Chapter 1

Selection and Characterization Of the *Badia* Benchmark research site

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How suitable an area is for WH depends on local society, farming practices, and whether the area meets the basic technical requirements of the WH system in question. When planning such systems, appropriate data must be available on the climate, soil, crops, topography, and socioeconomics of the project area. The available tools and methods of data acquisition for planning, designing, and implementing WH systems, include field visits, site inspections, topographic and thematic maps, aerial photos, satellite images, and geographic information systems (GIS) must also be considered.

1.1 Selection of the watersheds

1.1.1 Watershed selection process

During the early stages of the project, emphasis was placed on the fact that the approach used was multi-disciplinary and integrated technology, management, institutions, and research. It was also agreed that the final selection of the potential watershed sites should match certain criteria. These were divided into three major groups: (i) target area criteria, (ii) watershed criteria, and (iii) community criteria. These criteria are listed below under the relevant group.

Group 1. target area criteria:

- The area must have an annual rainfall of 100–250 mm
- The area must consist of rangeland where the barley–livestock-based land-use system predominates other land use systems
- Livestock production must be the main farming enterprise
- The land must be degraded (displaying low vegetative cover, soil erosion, and low levels of soil organic matter)
- There must be a shortage of feed
- The adoption rates for improved technologies must be low
- Levels of public and private investment must be low

Group 2. watershed criteria:

- The area must be representative of the major physical and social characteristics of the *Badia*
- There must be communities in the upper, mid, and lower part of the watershed
- The potential for WH must exist
- A rangeland-based land-use system must dominate
- The potential must exist for halting/reducing land degradation at a relatively low cost
- The area must display multiple rangeland uses
- The area must be 30–150 km^2
- The area must encompass both private and communal natural resources
- Land ownership in the area must include both private and government land
- Rangeland use must involve open access
- The area must have been exposed to other projects
- The potential must exist for the project to have a noticeable impact in the area
- The area must be easily accessible
- Basic data and previous studies must be available for the area

Group 3. community criteria:

- The community chosen must be poor
- The community must be committed to participating in the project
- Institutions (informal and/or formal) must exist
- A range of livestock-production systems must exist, from transhumant to sedentary systems
- Agriculture must play a significant role in household income-earning
- There must be access to government/ development projects

These criteria were suggested by an interdisciplinary team of specialists. However, while they are obviously very important for the success of the project, it must be recognized that selecting a watershed (or watersheds), which satisfies all these criteria would not be an easy task. Importantly, it was also recognized that the selection process should be simple, so that it could be easily reproduced in other similar areas.

Accordingly, the watershed-selection process was divided into the following sub-components:

- Scoring and weighting of the selection criteria
- Selection of potential watersheds (three stages)
- Rapid rural, hydrological, and environmental appraisals of the most promising watershed(s)
- Data management and manipulation
- Integration of sub-components 2–5 for the purposes of final selection

An integral part of the above sub-components were continuous field visits and verification by the inter-disciplinary team. The field visits were meant to verify GIS and remote-sensing information (maps, images, and other information) and to conduct ground-truthing. Most importantly, these field visits were also meant to provide greater insight into local communities at the project sites. The technical approach applied in the site-selection process is outlined in Chart 1.1.

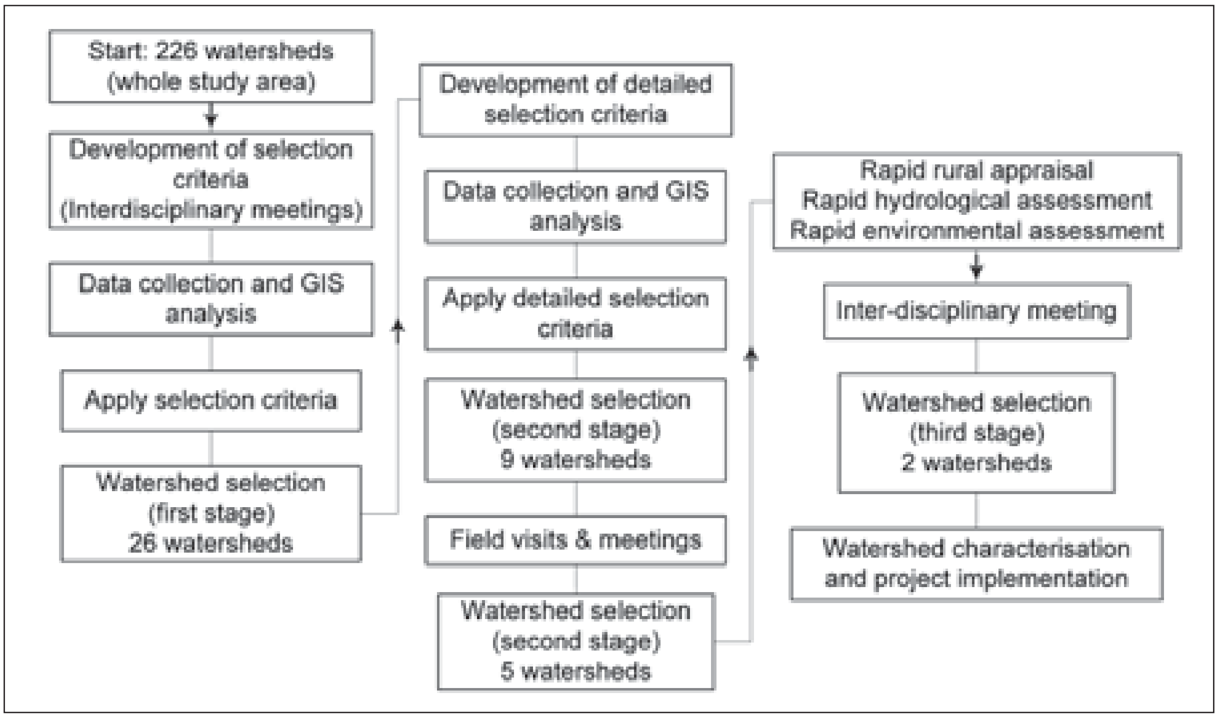


Chart 1.1 Flowchart of the watershed-selection process.

