Water Benchmarks
of CWANA project

7

Benchmarks Database Development:
the *Badia* research site

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Community-based Optimization of the Management of Scarce Water Resources in Agriculture in West Asia and North Africa

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Foreword

Water scarcity is a growing concern in West Asia and North Africa (WANA), threatening economic development and stability in many parts of the region. Rapidly growing demand for water in other sectors is causing a re-allocation from agriculture, which currently accounts for over 75% of total water consumption. There are no new sources of water since river systems suitable for large-scale irrigation have already been developed. Groundwater sources are over-exploited, while other renewable sources are either costly or environmentally not friendly.

A large proportion of the region's agricultural production is based on dryland farming systems, which are dependent on low and extremely variable rainfall. The challenge is to enhance productivity by improving on-farm water-use efficiency and supplementing rainfall through water harvesting or better utilization of renewable water sources. However, conventional water management practices, applied under normal water supply conditions, are not suitable under conditions of water scarcity. In the WANA region, there is a need for better management, to maximize the returns from each unit of water available for agriculture.

Technologies are available for improved management of scarce water resources. Adoption however is poor due to several technical, socioeconomic and policy constraints, and, most importantly, the lack of community participation in the development of the technologies.

The Water Benchmarks Project in CWANA is based on community participation in research, development, testing, and adaptation of improved water management options at the farm level. The project focuses on the best opportunities and potential for immediate impact on agricultural productivity, resource conservation and livelihoods in areas where water is most scarce.

Benchmark sites were established in three distinct agroecological areas: steppe (badia), rainfed, and irrigated sites. Water use is studied at different levels: household, community, watershed, and policy. A multi-disciplinary approach is used, to understand the current situation and develop and test water use efficient technologies under farm conditions.

This report is a documentation of data gathered during the project for the Badia Benchmark, organized in a way to facilitate the integration of various disciplines. The purpose is, to facilitate the use of this data for better management of resources during the project and to provide accessible and user friendly database that is suitable for use beyond the project lifetime. It is anticipated that future research and development projects, will build upon this database and continue the documentation to enhance the use of data for the Badia and similar areas.

Main Partner Institutions

Institute	Address	Website
International Center for Agricultural Research in the Dry Areas (ICARDA)	ICARDA, P.O. Box 5466, Aleppo, Syria	www.icarda.org
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Institut National de la Recherche Agronomique (INRA), Morocco	INRA, Talda BP 567 Beni-Mellal, Morocco	www.inra.fr.ma
Agricultural Research Center (ARC) Egypt	Ministry of Agriculture, 9 El Gama'a St., Giza, Egypt	www.arc.sci.eg
Institut National Agronomique de Tunis (INAT)	INAT, 43Av. Charles Nicollas 1082 Tunis, Tunisia	Under construction
Agricultural Research and Technology Corporation (ARTC), Sudan	ARTC, Ministry of Agriculture, WAD Medani, Sudan	www.arcsudan.sd
Institut Techniques des Grandes Cultures (ITGC) Algeria	Station ITGC, Route Nationale No. 14 (44225), Algeria	www.itgc.entreprises-dz.com
Institut National de la Recherche Agronomique D'Algerie (INRAA)	Institut Nationalde La Recherche Agronomique, INRAA - B.P. 115 Belfort El-Harrach, Algeria	www.inraa.dz
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Introduction

The rangelands of West Asia and North Africa are the grazing grounds for the Bedouin with their flocks of sheep, goats and camels and are known as *al Badia* in the Middle East region. Average annual rainfall in the *Badia* ranges between 50 and 250 mm (Haddad 2006). Despite its scarcity, rainwater is generally poorly managed and much of it is lost through runoff and evaporation. To improve production in these areas, there is a need for the sustainable management of natural resources – land and water (FAO 1983). The challenge is how to enhance productivity and halt land degradation in these marginal environments (Oweis et al. 2006).

Rainwater harvesting can improve the productivity of rainwater and maintain productive and sustainable agro-pastoral systems in marginal environments. To develop successful and sustainable integration of rainwater-harvesting techniques within existing agro-pastoral systems, the International Center for Agricultural Research in the Dry Areas (ICARDA), in cooperation with agricultural research organizations in Jordan, established a *Badia* Benchmark Watershed in 2004. ICARDA is using benchmark sites to develop, test, adapt, and evaluate improved genetic and natural resources management practices and technologies under 'real life' conditions. It is anticipated that the findings and approaches developed by this *Benchmark* project will be adopted and implemented by future similar development projects (Oweis et al. 2006, Ziadat et al. 2006).

