tool in applying MCDA that was introduced and deve Saaty [6]. It is based on decision making paired comparisons. The comparison of eac alternatives is evaluated according to the criteria and their relative weights. In A decision-making process starts with dividing the problem into a hierarchy of issues. hierarchical level, the weights of the elements are calculated. The decision on the fina made considering the weights of criteria and alternatives.

The pairwise comparison method employs an underlying scale with odd values f 9 to rate the relative preferences for two elements of the hierarchy. in some c intermediate values (i.e.2, 4, 6, and 8) could be used between two adjacent intensiti measures the inconsistency of judgments by calculating the Consistency Index CI of th A consistency index (CI) must be < 0.10.

Although AHP is widely used, AHP is unable to address the uncertainty in the decision judgments [7]

3-2 Ordered Weighted Averaging (OWA):

To overcome the shortcomings of the AHP, OWA is used. The OWA is a family criteria aggregation procedures developed by Yager [8] as a tool for decision-making ir environment. Conventional OWA operators are of limited applicability in situations inv large set of evaluation criteria, especially when the behavior of the decision-maker can range that goes from ‘all the criteria have to be satisfied’ to ‘at least one criterion satisfied [9].

OWA involves two sets of weights: criterion, or importance weights and order The critical element of the OWA procedure is the method for obtaining the order weigh are several methods for obtaining the order weights. This study uses a fuzzy linguistic q approach. The concept of fuzzy linguistic quantifiers allows converting natural langu formal mathematical formulations. They can be represented as fuzzy subsets over interval with proportional fuzzy statements, such as “All of the criteria should be s (“All” for short) [10].

The Boolean overlay operations and the weighted linear combination (WLC) are often used decision rules in GIS. Boolean approaches are extreme functions that resu averse (pessimistic) solutions when the "AND" operator is used or in risk-taking (op solutions when the "OR" operator is used. The WLC approach is an averaging techn softens the hard decisions of the Boolean approach, avoiding the extremes. In a conti risk, the WLC falls exactly in the middle [11].

3-3 AHP-OWA Procedures:

The two approaches, (AHP and linguistic quantifier guided OWA), have been integr implemented in ArcGIS environment [12].

An extension of the AHP using OWA operators (AHP-OWA) is introduced, suggesting capabilities of AHP as a comprehensive tool for decision making can be improved by in of the fuzzy linguistic OWA operators. The combination between AHP and OWA can more powerful multi-criteria decision-making tool for structuring and solving decision problems including spatial decision problems [13].

In this method (AHP-OWA), users are first asked to use the AHP method to 1) the hierarchical structure, and 2) obtain weights for objectives and attributes by co pairwise comparisons, then linguistic quantifier-guided OWA is used to support user’s making. Three main steps are involved at this stage: 1) specifying a linguistic quantif generating a set of ordered weights associated with *Q*, and 3) calculating the overall each alternative using linguistic quantifier-guided OWA [14].

4. CASE STUDY

4.1 Background and project description:

Qassim occupies a middle position in the Arabian Peninsula, as it is locate northern center of the Kingdom of Saudi Arabia between longitudes of 41 ° 30' and 45° and latitudes in 24° 25' and 28° 15' north. It is the link between Riyadh area and Haa

North, and the city of Medina in the West direction. Figure (3) shows the Location Qassim case study.

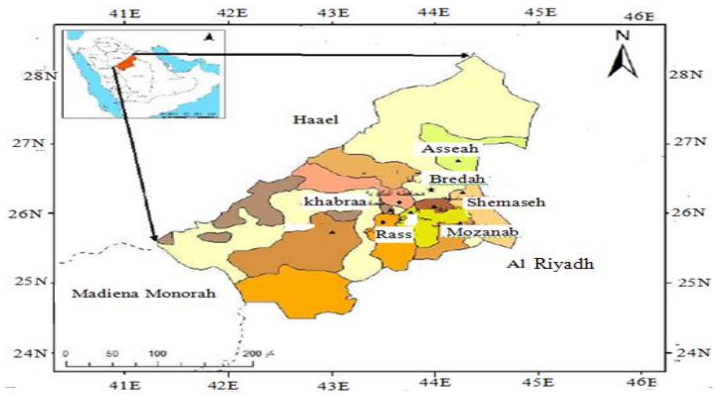

Fig.3. Location of AL-Qassim region

4.2 Rain water Harvest Site Criteria:

Selecting a suitable site for rain water harvesting requires the recognition c evaluate the abilities of different areas to be one of the suitable sites. It may be noted tha no fixed standards for all countries. Each country has its own standards, because every has its own conditions which are different from other countries. The criteria are used important standards and requirements which have been applied in similar studies. So criteria and relative sub-criteria could be extracted from experts' knowledge.