1.1.2 Development of selection criteria

The criteria and its application for the first stage of selection

The watershed selection criteria agreed upon at an early stage of the project were chosen and revised by a multi-disciplinary team of experts in several meetings. To be selected, watersheds had to satisfy a scoring of five main criteria (Table 1.1).

Rainfall was considered the most important factor at this stage, as it is integral to the definition of the study area. It was, therefore, agreed that areas receiving either < 100 mm or > 250 mm of annual rainfall should be excluded, and hence were given a score of zero (Table 1.1).

The basic map used in various analyses showed the subdivisions of each watershed. This map was developed from the hardcopies of topographic maps (scale 1:50 000) produced during a previous project (Jordan Arid Zone Productivity Project) conducted by the University of Jordan.

Contour lines and streams were used to define the boundaries of each main watershed and the sub-watersheds found throughout the transitional Badia (100–200 mm rainfall).

The output indicated that the Badia was covered by 226 main watersheds with range in area of 0.3–266 km^2. It would be very difficult to work with such a large number of watersheds; therefore, the criteria assigned for the first stage (Table 1.1), which were very general in nature, were applied to exclude unsuitable watersheds.

A large number of watersheds received a final score of zero (Figure 1.1). However, these watersheds should not necessarily be considered unsuitable for other research activities in the Badia, despite being unsuited to this project. Of the 226 watersheds, 158 were excluded, thus leaving 68 for further consideration (Table 1.2). Forty of the watersheds had scores of 60, 65, or 70, the three highest scores obtained. These were considered for further investigation. Some, however, were then excluded because their boundaries extended into Syria, something which could complicate project activities (Figure 1.2). Other watersheds were excluded because much of their area fell outside the Badia, leaving 26 watersheds (Figure 1.3).

The criteria and its application for the second stage of site selection

The second stage of site selection required the researchers to apply more rigorous

Table 1.1. Scoring criteria used in the first stage of site selection.

Criterion	Score*			
	0	5	10	15
Rainfall (mm/y), obtained from isohyets	< 100 or > 250	100–149	200–250	150–199
Presence of communities (no. of villages)	None	One	Two	> Two
Soil type (dominant soil)	Lithic, Calcic, Psamment	Lithic and/or Psamment	Calcic	Other
Watershed area (km^2)	< 30	110–150	30–70	70–110
Topography (relative relief, m)	> 200	100–200	50–100	< 50

Note: * If assigned a score of zero, the watershed was excluded.

Table 1.2. Final scoring (first stage) after excluding watersheds with scores of zero.

Watershed number	Area score	Rainfall score	Community score	Soil score	Topography score	Final score	Watershed number	Area score	Rainfall score	Community score	Soil score	Topography score	Final Score	Watershed number	Area score	Rainfall score	Community score	Soil score	Topography score	Final score
18	15	15	15	15	10	**70**	16	15	10	5	15	15	**60**	189	5	15	15	10	10	**55**
19	15	15	15	15	10	**70**	17	10	15	10	15	10	**60**	200	10	15	15	10	5	**55**
35	10	15	15	15	15	**70**	29	15	15	5	15	10	**60**	38	10	15	5	5	15	**50**
36	15	15	15	10	15	**70**	33	10	10	15	10	15	**60**	90	5	15	5	10	15	**50**
37	15	15	15	10	15	**70**	51	5	15	15	10	15	**60**	129	15	10	5	15	5	**50**
50	15	15	15	10	15	**70**	55	10	10	15	10	15	**60**	132	15	5	5	15	10	**50**
54	15	10	15	15	15	**70**	57	10	10	15	10	15	**60**	136	15	5	5	15	10	**50**
61	15	15	15	10	15	**70**	58	10	10	15	15	10	**60**	148	5	15	5	15	10	**50**
62	15	15	15	10	15	**70**	79	15	15	10	10	10	**60**	152	10	5	5	15	15	**50**
190	15	15	15	15	10	**70**	108	10	10	15	15	10	**60**	167	10	5	10	15	10	**50**
27	15	10	15	15	10	**65**	120	15	15	5	15	10	**60**	169	10	5	5	15	15	**50**
28	15	10	15	15	10	**65**	125	10	15	5	15	15	**60**	184	5	10	15	10	10	**50**
30	5	15	15	15	15	**65**	173	15	15	5	15	10	**60**	186	10	15	5	10	10	**50**
31	10	10	15	15	15	**65**	174	15	15	5	15	10	**60**	187	5	10	15	10	10	**50**
34	15	10	15	10	15	**65**	182	15	15	5	15	10	**60**	192	10	15	5	15	5	**50**
59	15	10	15	15	10	**65**	197	10	15	15	15	5	**60**	161	10	10	5	15	5	**45**
103	15	10	10	15	15	**65**	199	10	15	15	15	5	**60**	164	10	5	5	15	10	**45**
121	15	10	15	15	10	**65**	15	5	10	15	15	10	**55**	191	15	5	5	10	10	**45**
122	10	10	15	15	15	**65**	65	5	15	15	5	15	**55**	195	10	15	5	10	5	**45**
123	10	10	15	15	15	**65**	78	5	15	15	10	10	**55**	215	10	15	10	5	5	**45**
128	15	10	15	15	10	**65**	117	10	10	10	15	10	**55**	77	10	5	5	10	10	**40**
193	15	15	15	15	5	**65**	118	15	10	5	15	10	**55**	196	15	5	5	10	5	**40**
13	10	10	15	15	10	**60**	179	10	15	5	15	10	**55**							

Note: Bold text for each individual score per watershed signifies watersheds in Figure 1.1 whose boundaries did not fall outside the Badia, or outside the country.