During the four years of project activities, information has been continually collected and delivered. Some information was spatial and some non-spatial (attribute data). The integration and management of both types of information played a crucial role in facilitating these activities. Linking spatial data to attribute information was also important for certain types of analysis needed to carry out project activities. Furthermore, the project includes multi-disciplinary teams with plant specialists working with soil scientists, GIS specialists, socio-economists, and other team members. The organization of the database needs to facilitate interactive communication between these teams for the better exploitation of project results.

The aim of establishing a comprehensive and dynamic database is to provide information in a suitable format to allow the analyses and procedures needed by the project to be carried out. The data should also be suitable for future use beyond the lifetime of this particular project. The following steps were followed to achieve this objective:

- Receive information from various components of the project in different formats
- Undertake analysis and manipulation to arrange the data in formats and structures satisfying the needs of the various project components
- Monitor and correct the geo-referencing issues of all the data collected
- Undertake analysis and manipulation to arrange the data in formats and structures satisfying the needs of the various project components.

The project data is of two types. The first represents data collected by the *Badia* Benchmark project from previous research and from other national institutes and organizations. The second is the data collected by the project itself from the intervention sites implemented at Mharib and Majidyya villages. This report describes the establishment of the project database and associated activities. The objective is to provide a methodology for documenting information generated from similar projects, implemented on farmers' fields and extending over large areas.

The report focuses on three main activities:

i. Establishing a GIS database for the intervention sites, which defines each site in terms of its geographic location and extent and includes a method for providing a unique label for each site. This was used by all team members when collecting various types of data from the intervention sites

ii. Establishing a dynamic link to all available data and information (using an HTML-based application)

iii. Preparing forms for data collection (parameters to monitor indicators), entry and analysis, during different seasons.

Establishing GIS database for the intervention sites

Thirty-five intervention sites were implemented by the project. These were located at two villages, Mharib and Majidyya, 45 km southeast of Amman, Jordan. Each intervention site was visited and the coordinates of the boundaries were recorded using the GPS device (Garmin 12XL). The coordinates were recorded using geographic latitudes and longitudes (WGS 1984 datum). All GPS data were entered into an Excel worksheet together with labels for each site. Latitudes and longitudes were then converted to the Jordanian Transverse Mercator coordinate system (JTM) to enable integration with the other layers related to the study area, such as:

- Satellite images: merged LandSat and SPOT images.
- Digital elevation model, derived from topographic map (scale 1:50,000)
- Streams, derived from the topographic map (scale 1:50,000)
- Contour lines, derived from the topographic map (scale 1:50,000)
- Suitability maps for different water harvesting techniques
- Cadastral map from the Department of Land and Surveying

Further details are presented in Ziadat et al. (2006). The GPS points of each site were displayed in the GIS and each site was drawn as a polygon by on-screen digitizing between the collected points.

Maps were prepared showing the dimensions, location, and label for each site. The unique key used to label sites is as follows (an example is shown in Fig 1):
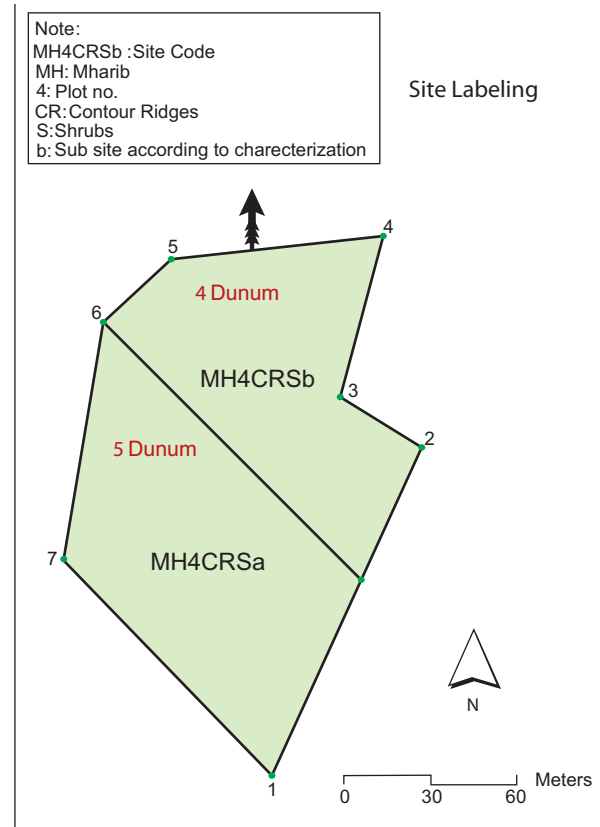