It was assumed that the criteria of rainfall harvesting site selection considered in t include three main groups; environmental (geographical), hydrological, and socio-e factors.

4-2-1-Geographical criteria (Environmental factors):

The environmental criteria in water harvesting site selection, includes:

a) Slope criterion::

Slope is an important factor in determining the water harvest site in the basin. It found that the amount of runoff or flow is proportional to the steepness of t Experts advised not to implement harvest projects in the territory in which the of more than 5%, where increase slope leads to difficulties during the implemen Scrape operations and flattening of land, in addition to an irregular distributi runoff [3].

b) Geologic criterion:

Geological criteria take into account the characteristics of the geological sites in the presence of the base rocks at the site and to determine the types and characteristi rocks, which help to provide the necessary construction raw materials. Water harvesting should be constructed on solid coherent rock, and as far away as possible from cracks an

c) Land use criterion:

Building water harvesting projects take into account the nature of the land use zones prefer pastoral areas for water harvesting projects. Also, they prefer it to be residential areas but not inside for several reasons, including the high cost of establis projects, considerations of public safety, environmental considerations and to en water is not subject to pollution.

***d)* Soil criterion:**

Soil properties affect the determination of the harvest type and the m construction. The soil must be thick in the water harvesting projects sites; w storage capacity and low permeability, silt or clay soil are the ideal soil for such [3].

4-2-2-Hydrological factors:

In the study for locating water harvest sites, some hydrological modeling and GIS ar required to obtain the pivotal elements involved in the work. These factors include:

a- Drainage network:

Rainfall harvesting structures are constructed near the valleys and on the stream.. must be located in a place where there is the most amount of water in the mai According to this, a distance near the waterways (up to 250 m) is considered as appropriate distance [3].

b- Rainfall:

One of the most important elements of climate, influences the process of selecting ap sites for water harvesting, where the sites of most rainfall are ideal areas for water ha areas while sites with less rainfall is the next appropriate sites.

4-2-3- socio-economic criteria:

These include:

a) Distance to population and residential areas:

The water harvest must be close to population and residential areas, because the obj this project is to serve the people and cities.

b) Distance to roads:

Must consider the ease of access to the water-harvesting site, so it preferably near should be close to the main roads to reduce the economic cost of transporting wa excavations or dams to the municipal areas to serve the surrounding communit project. Table (1) depicts the main and sub criteria for a water harvest dam.

Table (1) description the main and sub criteria:

Main criteria	sub-criteria	description
hydrology	**rainfall**	**dam must built on watershed of much rainfall or near it**
	stream	**dam must built on stream or near it**
socio-economic	**distance from roads**	**the distance between each site location and roads**
	distance from cities	**the distance between each site location and target area**
Environmental(geological)	**Topography(slope)**	**the slope of the land effect on runoff**
	landuse	**effect on cost of project and in runoff**
	Geology (type)	**strength of geologic formations effect in site**
	soil	**type of site soil effect on storage**

1- Data Preparation:

All the suggested criteria of rain water harvest (slope, geology, rainfall, drainage, soil, distance from roads, distance from cities) are generated using functions in GIS, and con raster having the same pixel cell size and number.

The distance option in GIS was used to determine the straight line from both the cities ar The slope map is defined from DEM obtained from Shuttle Radar Topography Mission data. In this study, the precipitation grid is obtained depending on the rain data of the st

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the basin. To get the spatial distribution of the rainfall, the rain data would have to be inte using the Inverse Distance Weighted (IDW) method. IDW is commonly used to generat surface with precipitation data. When the method is applied, the output grid is assig similar size and number of columns and rows of the original DEM. Figure (4) shows criteria adopted in this article. Each of the layers (geology, soil, and land use) is rec according to their importance in the selection of dam site.