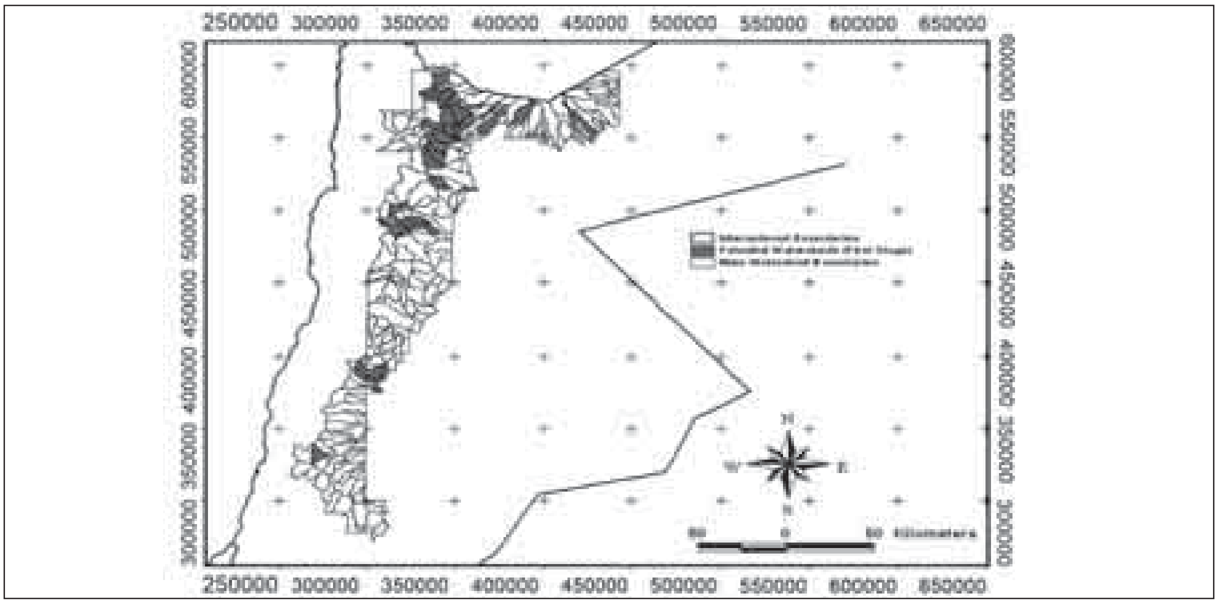


Figure1.1. Final selection of potential watersheds (first stage).

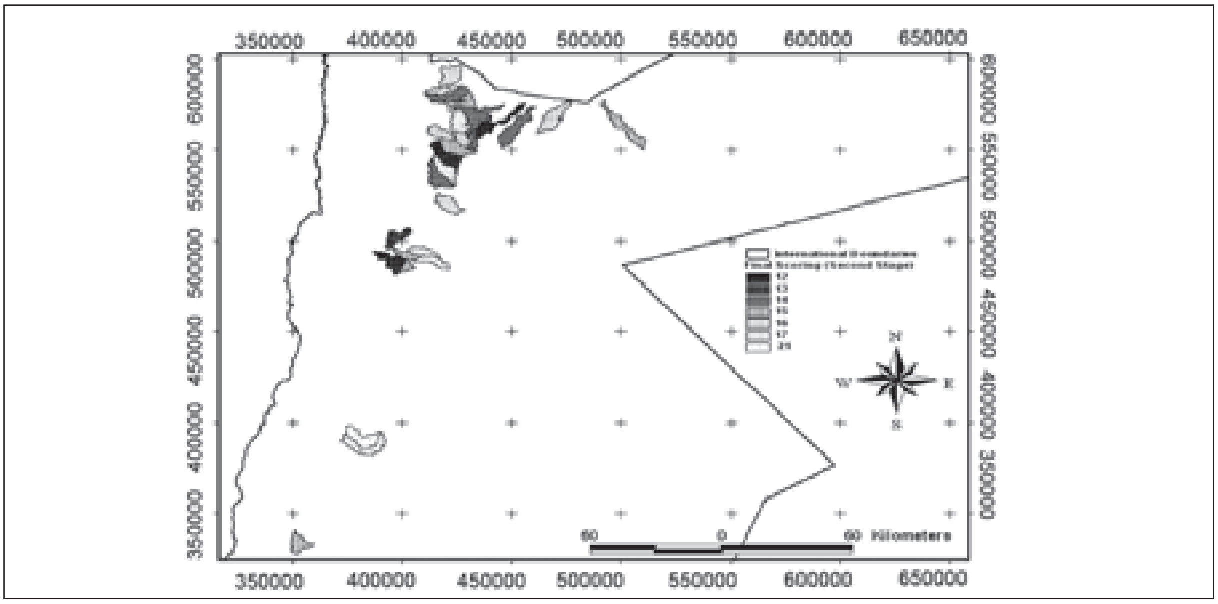


Figure1.2. Distribution of watersheds with different final scores (second stage).

criteria to the watersheds selected in the first stage. Those watersheds given a score of zero for any of the five selection criteria in the first stage were excluded. The rankings assigned to the revised selection criteria used in the second stage are given in (Table 1.3) and are discussed below.

The final scores were calculated for each of the 26 watersheds (Table 1.4) based on the eight selection criteria considered in the second stage.

The best possible score for a watershed was 8 (i.e. all criteria scored 1) and the worst was 32 (i.e. all criteria scored 4). The 26 water-

Table 1.3. Scoring of criteria for the second stage of the site selection process.

Potential for WH	4th (lowest score)	3rd	2nd	1st (highest score)
Soil depth (cm)	< 50	50–100	100–200	> 200
Slope steepness	< 1% or > 10%	8–10%	5–8%	1–5%
Community (location in watershed)	Upper and/or middle	Lower and/or middle	Upper and lower	Upper, middle and lower
Rangeland-based system	Irrigated agriculture dominates	Lack of native vegetation and barley	Native vegetation and barley dominates	Native vegetation dominates
Land use	Field crops	Bare	Range–barley–livestock-based system	Range–livestock-based system
Watershed area (km^2)		110–150	30–70	70–110
Accessibility and visibility	Not connected to roads	Connected only on one part	One road passing through watershed	Road network inside and main road passing through
Land tenure		Government	Private	Private and government
Basic data	Not available and no previous studies	Insufficient and previous studies	Available and previous studies	Available

sheds tended to have high scores (Table 1.4): the highest score for suitability was 12 and the lowest was 21, indicating that all watersheds selected in the first stage had the potential to satisfy the project's purposes.

