Volume 84(2). Published September, 01, 2021
www.jnsciences.org
E-ISSN 2286-5314

JOURNAL OF NEW SCIENCES
WWW.JNSCIENCES.ORG

Multicriteria assessment and prioritization of rainwater harvesting techniques in Southeast Tunisia

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Abstract – In arid area, rainfed agriculture is one of the most vulnerable system to climate change. Stabilizing smallholder crop yields under changing climatic conditions will require adaptation of strategies focused on soil and water management. In Oum Zessar watershed (South-East Tunisia), Rain Water Harvesting (RWH) techniques is one of the adaptation strategies that has been adopted by farmers. At the scale of this watershed, we aimed to identify the current and potential RWH techniques. Then, to analyze the socio-economic and ecological determinants of their adoption by farmer's and finally to evaluate and prioritize these techniques. Our approach was based on a comprehensive multi-criteria analysis method performed on data gathered with the help of a socio-economic surveys. Results show that age, gender, importance of the technology, education level, residence, household size, agricultural activity, exploitation size, farmer's income, structure cost, slope and erosion are the most socio-economic and ecological determinants of adoption of RWH techniques. Furthermore, the study found that in the three watershed compartments (upstream, middle stream and downstream), Tabias, Mejels and Fesguias are the top priority RWH techniques. In contrary, buried stone pockets are suitable in the upstream and downstream compartments and mountain spillways are appropriate at middle stream areas.

Keywords: Rainfed agriculture, RWH techniques, multicriteria analysis, determinants of adoption, assessment and prioritization.

1. Introduction

Rainfed agriculture accounts for about 80% of the world agricultural lands and contributes to over two-third of the global food production (Oweis and Hachum 2012). Aridity and climatic changes are the major challenges faced by farmers who rely on rainfed farming in arid and semi-arid regions (Adham et al. 2016). During the last 30 years Tunisia, has experienced a large annual mean temperature increase by an average of 0.4°C per decade. While in aggregate, no significant change in annual precipitation was observed from 1901 to 2013, over the past 30 years average annual precipitation has decreased by about 3%. The annual maximum temperature is likely to increase by 1.5°C to 2.5°C and 1.9°C to 3.8°C by 2030 and 2050, respectively. All models predict a likely decrease in overall precipitation by 2050, with most predicting a minimum decrease of around 4% and a maximum decrease varying from 7 to as much as 22%. The decrease of precipitation is accompanied by an anticipated increase in the frequency and intensity of both droughts and floodings (USAID 2018). With climate changes, farmers who subsist from rainfed agricultural systems will have to cope with increased risk arising from more frequent extreme events and poor intra-seasonal rainfall distribution (Barros et al. 2014). Several adaptation measures are being promoted, such as the use of different crops or crop varieties, soil conservation, changing crops calendars, and irrigation (Bryan et al. 2009). Nevertheless, these options may not all be viable choices for smallholder farming either due to their high costs, technical restrictions, or even cultural limitations (Adger et al. 2012). Thus, rainwater harvesting (RWH) techniques and structures could help mitigate the impacts of climate changes on crop production (Lebel 2015). The World Overview of Conservation Approaches and Technologies (WOCAT) defined RWH as: "The collection and management of floodwater or rainwater runoff to increase water availability for domestic and agricultural use as well as ecosystem sustenance" (Mekdaschi Studer and Liniger, 2013). Indeed, RWH techniques and structures serve for inducing, collecting, storing and conserving local surface runoff for agriculture particularly in arid and semi-arid regions. It can improve the productivity of rainwater and maintain productive and sustainable agro-pastoral systems in marginal environments (Prinz et al. 1998; Van Wesemael et al. 1998). It could also control soil erosion and reduce the impact of drought (Oweis et al. 2006). During the recent decades, interest in RWH has been renewed thanks to the potential of rainwater harvesting to mitigate the variability of rainfall (Mwenge Kahinda et al. 2008). Although in southeastern Tunisia there is a wealth of ancestral local know-how related to RWH implementation and management and the community is very familiar with RWH techniques notably: Tabia, Mejels, Fesguias, Jessours, mountain spillways, buried stone pockets, flood spreading, recharge wells and soil defence restoration, researches on this field are still limited. Due to the demographic increase and to the sedentarisation of the nomadic population, the mode of land management has shifted from pastoralism to rainfed and irrigated agriculture. Thus, to satisfy the water demand for agriculture and domestic purposes, there is a need to intensify and systematically replace or implement RWH structures in suitable sites. Several soil and water conservation (SWC) projects have been carried out in this degraded areas. Various SWC structures have been widely implemented throughout the drought-prone watersheds to harvest runoff. The first projects approached erosion from a strictly biophysical angle of view and fought against it by building heavy structures which are not only financially costly but also purely based on technical criteria. This is pointed out as one of the causes of continuing soil degradation, despite important investments.

Furthermore, researchers have focused on developing methodologies to select the most suitable sites and techniques for RWH (Mahmoud 2014). Nevertheless, little attention was paid to the appraisal of RWH structures once implemented. Investigations have shown that the effectiveness of these structures is largely depending on the perception of the local population to the interest of these structures and how they could effectively improve their living conditions. For these reasons, RWH structures should be performed in the framework of holistic and integrated projects of development of the watersheds. Besides, the assessment of their effectiveness should include biophysical and socio-economic criteria. Indeed, RWH structures should play simultaneously multi-functions:

i) Environmental function: protect land against erosion, limit runoff, control solid transport to downstream areas, recharge of water table, improve soil fertility, enhance agricultural production, extend land cover and restore ecological balance

ii) Economic function: Protect urban areas and infrastructure against flooding, agricultural development of sloping land, increase agricultural production, create employment and alleviate poverty.

iii) Social function: Access to safe drinking-water, establish new cultivation system, fight against the rural exodus, social justice, intergenerational equity, improve the living conditions of the population and reduce the development gap across regions.