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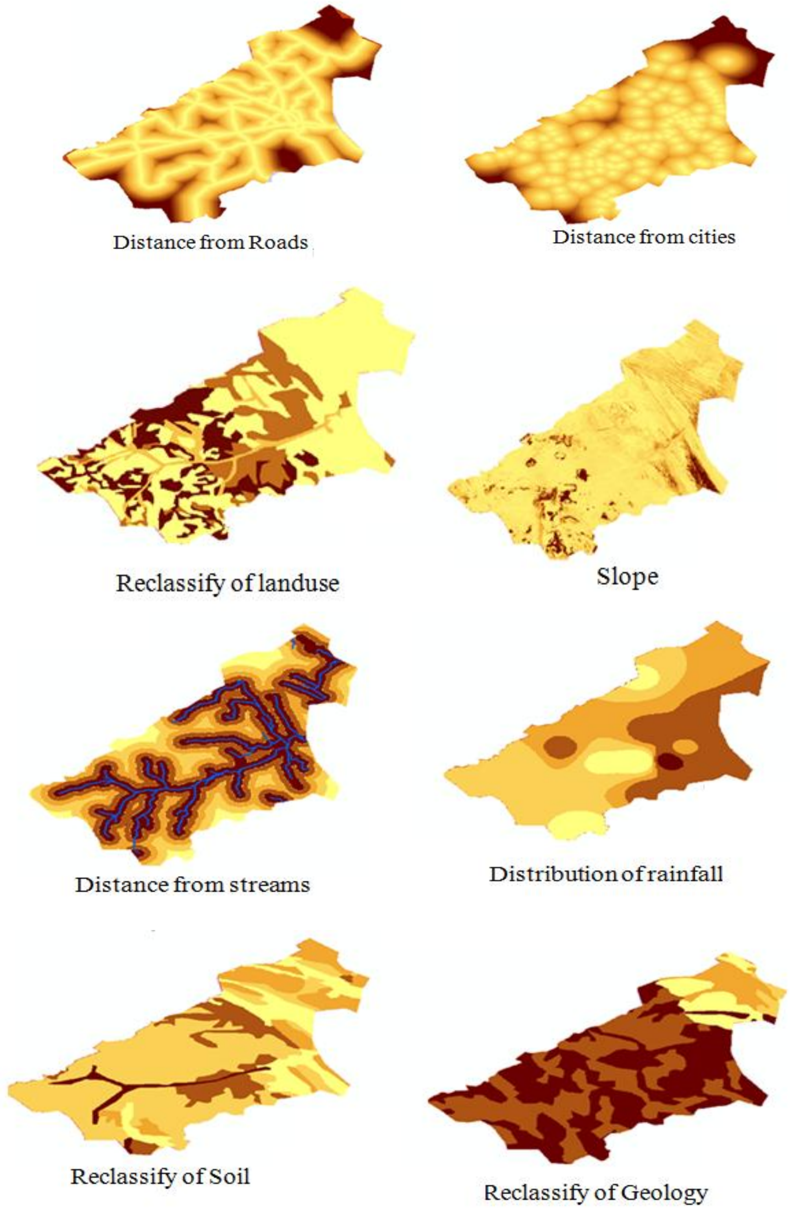

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Fig.4. Criteria for the selection of rain water harvest location

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2-Standardized Criterion Maps:

After defining the main and sub-criteria, by using Dam Site Selection toolbar in the GIS determine which criteria is maximum to goal or minimum, and select the standardized as in Figure (5). The first four criteria are to be maximized, that the suitable areas are re be located on suitable landuse, soil, slope, and geology. The distance-from-stream crit be minimized, the suitable site is where rainfall is maximum, and the distance from c distance from roads criteria are to be minimized.

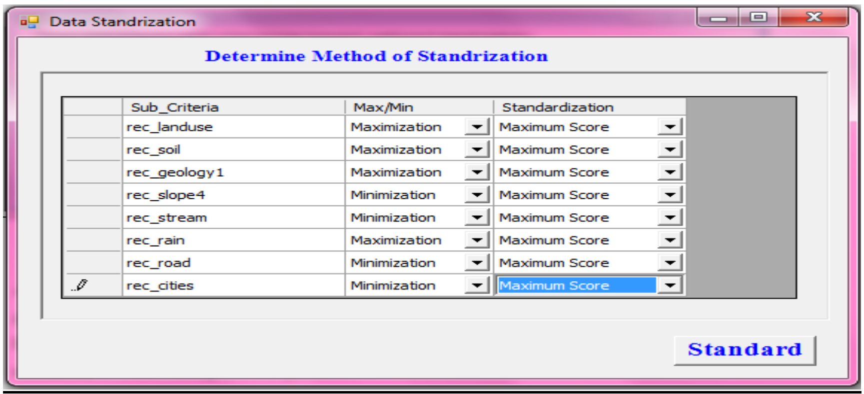

Fig.5. Data standardization

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3-AHP- OWA Procedure:

Choosing the AHP- OWA Procedure from toolbar, and then assigning each sub-cri relative main criteria as in Figures 6 and 7.