The distribution of watersheds and their final scores is illustrated in (Figure 1.2).

Nine watersheds (those with scores of 12–14) were selected, with their spatial distribution providing a reasonably comprehensive coverage of the Badia (Figure 1.2).

Table 1.4. Final scores for the second-stage selection.

Watershed Number	Soil depth	Slope steepness	Community	Accessibility and visibility	Watershed area	Rangeland system	Land use	Land tenure	Final* score
19	3	2	1	1	1	1	1	2	12
36	3	1	1	1	1	1	2	2	12
128	3	1	1	1	1	2	2	1	12
108	3	2	1	1	2	1	2	1	13
28	3	2	1	1	1	2	2	2	14
30	3	1	1	1	3	1	2	2	14
35	3	1	2	1	2	1	2	2	14
51	3	1	2	1	3	1	1	2	14
59	3	1	1	1	1	1	4	2	14
18	3	2	4	1	1	1	1	2	15
31	3	1	1	1	2	1	4	2	15
79	4	1	4	1	1	1	1	2	15
123	3	2	1	1	2	2	2	2	15
199	3	3	1	1	2	1	2	2	15
13	4	3	1	1	2	1	2	2	16
17	3	2	3	1	2	1	2	2	16
54	3	2	1	1	1	2	4	2	16
58	4	2	1	1	2	2	2	2	16
62	4	1	1	1	1	2	4	2	16
103	4	1	4	1	1	1	2	2	16
16	3	2	4	2	1	1	2	2	17
29	3	2	3	3	1	2	1	2	17
122	3	2	2	2	2	2	2	2	17
125	3	1	4	1	2	2	2	2	17
174	4	2	4	1	1	1	2	2	17
173	4	4	4	3	1	1	2	2	21

Note: * Low scores indicate higher potential for WH.

1.1.3 Field visits and outcomes

For the purposes of organizing the study, a detailed map was prepared for each of the nine watersheds and distributed to the whole project team. The maps show both the boundaries of each watershed as well as the network of roads. They also show villages and provide a coordinate grid. They helped investigators to navigate in the field and also to gather useful information about the watersheds, such as the actual distribution of communities.

The final decision regarding the selection or rejection of a watershed was made once all field visits for all the watersheds had been completed and the information gathered had been reviewed. Certain issues were highlighted by the team members during the field visits, some of which are listed below.

The large number of urban areas found within most of the watersheds visited was considered a disadvantage for some project activities.
The high concentration of irrigated farms within some watersheds was considered a disadvantage as WH would be less popular than intensive irrigated agriculture and so could not compete with it.

It has been also argued that most of the watersheds visited represent transitional Badia and are not typical of 'rangeland'. As a result of the issues discussed above, the team revised the scoring system for the community criterion and identified additional watersheds to be added to the nine watersheds already selected. The final scores obtained for the first stage of selection were recalculated to exclude the community score (i.e. the watershed scores without taking into account the community criterion). The distribution of the retained watersheds is presented in (Figure 1.3).

1.1.4 Final selection

The team held a final meeting after the field visits. During this, the results of the field visits were thoroughly discussed in order to determine which watersheds should be advanced to the third stage of the selection process.

The team started the discussion (i) by considering all the watersheds and then eliminating those they felt had any disadvantages, and (ii) by arranging the rest of the watersheds according to an agreed scaling methodology.

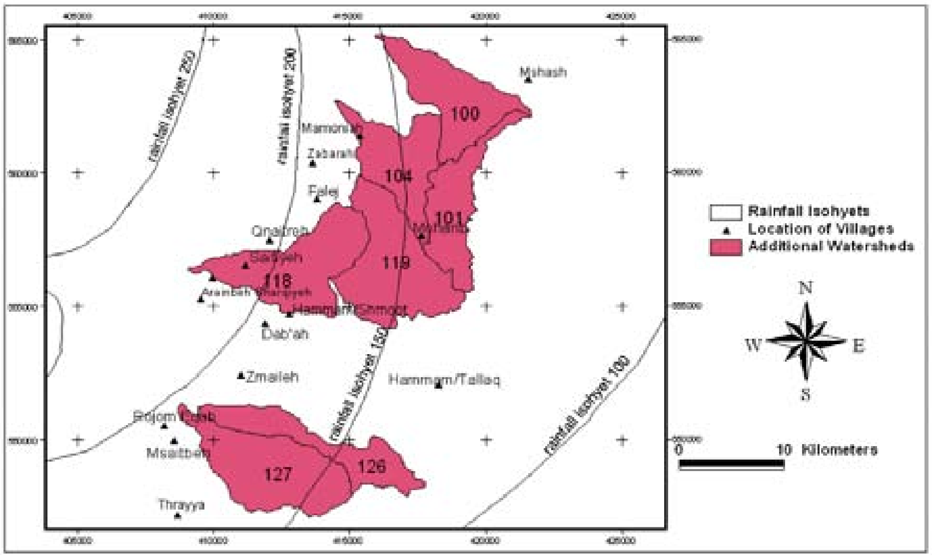


Figure1.3. Watersheds selected after revising the community criterion.

The aim of this process was to summarize the observations made in the field into rational items relevant to the project. These items fall under three major headings: biophysical factors, WH-related factors, and socioeconomic aspects.

Watershed number 128 was excluded for further consideration (in the third stage) due to its very low scores compared with the other watersheds considered (Table 1.5). In addition, watersheds 30 and 31 were combined, as they were adjacent and complemented each other in many respects. Ultimately, this stage of selection yielded a total of five watersheds (30 and 31, 59, 108, 104, and 119) which were further evaluated in the third stage.