Note:
MH4CRSb :Site Code
MH: Mharib
4: Plot no.
CR:Contour Ridges
S:Shrubs
b: Sub site according to charecterization

Site Labeling

Figure 1. Unique site name for each intervention site

- Site name: MH: Mharib, MJ: Majidyya
- Plot No.: 1, 2, ...,22.
- Water Harvesting technique: Contour Ridges = CR, Contour Strips = CS, Narrow Strips = NS, Vallerani = V.
- Plant type: Shrubs = S, Barley = B.
- Sub -Site according to biophysical characterization (mainly slope): (a, b, c, d, e, f, g, h,i)

The mapping process included a general description and subdivision of the sites where water harvesting structures were implemented (Fig 2). Fig 3 shows the intervention sites for both villages. These sites are presented in more detail together with their labels in Fig 4 for Mharib (22 sites) and Fig 5 for Majidyya (13 sites). The area of each intervention site was calculated (Table 1) in dunums (1 hectare = 10 dunums).
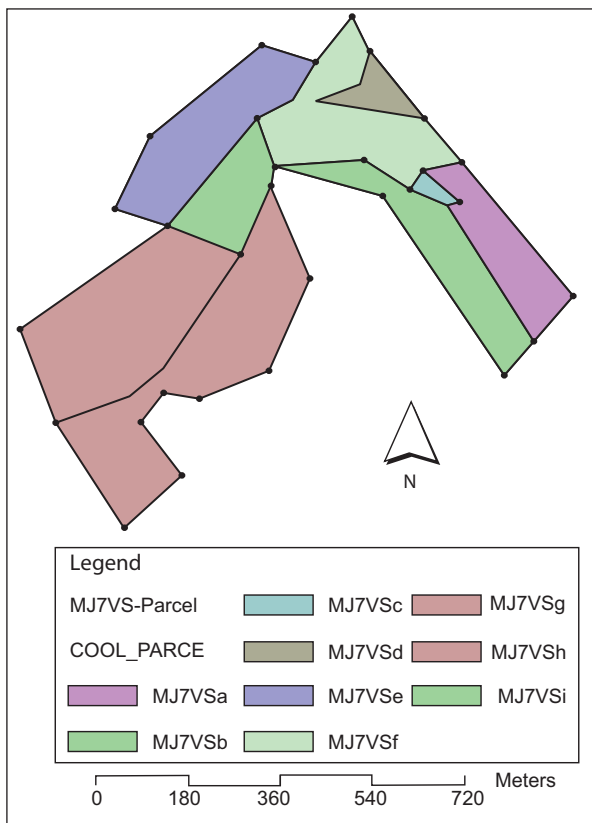
Figure 2. Digitizing between GPS points to delineate site boundaries in Majidyya (labels are explained in Fig 1).
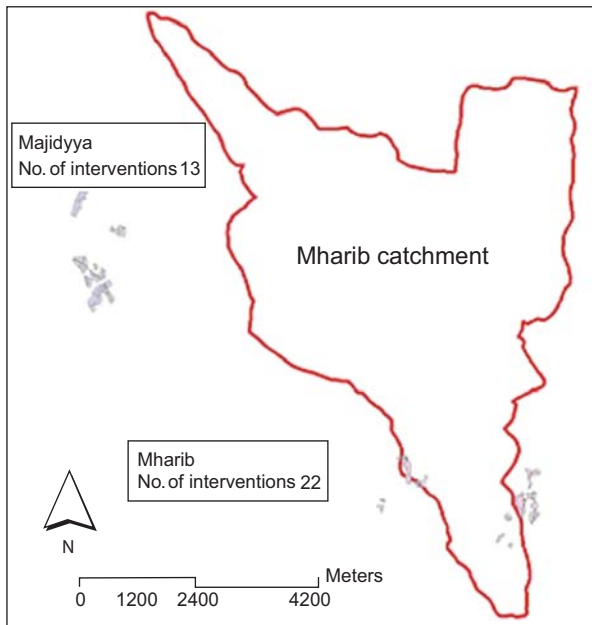