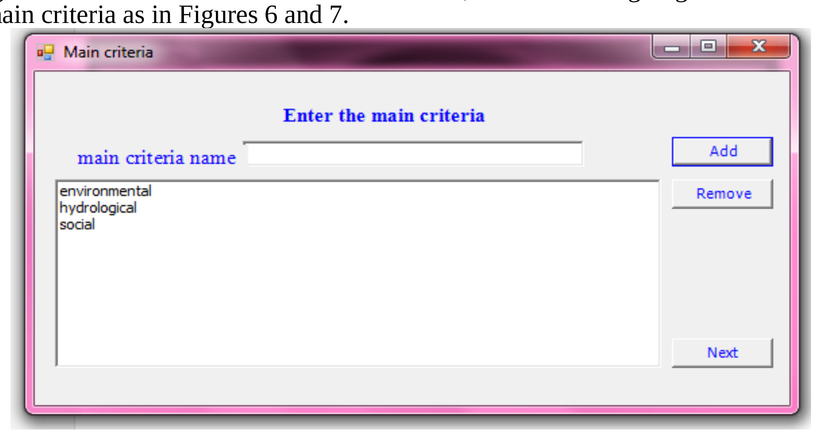

Fig.6. main criteria of water harvest structure.

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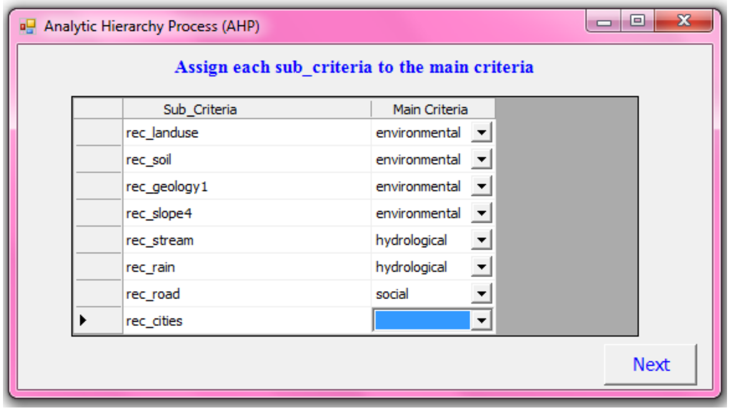

Fig .7.Main criteria and corresponding sub criteria

After building the AHP model, the relative weights for all objective clusters and thei attributes are calculated using pairwise comparisons [5]. The pairwise comparison required an expert in dams planning to provide his/her best judgments regarding the importance of objectives and attributes. In this paper, we get the important of main criteria from expert questionnaire and according to the study area. Figures from (8) to (: the pairwise comparison matrix between each main criteria and sub-criteria.

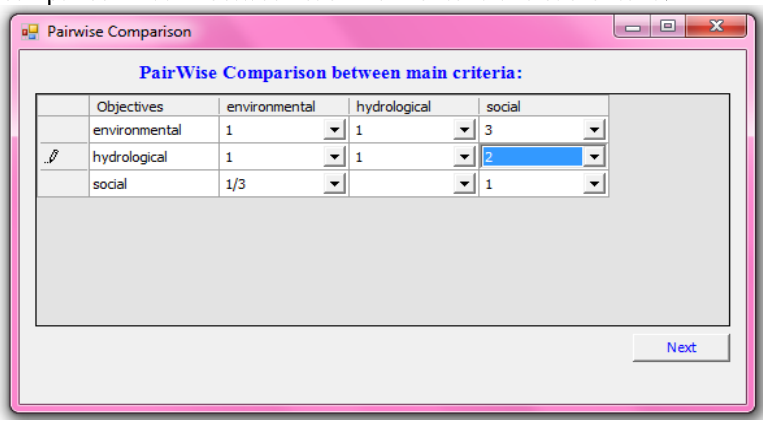

Fig.8. Pairwise comparison matrix between main criteria.