1.1.5 Third stage – selection of the final stage

The third stage of the site-selection process included the detailed investigation of (i) socioeconomic issues (through Rapid Rural Appriasal), (ii) hydrological issues, and (iii) environmental issues (through impact assessments). All available information concerning the five watersheds was provided to the socioeconomic specialists responsible for undertaking each type of assessment.

1.1.6 Final decision

The results of the above three investigations were synthesized to allow the multidisciplinary project team to reach a final decision. The team then met and discussed the whole site-selection process, paying particular attention to the following:

- The project's evaluation of the communities in each watershed
- The biophysical conditions within each watershed
- The degree to which each area was representative of the Badia
- Any obvious hydrological and environmental impacts

Ultimately, it was decided that two watersheds would be necessary to undertake project activities and that these should be representative of the wide range of conditions (biophysical and socioeconomic) found in the Badia. Consequently, watershed 104 was selected as the main watershed for the project, and watershed 59 as a supplementary watershed (Figure 1.4).

Table 1.5. Ranking of the potential watersheds.

	Watershed number					
Criterion	**128**	**30 and 31**	**59**	**108**	**104**	**119**
Production system	1	2	2	2	3	3
Community	3	3	3	3	1	0
Urbanization	–3	–2	–2	–3	0	–1
Institutions	?	?	?	?	?	?
Development projects	?	?	?	?	?	?
Scaling-out potential	1	2	2	3	3	3
Competitiveness of WH	1	2	2	2	3	2
Total score	3	7	7	7	10	7

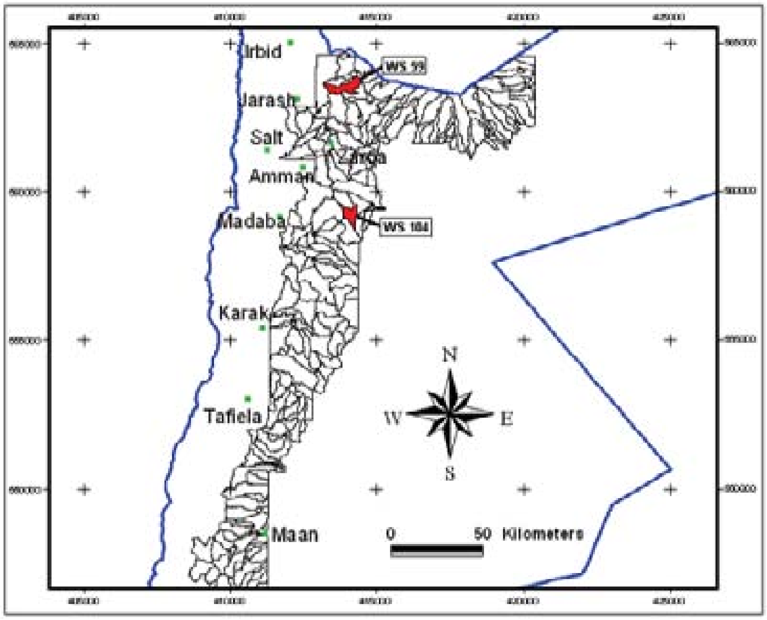


Figure1.4. The location of watersheds 104 and 59.

1.2 Characterization of the selected watersheds

1.2.1 Development of the suitability maps for water harvesting (WH) interventions

Watershed characterization aimed to provide data for the selection of sites suited to various WH interventions. To this end, data were collected from two watersheds (i.e. 59 and 104).

The main purpose of the characterization was to provide a suitability map showing the distribution of areas suited, from a biophysical point of view, to the various WHTs the project would implement within the watershed. The process emphasized the need for each unit to be suited to more than one type of intervention, in order to leave room to include socioeconomic issues in the selection process. In each case the intervention selected for an area must be acceptable biophysically, socially, and economically.

The sources of data used for the characterization of the selected watersheds were the Royal Jordanian Geographic Center for topographic and slope maps, and the Department of Land and Surveying for cadastral maps and data collection in the field. Suitability maps for WH interventions were then developed. The procedures and outcomes are detailed in a separate published report on Ziadat et al. (2006).

1.2.2 Watershed biophysical characterization (details described in Ziadat et al., 2006)

The dry rangelands of West Asia and North Africa are fragile and severely degraded due to low rainfall, drought, and mismanagement of natural resources. WHTs are used to improve soil moisture and hence vegetation cover and productivity in this environment. However, adoption of WHTs by the communities in the area is slow. To understand the constraints to adoption and to develop options for rapid and sustainable integration of WHTs within existing agro-pastoral systems, a benchmark watershed was established in the dry rangelands of Jordan. A methodology for identifying the suitability of different WHTs to various conditions at the watershed level was developed. The main biophysical parameters used to assess the suitability for WH in this environment were rainfall, slope, soil depth, soil texture, and stoniness. Criteria for each parameter were integrated and a suitability map was produced in a GIS environment. The suitability map was superimposed with land tenure and other ancillary maps. These maps were used to identify options for implementation of different WHTs with the local communities. Field investigations revealed that the applied approach helped in selection of the most promising fields. Within two years, four types of WH interventions were implemented in the fields of 41 farmers with a total area of 62.9 ha and in close collaboration with the local community. This approach showed that GIS may be used to integrate biophysical and socio-economic criteria to facilitate the selection of land that is suitable for implementing new land use alternatives. This ensures sustainable integration of WH interventions in the dry rangeland systems.