Currently, it is obvious that despite the very high costs of the RWH works they are more than ever essential. Thus, as a key strategy, to justify these budget allocations which are largely borne by the taxpayer these works should be better approved and valorized by the beneficiary local population. Their achievements must refer to an approach of site selection and techniques coupled with a process of prioritization that involve local users in planning and managing natural resources at the watershed level. RWH involves an appraisal of several factors at the same time, and this could be appropriately solved in the framework of multi-criteria analysis (MCA) (Mosase et al. 2017). Multi-criteria decision support provides decision-makers with tools to put into context the structuring factors of the decision. The formalization of the perceptions specific to each of the groups of the territorial actors contributes to improving impartiality in solving a complex problem by taking into account several objectives, which are conflicting to some extent. This is a simultaneous optimization problem of the type: Opt {g1 (x), g2 (x), gm (x): x ∈ A}, Where A is a set of eligible actions and g1, g2, gm are the functions of the criteria to be optimized (Laaribi, 2000). MCA process goes through the following steps:

1. Establish a shared understanding of the decision context with all the key actors.
2. Identify the options.
3. Identify the objectives and criteria that reflect the value associated with the consequences of each option.
4. Describe the expected performance of each option against the criteria.
5. Score the options, i.e. assess the value associated with the consequences of each option.
5. Assign weights for each of the criteria to reflect their relative importance to the decision.
6. Combine the weights and scores for each of the options to derive and overall value.
7. Examine the results.

The Hierarchical Analysis Process (HAP) is a MCA Method introduced by Saaty (1980). It helps the decision maker, reducing complex decisions to a series of pairwise comparisons, then synthesizing the results, prioritizing and making the best decision. HAP helps to capture both subjective and objective aspects of a decision. The HAP considers a set of evaluation criteria, and a set of alternatives. As some of the criteria might be contrasted, the most consensual alternative is the one that achieves the most appropriate compromise among the different criteria. According to the pairwise comparisons of the criteria made by the decision-maker. The HAP generates a weight for each criterion. The greater the weight, the more important the corresponding criterion. Then, for a fixed criterion, the HAP assigns a score to each alternative based on the decision maker's pairwise comparisons of the alternatives based on that criterion. The higher the score, the better the performance of the alternative corresponding to the considered criterion. Finally, the HAP

combines the criteria weights and the scores of the alternatives, thus determining an overall score for each option, and a resulting ranking. The overall score for a given option is a weighted sum of the scores it obtained on all criteria. The HAP is a very flexible and powerful tool since the scores, and therefore the final ranking, are obtained on the basis of the relative ratings of the pairwise comparison of criteria and alternatives provided by the decision maker. The calculations performed by the HAP are always guided by the experience of the decision maker, and the HAP can therefore be considered as a tool which is able to express the evaluations (qualitative and quantitative) made by the decision maker into a multi-criterion ranking. HAP method is integrated as a WOCAT tool embedded in Facilitator open software (Heilman et. al. 2002). Using WOCAT methods and tools that provide us with a participatory framework that brings local populations, technicians, extension workers and researchers together, the purpose of this study was three-fold:
- Identification of current and potential RWH techniques at the three Oum Zessar watershed compartments.
- Inventory of biophysical and socio-economic determinants underlying farmer's adoption of RWH techniques
- Prioritization of suitable RWH sites and techniques, helping to identify where they are most needed and could be effectively implemented.

2. Materials and methods

2.1Study area

Oum Zessar watershed, is located in the Northeastern of Tunisia in Medenine governorate. Its geographical position is between the parallel 33° and 33°10' North, and the meridian 10° and 10°30' East (Figure, 1). The catchment has an area of 367 km^2. It has a lower arid Mediterranean climate with dry summers and cool winters, an average annual rainfall of 150–230 mm with an average of 30 days of rain, an average annual temperature of 19–22 ◦C, and an average annual potential evapotranspiration of 1450 mm (Adham et al. 2016).
The watershed suffers from great environmental vulnerability (Ouessar 2007). Indeed, land is cultivated, both in rainfed (especially olive tree and cereals) and irrigation system, to the detriment of natural rangelands. But these two forms of land use are strongly constrained by the scarcity of water. This watershed has been a target area of the main national strategies for natural resource and combating desertification: water and soil conservation, water resources, pasture and rangelands, sand encroachment, rural development, etc, (Fetoui et al. 2014). It is considered as priority area for the planning of RWH techniques as it is seriously vulnerable to water erosion. Besides, due to precipitation scarcity the promotion of agriculture activity in this area is mainly based on the collection of runoff water behind the RWH constructions.

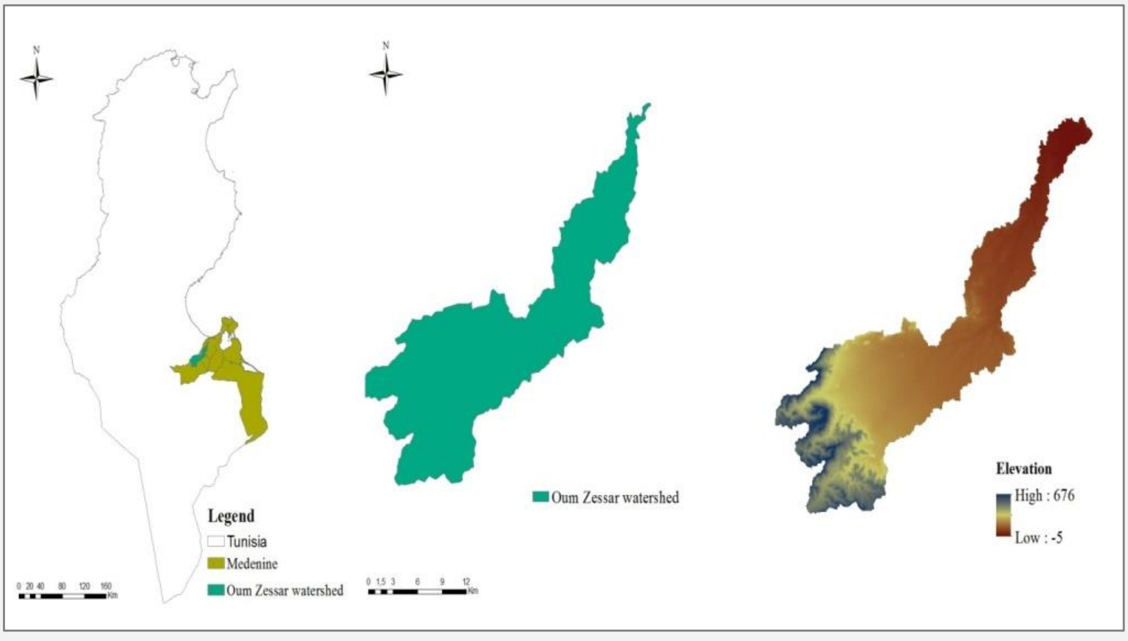

Figure 1: Geographical location map of Oued Oum Zessar watershed

2.2 Methodology

Our methodology was based on a semi-structured questionnaire involving a face-to-face interview (450 farmers: 150 farmers for each of the three compartments of the watershed: upstream, middlestream and downstream) and in a set of focus group meetings. A complex of factors determines the relevance and the effectiveness of RWH techniques achievements. WOCAT questionnaires go a long way towards handling these complexities. Our methodology was focused on identifying advocated RWH techniques to meet: social, economic and ecological objectives. These techniques are identified and evaluated with the help of both farmers and extension workers. Prioritization of these techniques was done using HAP method integrated in WOCAT Tools and embedded in Facilitator open source software (Heilman et al. 2002). Figure 2 shows the flowchart of our methodology.