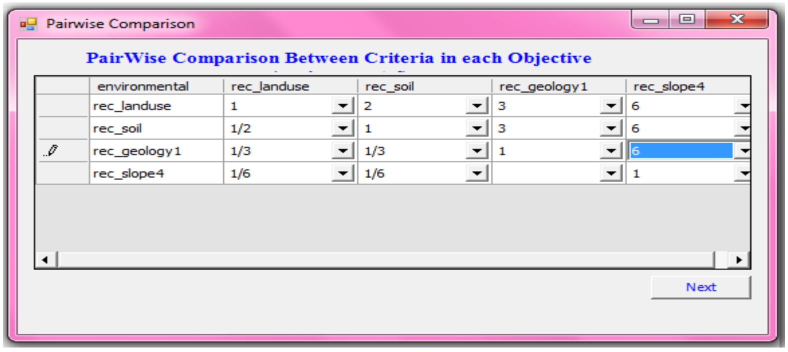

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Fig.9. Pairwise comparison matrix between sub- criteria according to environmental cri

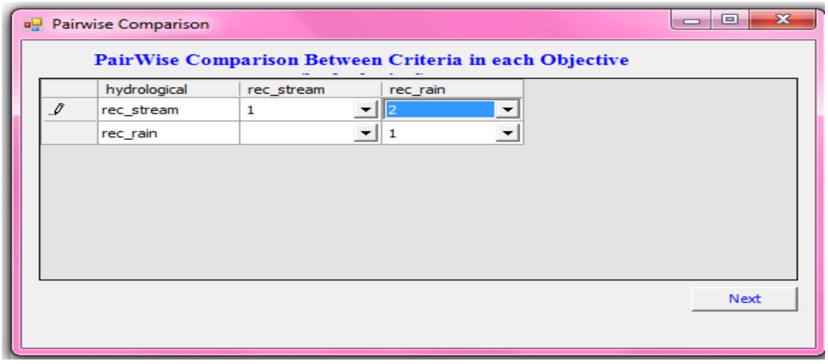

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Fig.10 Pairwise comparison matrix between sub- criteria according to hydrological cri

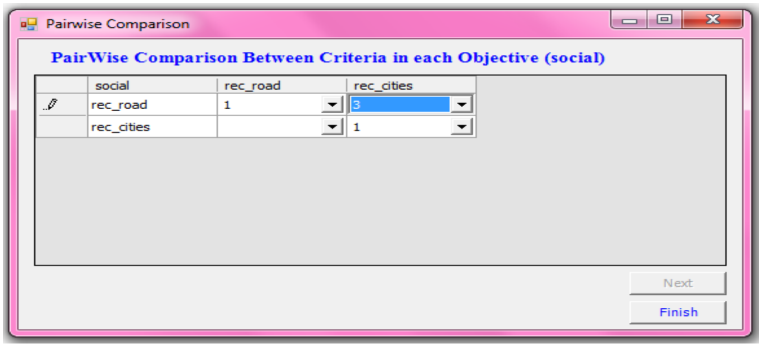

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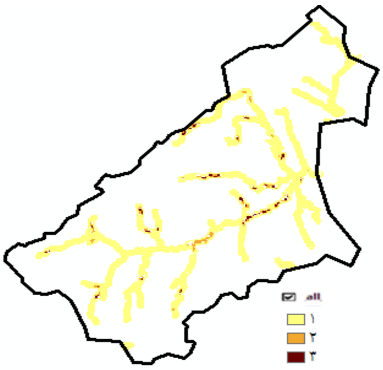
Fig.11. Pairwise comparison matrix between sub-criteria according to socio-economic criteri

4-Linguistic Quantifier-Guided OWA Combination:

Different outcomes can be generated by varying the linguistic quantifiers in t OWA procedures. There are 7 linguistic quantifiers associated with the goal a objectives. Thus, theoretically $7^{(1+3)}$ alternative evaluation scenarios can be generate case study.

In this paper, different quantifiers (Some", "Half", "Many", "Most", "few" ar are used. Figures (12) to (17) show alternative land suitability zones for building t harvest structure.