1.2.3 Study site and approach

The research site, named Mharib, is located in the eastern part of Amman district in Jordan within 31º39'–31º43' N and 36º12'–36º 18' E (Figure 1.5). The watershed has an area of approximately 60 km^2, within the xeric–aridic transitional moisture regime where annual rainfall range is 100–150 mm (Jordan transitional Badia). The major geologic formation is very finely dissected limestone, chert, and marl. The soils are highly calcareous and weakly saline, and have high silt contents, hard crusts, and weak aggregation on the surface layer. They are classified as Xerocherptic

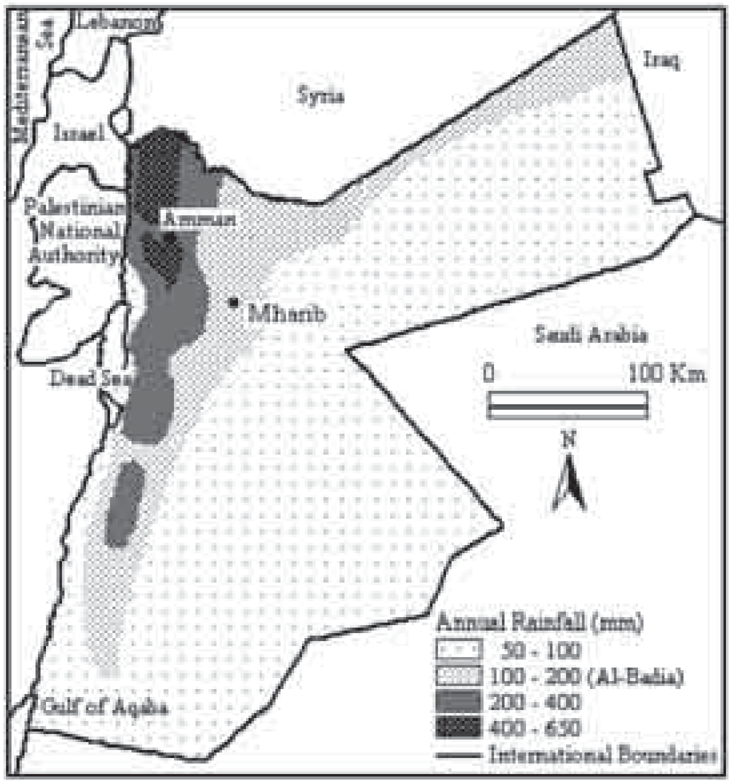


Figure1.5. Location of the study site (Mharib watershed) within the Jordanian transitional Badia.

Haplocambids and Haplocalcids (MoA, 1995). About 75% of the study area has shallow soils (< 50 cm) and slope gradients < 12%. The remaining part of study area has medium deep and deep soils with depth range of 50–140 cm. Rock outcrops cover 10% of the study area (MoA, 1995).

The elevation is 676–925 m above sea level. The watershed has rounded hills and crests, with steep upper slopes. Alluvial and colluvial fans merge downslope to fill the valleys. The watershed is characterized by highly degraded steppe vegetation, and barley is grown in the valley bottom and along the slopes where the moisture from the limited rainfall is augmented by runoff from the hill slopes. Barley and uncultivated land are the main land cover/land use types in the area. The dominant natural vegetation species are *Anabasis syriaca* and *Poa bulbosa*. The natural vegetation cover is degraded due to cultivation, overgrazing, and wood cutting.

A suitability analysis was undertaken to identify areas biophysically suitable for different WHTs. The process consists of three steps: (1) determining the bio-physical requirements of different WHTs, (2) biophysical characterization of land units, and (3) identification of areas suitable for WH interventions by matching steps (1) and (2).

a) Requirements for WH: The criteria used to determine the requirements of different WH interventions were: slope, soil depth, soil texture, vegetation cover, stoniness of the soil surface, and farm-size (Oweis et al., 2001) – discussions among an inter-disciplinary team of researchers led to some modifications of these criteria. For each criterion there were two ratings ('best' and 'second best' options), intended to provide more flexibility when determining the suitability of an intervention, and allowing for the incorporation of socioeconomic factors at a later stage. For example, if the land was suitable for three different interventions, the land user could select one of them based on his/her own preferences and needs. The final criteria agreed upon by the inter-disciplinary team of researchers are summarized in (Table 1.6).

b) Characterization of land units: The data required for the bio-physical characterization of the watershed were partly obtained from available data and from a dedicated field survey. Contour lines, stream lines, and spot heights were extracted from topographic maps (scale 1:50 000). A digital elevation model (DEM) with a 20-m resolution was generated from the contour lines and spot heights.

A slope map was derived from the DEM. The Arc/Info standard command 'SLOPE' was used to derive the slope grid. A 5 × 5 average (smoothing) filter was applied to clean the layer of small (suspicious) units.

The grid was then converted into polygons for subsequent analyses. Slope units (slope 1–18%) derived from this step were used as basic land-mapping units for the suitability analysis. Theoretically, soil mapping units should be used; however, this was not possible as the soil map available for the area (scale 1:250 000) provided insufficient detail. Fortunately, in the study area there was a strong relationship between slope steepness and the distribution of soils (Taimeh, 1989; Ziadat et al., 2003). In addition, slope steepness is one of the most important criteria for the selection and implementation of WH interventions.

The absence of detailed soil data is a common problem in arid areas. A field survey was designed to provide information on the relevant biophysical factors in the watershed. Samples were collected using a combination of two methods of sampling: free sampling and grid sampling. Grids composed of uniformly-sized cells were used (500 m × 500 m). One field observation was taken from each grid cell. To avoid an un-representative site being sampled, the surveyor was free to select the best site within each cell. This also ensured that the various conditions within

Table 1.6. Guidelines for selecting WHTs (modified from Oweis et al. 2001).