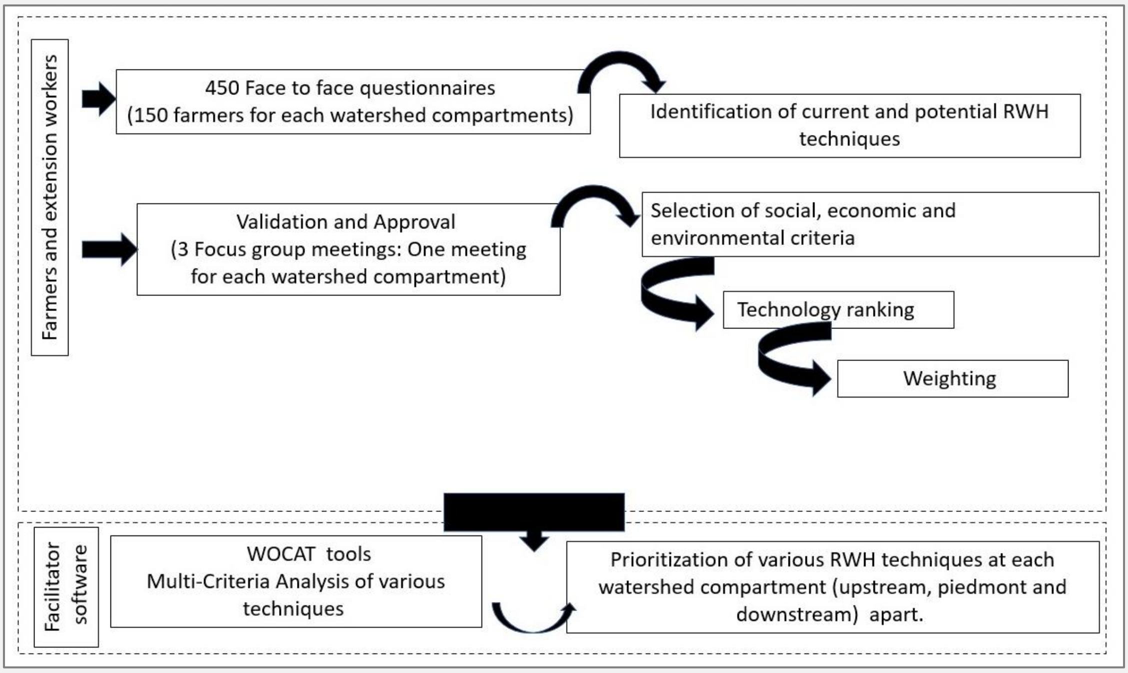

Figure 2: Flowchart of the adopted methodology

2.2.1 Identification of current RWH techniques

Oum Zessar watershed has always been considered as an intervention zone for RWH techniques. These techniques are carried out both by the public and the private sectors. The inventory of current RWH techniques across the watershed was done by the commissary of agriculture of Medenine but amended and validated by the extension workers and the local population during focus group meetings.

2.2.2 Identification of determinants of adoption for RWH techniques

Individual surveys and meetings with focus groups are undertaken with farmers in the three watershed compartments to identify the different determinants of adoption of RWH techniques. Comprehensive questions were addressed to households for the factors that motivate their adoption of RWH techniques.

2.2.3 Multicriteria prioritization of RWH techniques

Multi-Criteria Analysis (MCA) uses programming techniques to select options based on objectives functions, including the weighted objectives of decision-makers. It provides a consistent basis for decision making that takes into account all the objectives and constraints embedded in the model. However, prioritization results depend on the quality of input data in the decision-making process.
Selection of criteria, ranking and weighting are done by farmers originating from the three compartments of Oum Zessar watershed according to a bottom-up approach. Then, we finish by embedding the list of criteria and technologies in the WOCAT database which enables us to have a range of technologies based on the selected criteria.

- **Selection of criteria:** the suitability of one RWH technique, for one given site, can be assessed against several technical and socio-economic criteria. In our study, the criteria on which the prioritization was based were shortlisted after consultation of farmers from the upstream, piedmont and downstream compartments of Oum Zessar watershed. The criteria used in the analysis are erosion (slope as a parameter for topography, land use/land cover LULC as a parameter for agronomy, soil texture as a parameter for soils intrinsic property), soil fertility and water harvesting as parameters for ecology, increase in crops production and minimization of production costs as parameters for economy, creation of employment and fight against rural exodus as parameters for social conditions.

- **Technology ranking:** for prioritization purpose, selection criteria of social, ecological and economic orders have been ranked and then combined. At this stage, for one given site, the profitability of each technology was assessed against each of the criteria. The rating scale for each criteria was ranging from 0 to 10, marking 0 as the technology is not efficient according to this criteria and 10 as the technology is very efficient according to this criteria. Then, for each compartment, technologies were classified from the most preferred technology to the least preferred technology.
- **Weighting:** for each RWH technique, we have assigned a weight relative to its importance in relation to the criterion. The score attributed to each technique is the weighted summation of the different scores awarded by farmers for each technique.

3. Results and discussion

3.1 Identification of current RWH techniques

The identified and listed techniques during workshops are: Tabia, Mejels and Fesguias, Jessour, mountain spillways, buried stone pockets, flood spreading, recharge wells and soil defence restoration.

3.2 Determinants of adoption of RWH techniques

In Oum Zessar watershed, factors that drive the farmer's adoption of RWH techniques can be organized into three main groups, namely: social, economic and ecological determinants.