Figure 3. Intervention sites for Mharib and Majidyya, 2005/06

Table1. Site labels and their areas, 2005/06

Site label	Area (dunum)	Site label	Area (dunum)
Mharib		Majidyya	
MH1CRS	6.0	MJ5CRSa	5.2
MH2NSB	6.2	MJ5CRSb	19.3
MH3CRSc	19.6	MJ12CRS	10.6
MH3CRSa	9.4	MJ9CRSb	5.4
MH3CRSb	36.1	MJ9CRSa	9.3
MH4CRSa	4.9	MJ8CRS	11.1
MH4CRSb	4.1	MJ1CSBa	30.7
MH6CRSa	2.3	MJ1CSBb	52.1
MH6CRSb	3.3	MJ2CSB	7.2
MH7CRS	1.3	MJ4NSB	19.1
MH8CRS	3.3	MJ6NSB	7.3
MH9CRS	1.8	MJ10NSBb	14.2
MH12VSb	6.1	MJ10NSBa	21.1
MH12VSa	20.8	MJ11NSBa	8.2
MH13VS	6.1	MJ11NSBb	16.1
MH14VS	17.3	MJ3CRSa	20.6
MH18CRS	10.7	MJ3CRSb	11.6
MH19CRSb	2.1	MJ3CRSc	10.8
MH19CRSa	8.4	MJ7VSd	4.1
MH22VSb	10.3	MJ7VSe	20.7
MH22VSa	10.1	MJ7VSh	33.0
MH10CRS	12.4	MJ7VSb	16.9
MH11CSBa	6.2	MJ7VSc	1.1
MH11CSBb	10.9	MJ7VSa	13.2
MH15CSB	5.3	MJ7VSf	20.9
MH16NSB	4.3	MJ7VSg	35.8
MH17VSb	16.5	MJ7VSi	10.6
MH17VSa	17.2	MJ13NSBa	22.6
MH17VSd	5.3	MJ13NSBb	7.8
MH17VSc	45.1		
MH20CRS	2.9		
MH21CRSa	4.9		
MH21CRSb	11.7		
MH5CSB	17.4		
Total	350.3	Total	466.6

10 dunum = 1 hectare

New intervention sites selected by the project team during the 2006/07 season were added to the existing sites at Mharib and Majidyya. Six sites (three sites in each village) were characterized and geo-located on the field using GPS (Fig 6). These sites are presented in more detail together with their labels in Fig 7. The area (in dunums) of each intervention site is shown in Table 2.
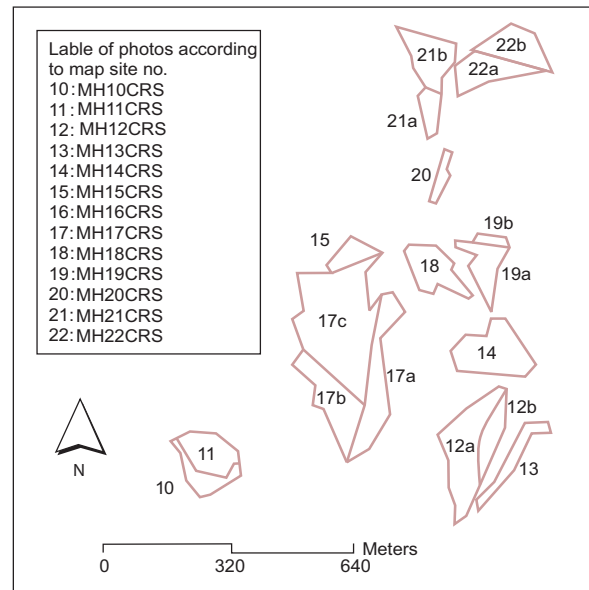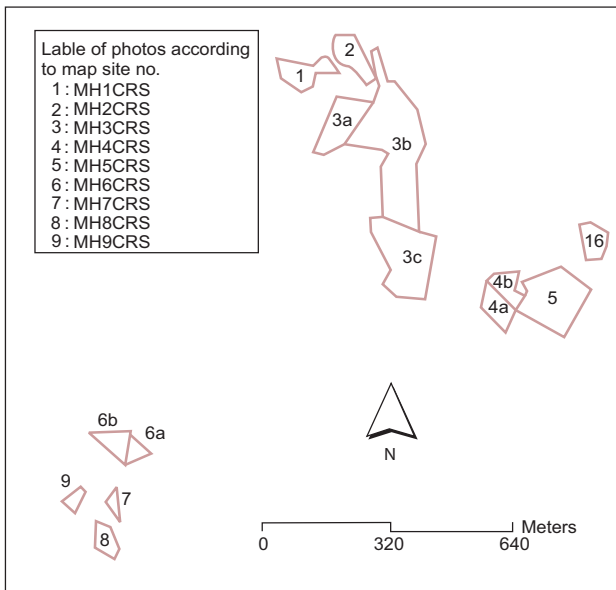