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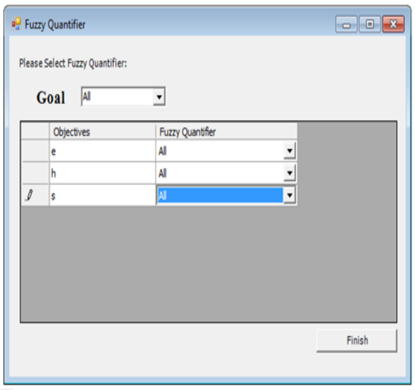

Fig.12. Site suitability for dam site using Linguistic Quantifier (all)

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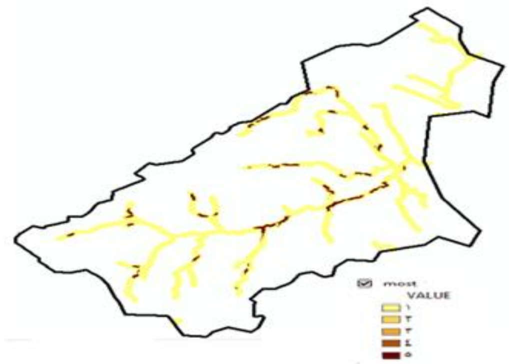

Fig.13. Site suitability for dam site using Linguistic Quantifier (most)

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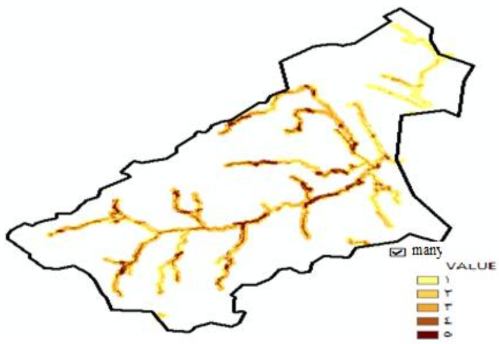

Fig.14.Site suitability for dam site using Linguistic Quantifier (many)

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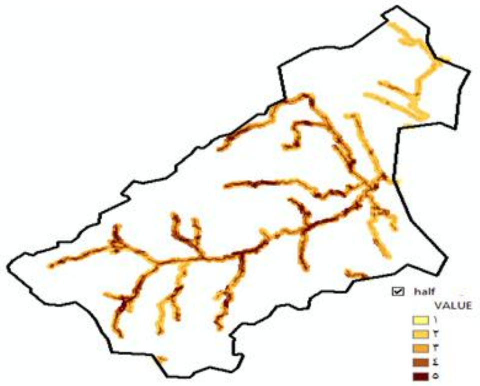

Fig.15. Site suitability for dam site using Linguistic Quantifier (half)

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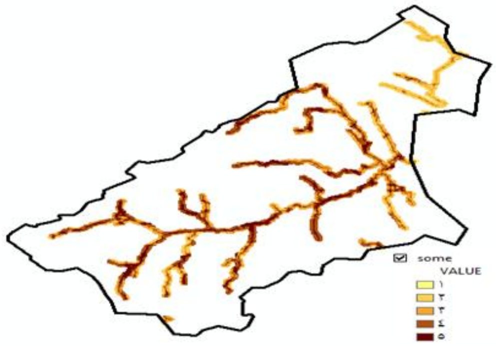

Fig.16. Site suitability for dam site using Linguistic Quantifier (some)

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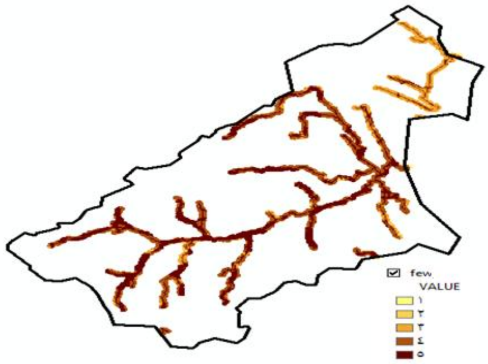

Fig.17. Site suitability for dam site using Linguistic Quantifier (few)

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In other words, these alternative scenarios have been developed under the assumption t the linguistic quantifier associated with the goal of the decision making problem changes

The linguistic terms 'Few' the results of AHP–OWA procedure show that mo study area is suitable for water harvest.

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The use of linguistic term 'Half' means that equal order weights are assigne criteria. This leads to a neutral strategy. This strategy corresponds to the convention When linguistic term 'All' is applied, an extremely pessimistic strategy is adopted. It re the worst-case scenario. Under this scenario, the suitability pattern for dam site is com the worst possible outcomes.