3.2.1 Social determinants

Different social determinants have been identified by farmers to adopt RWH techniques in Oum Zessar watershed. According to them, the average age of farm manager is an important determinant. Results indicated that the average age of farm managers is 40 years. In the upstream compartment, the proportion of farmers aged between 40 and 60 is estimated to 50%; 47% and 38% respectively for the upstream, piedmont and downstream compartments. Figure 3 depicts the age of the questioned farmers per compartment

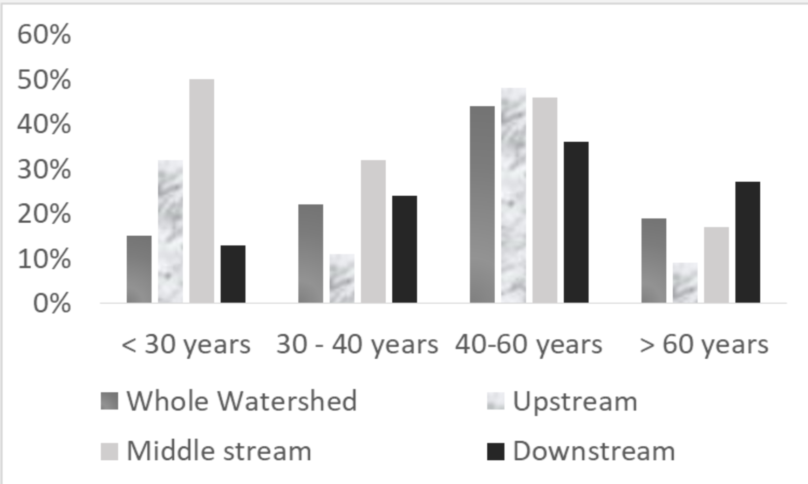

Figure 3: Age of the questioned farmers per compartment

Rural women make a very significant contribution to the agricultural production systems of the Oued Oum Zessar watershed. In fact, the heads of farms surveyed in the three upstream, piedmont and downstream compartments are women at 19%, 21% and 18% respectively.

Further, the study found out that there is a significant positive relationship between adoption of RWH techniques and the gender of the interviewees. The findings reveal that 87% of the respondents believed that RWH was a big shared responsibility. However, a considerable number of respondents, majority of whom were female, representing 69% indicated that men and boys were viewed to have the biggest responsibility to cope with RWH techniques. The rural women contribute in a little significant way nearly 19%. Results indicated also that most respondent (75%) is aware of the usefulness of RWH techniques. Discussing adoption of this technology among the members of the community in an indicator of an interest to adopt the technology and that the community had strong mutual ties.

The findings further indicates that the education level is an important determinant to adopt RWH techniques. Individual surveys show that 33% of farmers are illiterate and 32% of them have a primary education. Upstream farmers have the highest rate of illiteracy that exceeds 54%. Figure 4 depicts the level of education of households.

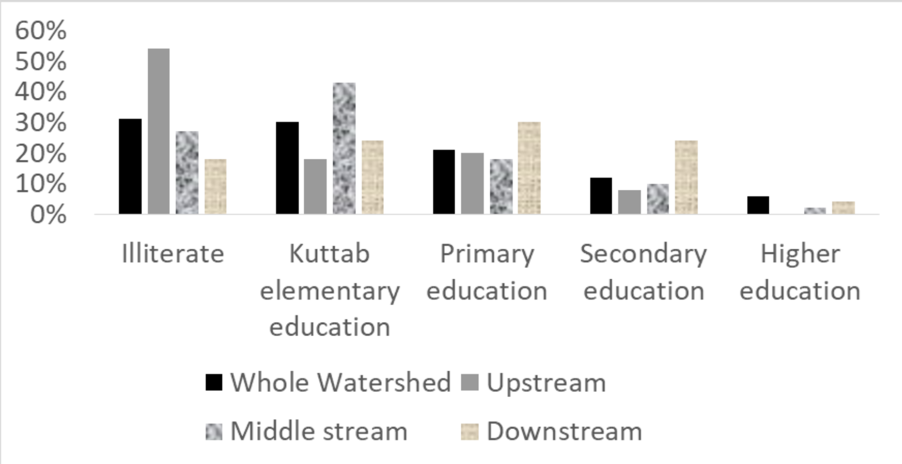

Figure 4: Level of education of households

Also, results revealed that the residence of households have a big impact in the adoption of RWH techniques. Only 39% of the upstream population lives outside their farm. This is due to its mountainous nature and the fact that their children study at secondary schools located in the downstream zone. Regarding the household size, the average in the watershed is 4 people. The size is 6 people in the upstream. However, in the piedmont and downstream compartments, there is a reduction in fertility. This confirms the survival of the extended family of traditional type at the mountain level. The study found out that there is a significant positive relationship between RWH adoption and social determinants. According to farmers, the most important determinants are the average age of farm manager, the gender and the perception of the importance of the technology. Similar to our study findings, Cheserek (2013) states that the social determinants influencing farmer's decision to adopt RWH techniques were categorized in gender, education and age. According to our findings, the perception of the importance of the technology is more important than the education level. Households mentioned that RWH techniques are an ancient structures that they adopted from their parents and their grandparents.

3.2.2 Economic determinants

Findings revealed that, agricultural activity play an important role in the adoption of RWH techniques. Most of the interviewees are engaged in agriculture activity (66%) as their source of income. Another, 23% are engaged in civil servants, trading and others. In fact, in the upstream and downstream compartments 89% of households agree that the agriculture is their first source of income. In the piedmont part, agriculture is practiced by the entire population surveyed as a secondary activity. Figure 5 depicts Main activities of householders by compartment.