Technique	Crop	Soil						Land cover				Socio-economics	
		Depth (1)		Texture		Land slope (2)		Vegetation (3)		Stoniness (4)		Farm size (5)	
		P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2
Contour ridges	Range	shl	med	med	var	med	steep	poor	med	med	low	var	var
	Field	med	deep	med	var	low	med	poor	poor	low	low	sml	med
	Trees	deep	deep	heavy	med	med	low	poor	poor	low	med	sml	med
Semi-circular and triangular bunds	Range	shl	med	var	var	med	low	poor	med	med	low	var	var
	Field	med	deep	med	heavy	low	med	poor	poor	low	low	sml	med
Small basins	Trees	deep	deep	heavy	med	low	low	poor	med	low	med	sml	sml
Runoff strips	Range	med	var	med	var	med	low	poor	med	med	var	med	var
	Field	deep	med	med	med	low	med	poor	poor	low	med	sml	med
Inter-row system	Trees	deep	deep	heavy	med	low	low	poor	med	low	med	sml	med
Contour bench ter-races	Trees	deep	med	heavy	heavy	steep	med	poor	med	low	med	sml	med
	Field	deep	med	heavy	var	steep	med	poor	poor	low	med	sml	med
Narrow-base contour terreces (Gradon)	Trees	deep	deep	med	heavy	steep	med	poor	med	low	low	sml	med
	Range	deep	med	med	var	med	steep	med	dense	low	med	med	var

Notes: P1= best conditions for this intervention (first priority), P2 =second-best conditions for this intervention (second priority)
(1) shl <50 cm, med: 50-100 cm, deep > 100 cm: (2) low < 4%, med: 4-12%, steep > 12%; (3) poor < 15%, med: 15-30%, dense > 30%; (4) low < 10%, med: 10-25%, high > 25%; (5) sml < 5 ha, med: 5-25 ha, large > 25 ha

the watershed were sampled by distributing the sampling evenly across the grids. The location of the sampling points was recorded with a GPS. The total number of sampling sites was 160. The following parameters were recorded for each field observation:

- Surface cover of stones (percentage stoniness)
- Vegetation type and coverage (visual estimation)
- Texture of the soil surface horizon (estimated by touch)
- Soil depth (cm): boreholes involved the digging of small 'chisel pits' to 40–50-cm depth, followed by augering to the auger's maximum depth or to an impeding layer (rock or large stones).

The Inverse Distance Weighted (IDW) interpolator of ArcView Spatial Analyst 3.2 was used to produce a continuous surface (grid file) of soil depth, stone percentage, soil texture, and vegetation cover. The interpolated grids were intersected with each other and with the slope-unit map. For each slope-unit the value of each variable was defined accordingly to provide a biophysical characterization of each unit.

c) Biophysical suitability for WH interventions: The criteria listed in (Table 1.6) were applied to each characterized slope-unit. The results in a row (Table 1.6) for each mapping unit and number of columns represent combinations of different WH interventions, each with different crop types (trees, field crops, and rangeland vegetation). For some cases two options were considered: best and second-best. In each column, the mapping units suited to the relevant intervention were marked with the symbol S1 (suitable), while those not suited to a particular intervention were assigned NS (not suitable). These data were compiled together to produce a biophysical suitability map of the watershed.

The biophysical suitability map (figure 1.7) was overlaid with the cadastral map to incorporate the area of the parcel as a final criterion for selection, resulting in a final WH suitability map. This is crucial for interventions that require a minimum area for successful implementation. The cadastral map was also used to identify the owner(s) of land suited for particular WH intervention(s). The socioeconomic team used this information to approach the relevant owner(s) and inquire about their interest in applying the recommended WH interventions in their land.

1.2.4 Findings and discussion

Interpolations for soil depth, stone percentage, soil texture, and vegetation cover were made for Mharib watershed (Figure 1.6), with the classes representing the values of each attribute as shown in (Table 1.6). The intersection of these grids with the slope-unit grid provides a biophysical characterization of each slope unit. Matching the requirements for various WHTs with

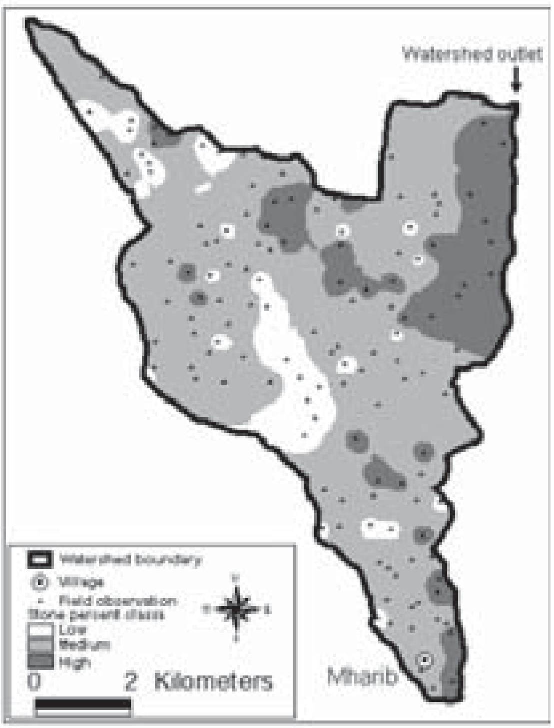


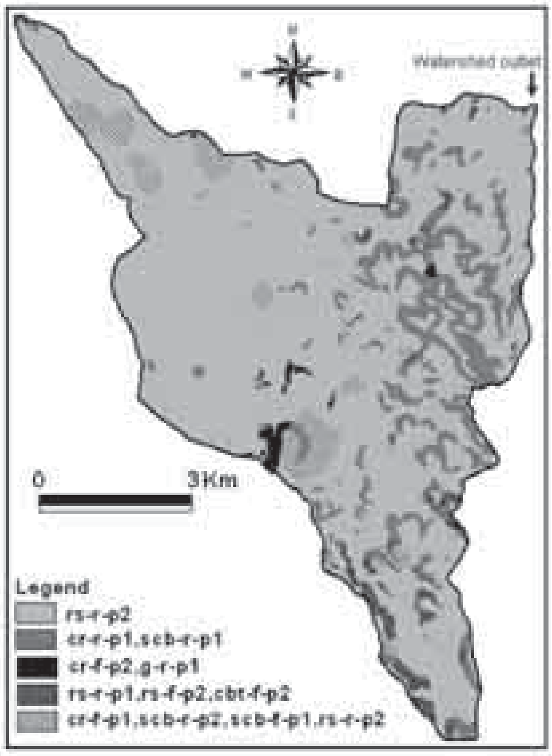
Figure 1.6. Surface stone cover classes (low < 10%, medium 10–25%, and high > 25%) in Mharib watershed, interpolated from field observations with the IDW method.

the characteristics of each slope-unit thus generated the biophysical suitability map of the watershed (Figure 1.7) – the abbreviations used in the legend are explained in (Table 1.7).