Finally we suggested nine locations of dams for rain water harvest in Qassim r shown in Figure (18).

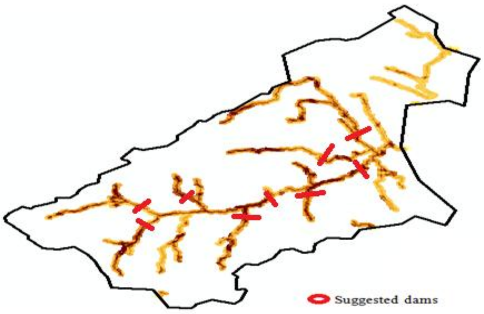

Fig.18. suggested water harvest dam site

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Model validation was done to guarantee if the model offers reliable representation system it represented. Validation was done as follows:

a) Comparing the resulting suitability sites of AHP, OWA approach with previous stu Qassim region as in Figure (19).

b) Visual comparisons were performed between the resulting suitability index values google images of region the comparison shows similarity with the present dams in t area figure (20).

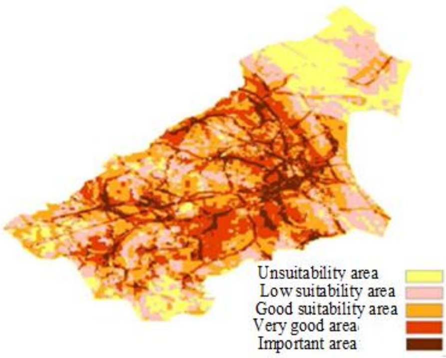

Fig.19 Site suitability for dam site using raster calculation

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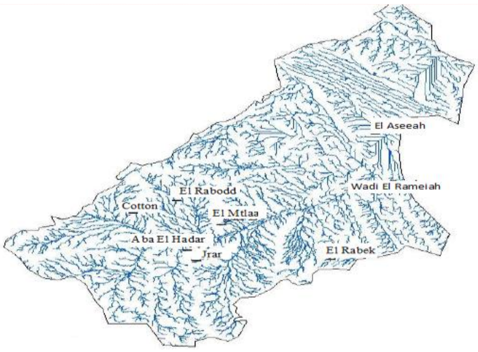

Fig.20 present dams in the study area

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5- SUMMARY AND CONCLUSION:

One of the most important and complex problems in arid and semi-arid regions is a water harvest site. A large mass of information must be gathered, combined and ana make correct criteria that may effect on making the final decision. This paper has p the theoretical basis for a novel GIS-based MCE procedure. The paper has suggested a extension of Saaty's AHP using the fuzzy linguistic OWA operators instead of a weighted average in the process of aggregation of component satisfactions, which in tu natural language quantification to spatial decision analysis. GIS-based MCE Dam Site S Tool has been developed as a toolbar in ArcGIS 9.3

Site selection for rain water harvest is carried out by considering the slope, s use/land cover, geology, buffered stream order, distance from roads, distance from citie for decision machining.

The following conclusions are made:

1. Geographical information systems are very useful tools to determine the best loca water harvesting projects. The application of multi-criteria increases the accurac results and limits the appropriate areas of the sites selected carefully to ensure the su the project
2. The study showed that geographic information systems open the door to the introdu new criteria to locating water harvesting projects, making it easier to take the de implement water harvesting projects.
3. It has also been found that this module is a valuable and user-friendly tool. In comparison to the conventional GIS-based multicriteria evaluation methods, it giv flexibility and high efficiency for evaluating land suitability of dams. The capability generate and visualise a range resultant scenarios is particularly useful.
4. This extension allows decision-makers to define a decision strategy on a continuum pessimistic (risk-averse) and optimistic (risk-taking) strategies. Also, the pa demonstrated how, by applying different linguistic quantifiers, decision-makers cou a wide range of decision strategies and scenarios taking into accounts the level of decision-makers wish to assume in their MCE.
5. The paper has suggested a possible of AHP using the fuzzy linguistic OWA operator of a simple weighted average in the process of aggregation of component satisfactior in turn brings natural language quantification to spatial decision analysis.

6. Several alternative scenarios of site suitability for rain water harvesting have been d in this study. They show how the decision-maker's attitude involved in suitability decision-making process can influence the outcomes.

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7. As a result, this work could be taken further by conducting field validation in compare and technically evaluate all the candidate sites in terms of their enviro impact assessment, from which the top ranking sites will undergo further geotechi hydro-geological detailed investigations.