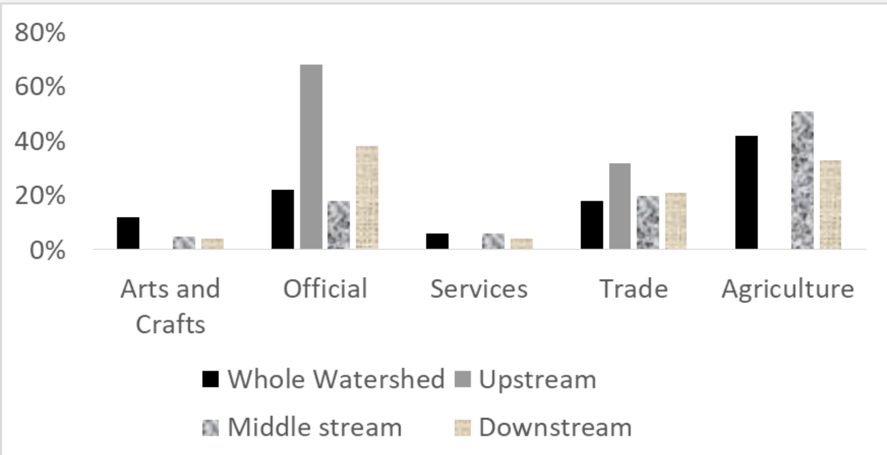

Figure 5: Main activities of householders by compartment

The findings further revealed that the size of the exploitation is also a significant determining factor in the adoption of RWH techniques and in particular for the combination of two or more techniques. 58% of the surveyed farmers in the downstream area hold an area of more than 20 ha and 67% hold an area less than 5 ha in the upstream compartment. The cropping systems encountered are mainly oriented towards the production of the olive tree behind RWH techniques. Furthermore, the farmer's income determines the overall volumes of rainwater that can be harvested in the household in a particular season. According to the survey data, the average total income of the households is 1689.95 DT / year in Oum Zessar watershed. Results shows that the average farm income is around 1412.5 DT/ year, the highest value is registered in the downstream compartment with 1600.3 DT per year. The average of off-farm income is about 1967.4 DT/year and the highest value is registered in the upstream part (Table 1).

Table 1: Householders' incomes by compartment expressed in DT / year

Compartment	Agricultural income	Extra-agricultural income	Total income
Upstream	1389,2	2450,4	1919,8
Middlestream	1248,1	1652	1450
Downstream	1600,3	1800	1700,1
Total	1412,5	1967,4	1689,95

Our results are similar to those of CSE India (2003), which states that the increased income by the households shows greater incentive for investment in the rainwater harvesting techniques. The findings indicated also that the cost of the implementation and maintenance of RWH techniques is an important determinant. The estimation of the cost of adopting RWH techniques takes into account both the financial and the physical aspects. In the three compartments of Oum Zessar watershed, 80% of the households uses their own physical effort during the implementation and maintenance of RWH techniques. The study found out that there is a significant positive relationship between the adoption of RWH techniques and the economic determinants. In tandem with the study findings, Marenya and Barret (2007) found that the economic determinants affecting the adoption of RWH techniques are farm size, livestock value, off farm income, family labor supply and education.

3.2.3 Ecological determinants

Ecological determinants such as slope and erosion are the most important determinants in the adoption of RWH techniques in Oum Zessar watershed. Results indicated that 97% of the upstream population surveyed reveals that this mountainous area suffers from a severe risk of erosion and essentially water erosion, which has worsened during the last 10 to 15 years. Concerning the piedmont compartment, the risks of erosion are moderate and especially characterized by a wind erosion due to the sandy nature of this zone essentially during the last 5 years when the frequency of the wind is increased. Furthermore, results indicated that slope plays an important role in the generation of runoff and thus influences the amount of sedimentation, the speed of water flow, and the amount of material required to construct dams (Adham et al. 2016). The results of the survey showed that the slope differs from one compartment to another in addition, 62% of the mountainous area is characterized by a very steep slope (greater than 60%), while the piedmont and the downstream area in general are characterized by a slight slope (from 2 to 5%). Table 2, 3 and 4 recapitulate the ranking matrix and weighting of RWH technical options and solutions in the upstream, middlestream and downstream compartments, respectively.

Table 2: Ranking matrix and weighting of RWH technical options and solutions in the upstream compartment

RWH Techniques	Environnement			Economy		Social	
	Erosion	Soil Fertility	Water Harvesting	Increase in Plant Production	Minimization of charges	Job creation	Fight against rural exodus
Mountain spillway	8	7	8	8	6	4	2
Flood spreading	7	6	8	6	7	4	2
Buried stone pockes	9	8	9	6	7	6	1
Tabias	9	8	8	8	8	5	1
Jessours	8	7	9	8	8	6	1
Mejels et Fesguias	10	3	10	9	9	6	4
Soil defence restoration	7	6	7	5	6	3	1
Recharge wells	6	7	3	7	3	6	1

Tableau 3: Ranking matrix and weighting of RWH technical options and solutions in the Middle stream compartment

RWH Techniques	Environnement			Economy		Social	
	Erosion	Soil Fertility	Water Harvesting	Increase in Plant Production	Minimization of charges	Job creation	Fight against rural exodus
Mountain Spillway	5	8	7	5	5	5	1
Flood spreading	7	4	7	5	6	4	1
Buried stone pockets	6	6	7	6	5	6	1
Tabias	8	5	7	8	5	5	3
Jessours	7	8	8	6	5	5	2
Mejels et Fesguias	9	2	9	6	8	7	7
Soil defence restoration	5	5	3	5	5	1	1
Recharge wells	4	4	1	5	4	2	1

Tableau 4: Ranking matrix and weighting of RWH technical options and solutions in the downstream compartment

RWH Techniques	Environnement			Economy		Social	
	Erosion	Soil Fertility	Water Harvesting	Increase in Plant Production	Minimization of charges	Job creation	Fight against rural exodus
Mountain Spillway	8	9	6	8	6	4	4
Flood spreading	8	8	8	10	6	4	5
Buried stone pockets	8	7	7	8	6	3	4
Tabias	8	7	7	8	6	2	1
Jessours	7	8	9	7	9	3	2
Mejels et Fesguias	0	1	10	4	4	0	1
Soil defence restoration	8	8	1	6	8	0	0
Recharge wells	0	2	1	2	0	2	1

3.3 Multi-criteria prioritization of RWH techniques with WOCAT tools

In order to make the rational decision about RWH techniques that can jointly meet social, ecological and economic objectives; a multi-criteria approach (WOCAT methodology) was carried out at the level of the three compartments of Oum Zessar watershed. This approach relates to the average of the weights given by farmers to have results that compromise between ecological requirements and socio-economic challenges, these results are given by the figures below for each of the three compartments.

These results are displayed as horizontal green bars, which show the overall option scores, where the best option is the one facing up and to the right. The red bars show that the prioritization of the different techniques remains relatively identical between the different elements of the focus group. For each compartment, a global, social, ecological and economic assessment is made to allow the choice of three or four potentially interesting solutions.

3.3.1 Multicriteria prioritization of RWH techniques in the upstream compartment

In this area, the means of global analysis on the various aspects, show that Jessour as well as Mejels and Fesguias are the best options followed by Tabias and buried stone pockets. The evaluation of the options according to the social, economic and ecological components gives another rating of the options (Figure 6). Socially based, the local population affirms that buried stone pockets and Jessour are the best options followed by Mejels and Fesguias. This result is plausible, given that the majority of the interviewees were engaged to work in construction site of Jessour and buried stone pockets implemented by the public authorities (Figure 7). Ecologically, results show that Jessour and Tabias are the best options. Interviewees consider that these two techniques are the most effective in the collection of runoff water therefore to protect their land against water erosion (Figure 8). From an economic point of view, Tabias and Jessour are classified as firsts by the local population, followed by Mejels and Fesguias. This classification finding is validated by the focus group, 80% of Tabias and Jessours are exploited in fruit trees crops and field vegetable crops and 13.4% are exploited in cereal crops which confirms the fact that Tabias and Jessours have helped to promote increased arboriculture and cereal production (Figure 9).