The team undertook several field visits to randomly selected sites to match the land suitability results with field suitability for various WH interventions. These visits indicated an acceptable agreement between land suitability from maps and those judged in the field.

A multi-disciplinary team visited the study area. The following data were used during the visits: (i) the land suitability map for different WH interventions (Figure 1.7); (ii) information on the locations of potential earth dams and hafair (small ponds), from separate hydrological analysis; (iii) satellite images and GPS (used for navigation); and (iv) cadastral maps. The team visited several sites and took notes and made observations (preliminary sites, Figure 1.8). The information was then summarized and used to decide on sites that should be selected, the interventions that should be applied at each site, and the priority of the selected sites for implementation.

The data collected was discussed during a meeting between the project team and the community. The results of this discussion are summarized in two points. First, the chance of successful implementation of interventions like earth dams and hafairs



Legend example, rs–r–p2: runoff strips – range crops – second best.

Figure 1.7. Potential land suitability for various WH options in Mharib watershed, see (Table 1.7) for legend abbreviations.

at sites which do not have communities nearby is limited. Such sites should be eliminated from further consideration. This decision excluded sites 1–5 (Figure 1.8), despite being rated as highly suitable from a biophysical point of view, the absence of community nearby would limit their use

Table 1.7. Index for WHTs.

Code	Wates-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		
IRS	Inter row system		
CBT	Contour bench terraces	P1	Best
G	Gradoni	P2	Second Best

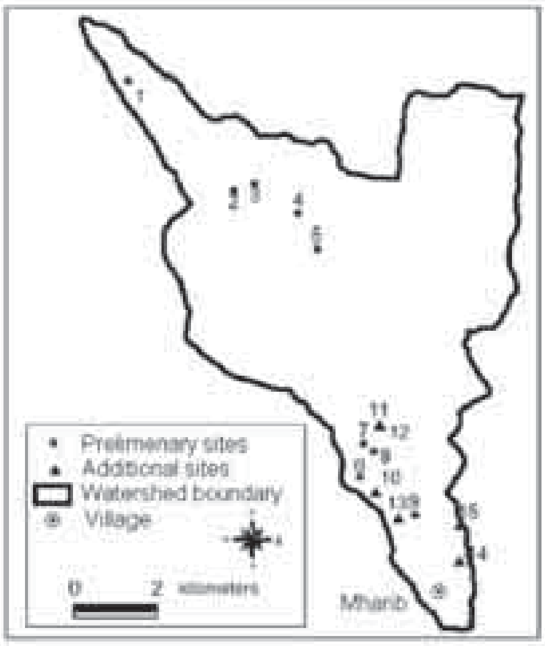


Figure 1.8. Locations of the sites considered for WH implementation.

and maintenance and therefore threaten their sustainability. Second, the project needed to collect information about the owners of sites deemed to have potential as a first step in the actual implementation of WH interventions. For potentially suitable sites, the owners were approached and the implementation of techniques discussed.

Some of the sites selected as potentially suitable were excluded from the study because their owners did not wish to participate in the project. Other sites were excluded because their owners did not live in the area (absentee owners) – a large number of land parcels were owned by people who have never lived in the area, since it is considered now suitable for investment, thus complicating the development of the area. A different approach was then followed by visiting the land of people who had indicated willingness to participate in the project. The biophysical suitability of their fields for their proposed interventions was assessed and consequently more sites were added to those previously considered and were marked as additional sites (Figure 1.8). This approach gave the farmers the opportunity to express their needs and at the same time incorporate the biophysical suitability of their land, which is an effective way to gain more involvement and participation of the local community.

Ultimately, all sites selected by this process were judged to be both biophysically and socioeconomically suitable to implement WH intervention(s) and to have a high chance of success. The project's technical team undertook data collection and detailed surveys at these sites, in order to design and implement various interventions. Within two years, four types of WH interventions were implemented in 41 farmers' fields (total area 62.9 ha) in close collaboration with the local community.

The Vallerani WHT (mechanized semi-circular bunds) was implemented in 17 fields (43.4 ha), contour ridges in 18 fields (14.5 ha), contour strips in four fields (3.9 ha), and narrow strips in two fields (1.1 ha).

Evaluation during field investigations showed that the applied approach for assessing WH suitability was very promising. 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 WHTs in arid and semi-arid areas. GIS facilitated the integration of bio-physical and socio-economic aspects to undertake the selection process.
The findings of the field visits agreed with those of the suitability analyses. This emphasizes that these methods are reliable and could be used to choose sites suited to different types of WH interventions. The analyses undertaken using GIS information narrowed down the number of sites visited

by the team, guiding them to sites with a high potential for the intended WHTs.

Two methods of selection were adopted and used successfully to pick the most promising sites. The first utilized the suitability maps and then, using information from cadastral maps, the owners were approached and their willingness to cooperate was assessed. The other method was by allowing the local inhabitants to express their need for implementing of WHTs and then, by referring to the land suitability maps, the possibilities of implementing WH based on biophysical conditions was assessed. This iterative process proved to be efficient and practical in planning a successful WH scheme. The approach integrated biophysical and socioeconomic aspects in a dynamic way that benefited the whole process (Ziadat et al., 2006)[1].

1.3 References

Ziadat,F., Oweis, T., Mazahreh, S., Bruggeman, A., Haddad, N., Karablieh, E., Benli, B., Abu Zanat, M., Al-Bakri, J., Ali, A. 2006. Selection and characterization of badia watershed research sites. International Center for Agricultural Research in the Dry Areas, Aleppo, Syria.