REFERENCE:

[1] Ramakrishnan, A Bandyopadhyay and K N Kusuma (2009): „SCS-CN and GIS- approach for identifying potential water harvesting sites in the Kali Wa-tershed, Ma Basin, India", Journal of Earth System Science, 118, No. 4, August 2009, pp. 355–368.

[2] Nihila A,2012 " Water Poverty Index Mapping And GIS-BASED Approach For Ide Denitrifying Potential Water Harvesting Sites ", International Journal of Remote Se Geoscience (IJRSG)

[3] الدعدي، ماجدة، استخدام تقنية الاستشعار عن بعد ونظم المعلومات الجغرافية لدراسة الحصاد المائي لمياه السيول في منطقة القصيم، المملكة العربية السعودية، وزارة التعليم العالي، جامعة أم القرى، 2014

[4] Harish (2014)," Site Suitability Analysis of Water Harvesting Structures Using Sensing and GIS – A Case Study of Pisangan Watershed, Ajmer District, Rajasth International Archives of the Photogrammetry, Remote Sensing and Spatial Inf Sciences, Volume XL-8, 2014 ISPRS Technical Commission VIII Symposium, (December 2014, Hyderabad, India

[5] Eldrandaly K. , 2013" Developing a GIS-based MCE Site Selection Tool in ArcGIS COM Technology", ", IAJIT ,Vol.10, No.3.

[6] T. L. Saaty, 1980 "The Analytic Hierarchy Process," McGraw--Hill, New York.

[7] H. Deng, 1999 "Multi-Criteria Analysis with Fuzzy Pairwise Comparisons," Inte Journal of Approximate Reasoning, Vol. 21, pp. 215-231.

[8] Yager, R., 1988. On ordered weighted averaging aggregation operators in mult decision making. IEEE Transactions on Systems, Man and Cybernetics, 18 (1), 183–190

[9] Yager, R., 1996. Quantifier guided aggregation using OWA operators. Internationa of Intelligent Systems, 11, 49–73

[10] Yager, R., 1997, "On the Inclusion of Importances in OWA Aggregation," In: R. and J. Kacprzyk, Eds., The Ordered Weighted Averaging Operators: Theory and appl Kluwer Academic Publishers, Boston, pp. 41-59.

[11] Eldrandaly, , 2013"Exploring multi-criteria decision strategies in GIS with li quantifiers: an extension of the analytical network process using ordered weighted a operators" , International Journal of Geographical Information Science, Vol. 27, No. 1 2482,

[12] Yager R. and Kelman A, 1999, "An Extension of the Analytical Hierarchy Proce OWA operators," Journal of Intelligent and Fuzzy Systems, vol. 7, no. 4, pp. 401-417.

[13] Khalid, " Developing a GIS-Based MCE Site Selection Tool in ArcGIS Usin Technology" The International Arab Journal of Information Technology, Vol. 10, No 2013

[14] Menget.al, , 2011" A GIS-Based Multicriteria Decision Analysis Approach for Accessibility Patterns of Housing Development Sites: A Case Study in Canmore, Journal of Geographic Information System, 3, 50-61 doi:10.436/jgis.2011.31004 P Online January,2011 (http://www.SciRP.org/journal/jgis)

~~من أجل إيجاد موقع سدود حصاد المياه في القصيم، المملكة العربية السعودية AHP-OWA_ GIS اعتماد تقنية~~

~~ع سدود حصاد المياه هو عملية اتخاذ قرار معقدة. حيث إن إيجاد الموقع الأفضل يتطلب دمج تقنية المعايير المتعددة AHP-OV مع نظم المعلومات الجغرافية. في هذا البحث تم استخدام نظم المعلومات الجغرافيه بالاعتماد على تقنية ع لبناء السدود في منطقة القصيم في السعودية. تم اعتماد انحدار الحوض، استخدامات الأراضي، نوع التربة، لسطح، توزع الأمطار، المسافة إلى الطرق، والمسافة للمناطق المخدمة كمعايير لاتخاذ القرار. أظهرت النتائج لطريقة في إيجاد أفضل مواقع لبناء سدود حصاد المياه، مع السماح لمتخذ القرار أن يأخذ في الاعتبار سيناريوهات مختلفة بين المتفائلة والمتشائمة.~~