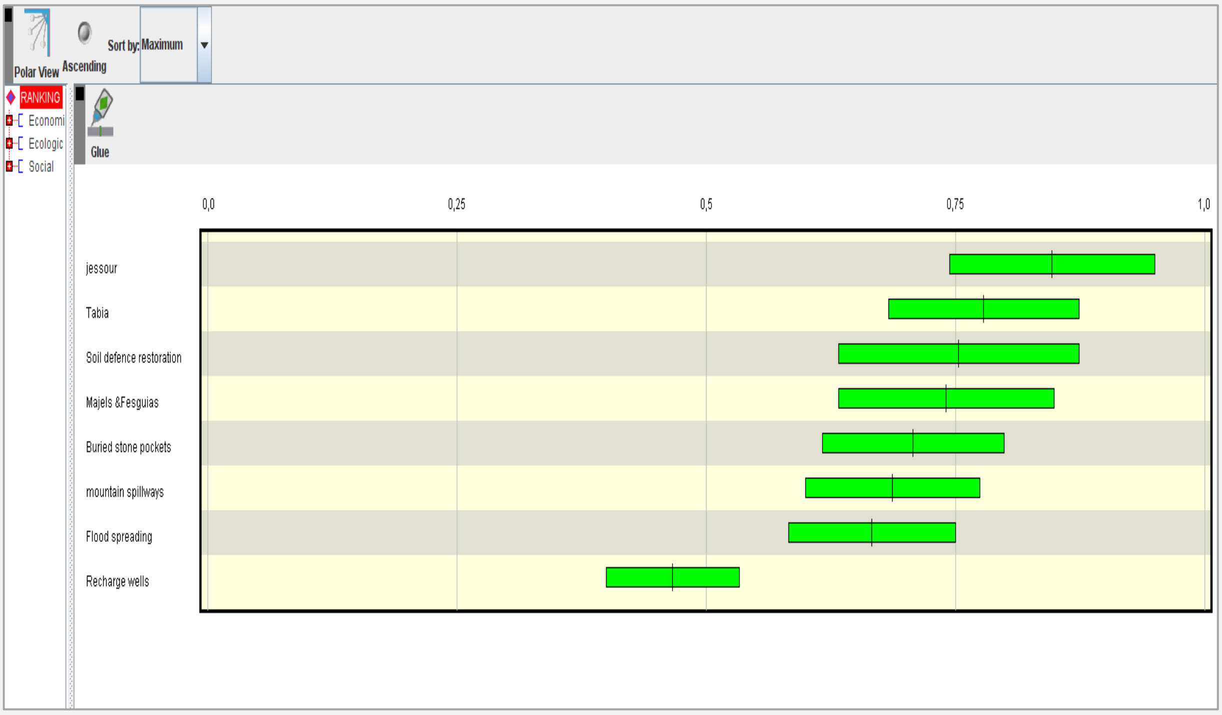

Figure 6: Global multicriteria prioritization of options

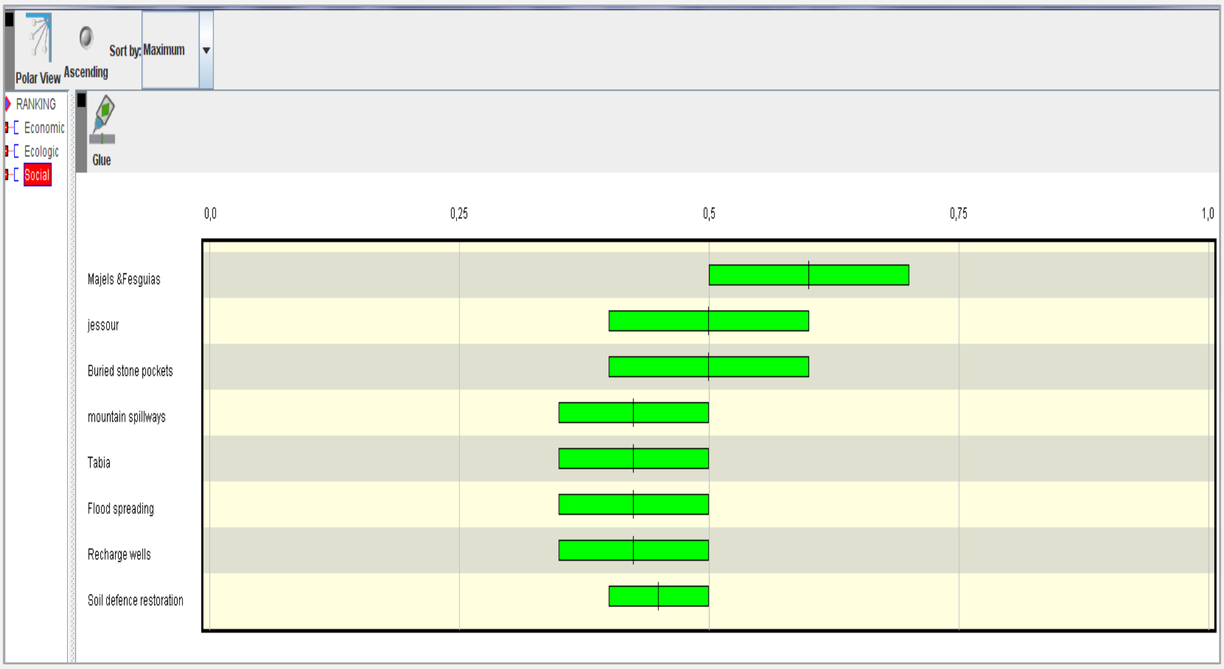

Figure 7: Social multicriteria prioritization of options

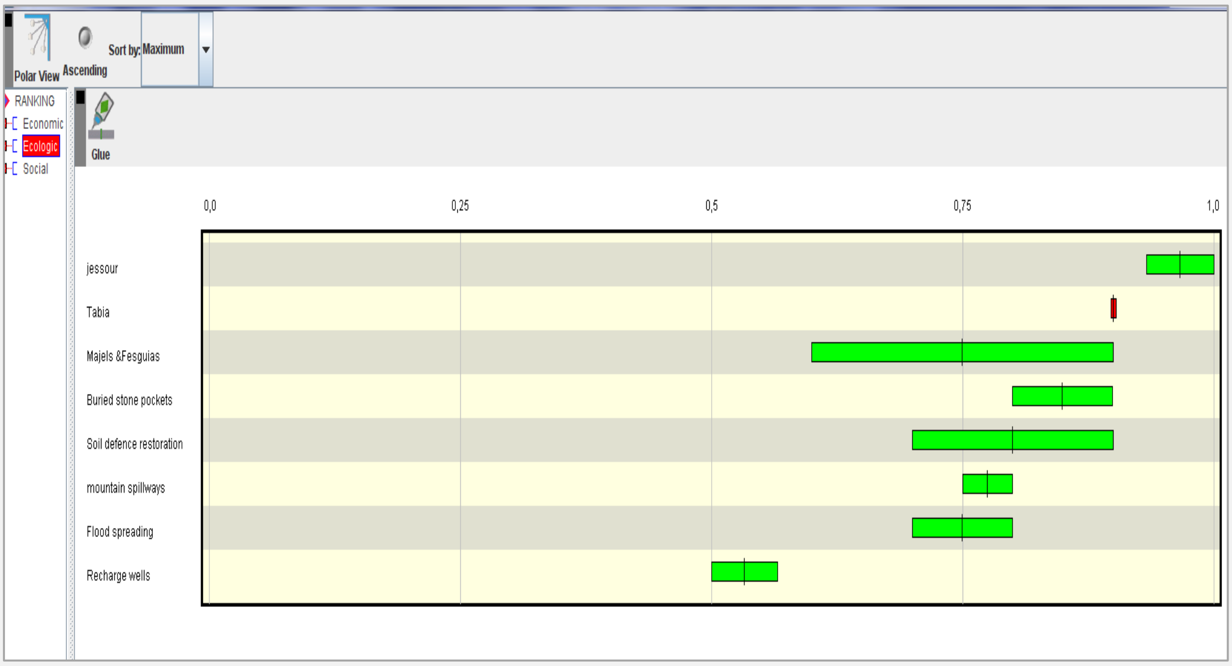

Figure 8: Ecologic multicriteria prioritization of options

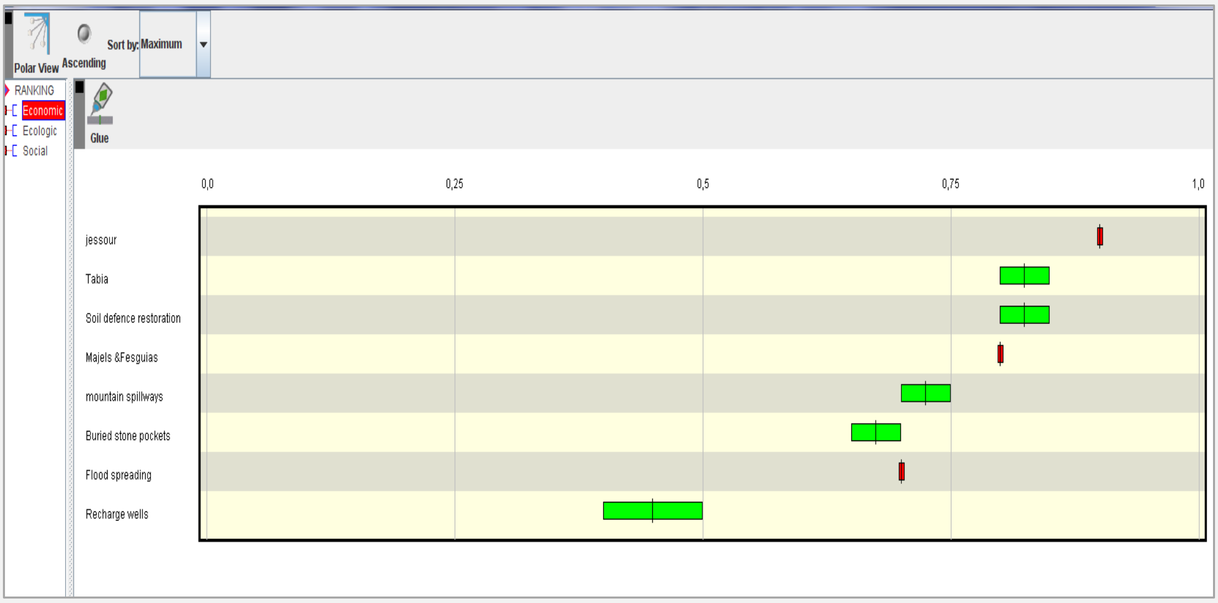

Figure 9: Economic multicriteria prioritization of options

3.3.2. Multicriteria prioritization of RWH techniques in the middle stream compartment

Results showed that Mejels and Fesguias then Tabias and Jessour are the most common practices in the piedmont area (figure 10). Socially, RWH techniques are classified by priority as follows: Mejels and Fesguias, mountain spillways, buried stone pockets and Tabias. This prioritization is confirmed by the interviewees given the role of these structures to fight against the rural exodus and to create employments. Ecologically, Mejels and Fesguias are considered very effective, followed by Tabias and Jessours. Likewise, the interviewees confirm this fact given the role of these techniques in the collection of water, protects their lands against erosion and increases the soil fertility. Economically, Tabias, Mejels and Fesguias are the most widely used. This classification is validated by the interviwees, who declare that the costs of their plant production have decreased by 50% when they used Tabias and 40% with the installation of the Mejels and Fesguias.

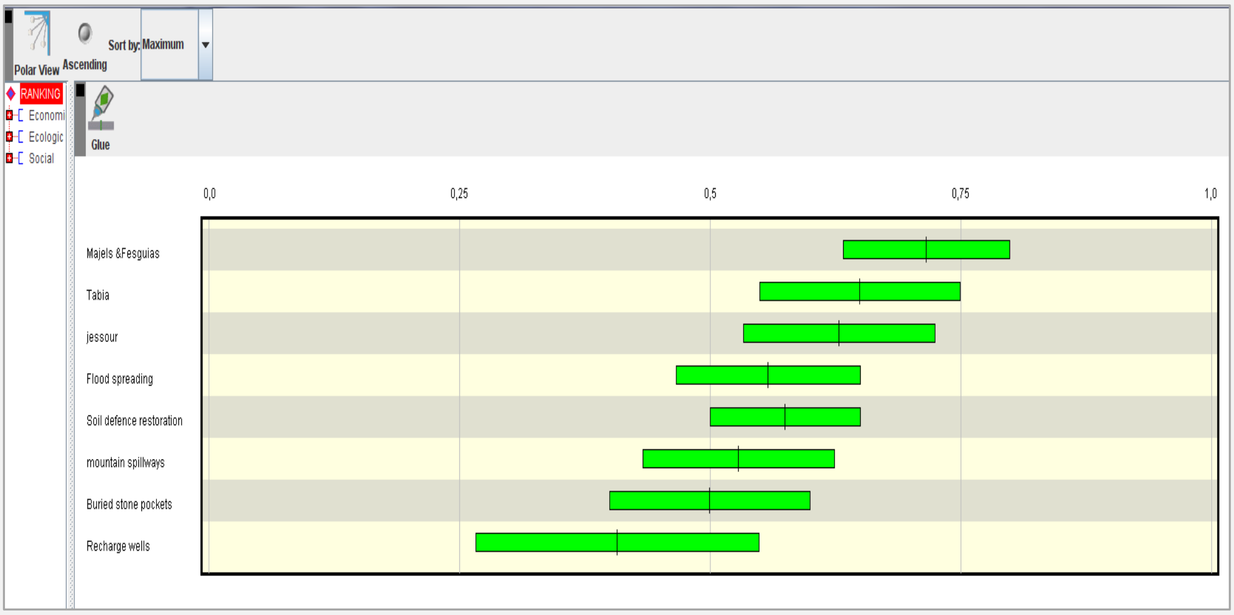

Figure 10: Global multicriteria prioritization of options

3.3.3. Multicriteria prioritization of RWH techniques in the downstream compartment

Flood spreading, buried stone pockets and Tabias are the most important practices from a social, ecological and economic point of view in the downstream compartment (figure 11). Socially based, the local population classified flood spreading techniques in the first place followed by the mountain spillways and the buried stone pockets. From an ecological point of view, such a classification, which first places buried stone pockets and secondly the flood spreading is validated by the interviewees. Those techniques allow to control runoff, to replenish the aquifers and therefore to protect the soil against erosion. The economic prioritization ranked the flood spreading and Tabias in the first rank. This result is validated by the respondents, given the role of these techniques in increasing crop production, by comparing the situation between before and after the installation of the flood spreading structures; 90% of respondents declare that crop production has increased.

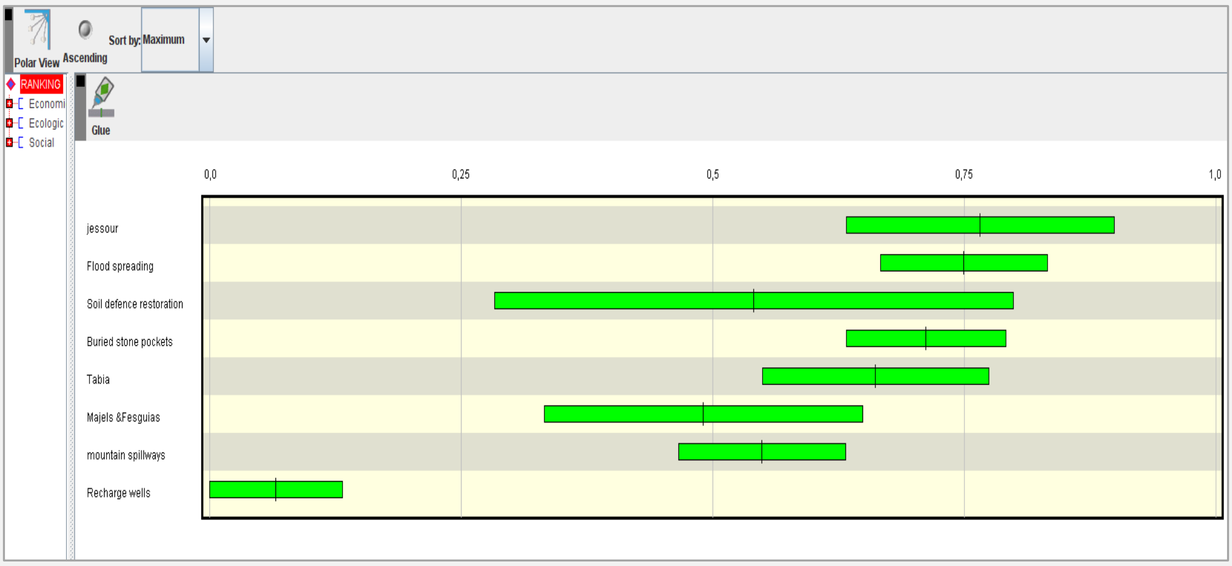

Figure 11: Global multicriteria prioritization of options

4. Conclusion

Medium-term planning of rainwater harvesting techniques in Oum Zessar watershed poses a problem in selecting and prioritizing appropriate technologies in arid areas. This prioritization relates to multiple economic, ecological and also social factors. The multi-criteria approach is suggested to reduce these discrepancies and improve the effectiveness of the conservation of water and soil. The present study found that WOCAT multicriteria analysis was a very useful tool for combining diverse factors to prioritize RWH techniques.

Results show that, farmer's age, gender, perception of the importance of the technology, education level, residence, household size, agricultural activity, exploitation size, farmer's income, implementation and maintenance cost, slope and the perception of erosion are the most socioeconomic and ecological determinants of adoption of RWH techniques. The results of evaluation and prioritization of RWH techniques have shown that Tabias and Mejels and Fesguias are prioritized as the best RWH techniques in the three compartments followed by buried stone pockets in the upstream and downstream compartments and weirs mountainous in the piedmont area. Which indicates that RWH alternatives should be promoted based on farmers preferences and specific socioeconomic and ecological conditions.

Multi-criteria techniques constitute an effective decision-making tool for the protection and conservation of soil and water, and suggested as an approach to guide decisions in the field of RWH other than the cost-benefit evaluation which takes into account only quantitative aspects of RWH. The prioritizing of RWH techniques allow to determine suitable maps for potential RWH techniques. The suitability map will be useful to hydrologists, decision makers and planners for quickly determining areas that have RWH potential.

Acknowledgments

The authors address their acknowledgments to two blinded reviewers. Their comments and suggestions have incontestably improved the manuscript quality.

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