Figure 4. Intervention sites for Mharib, 2005/06
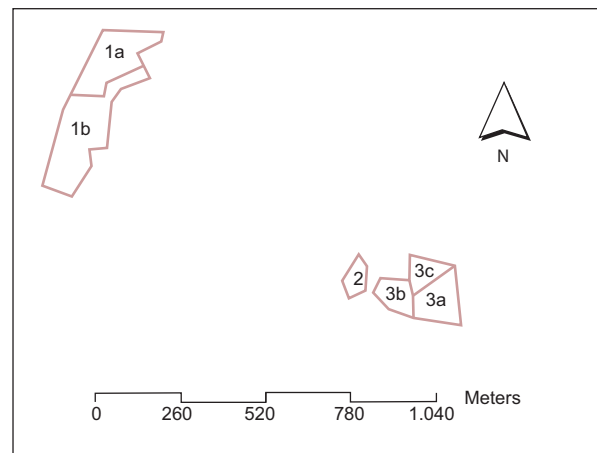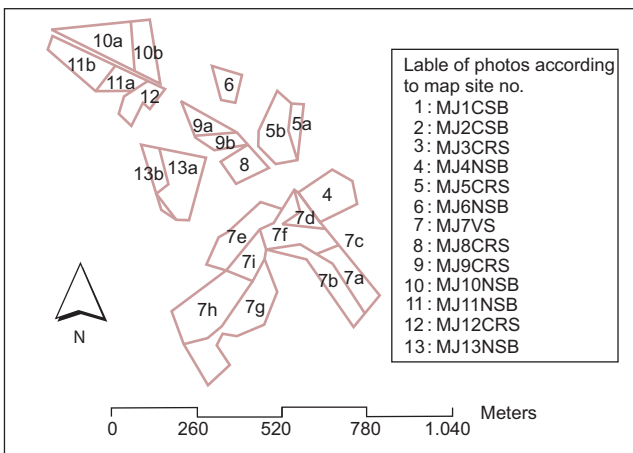
Figure 5. Intervention sites for Majidyya, 2005/06
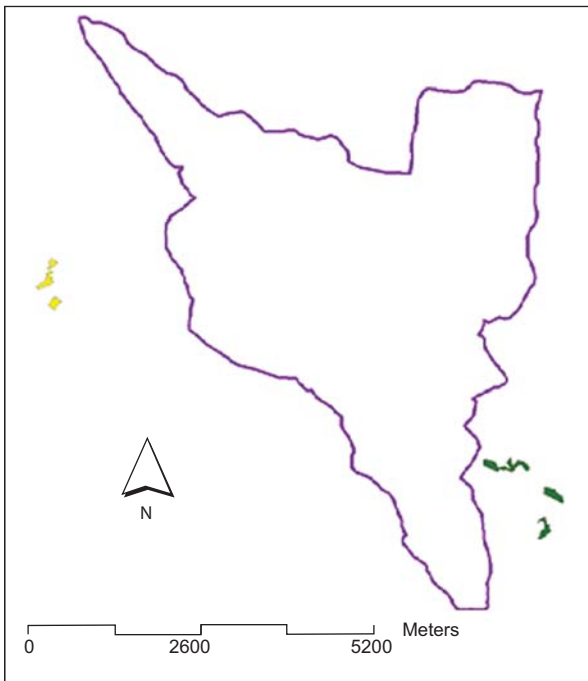
Figure 6. Intervention sites for Mharib and Majidyya, 2006/07

Table 2. Site labels and areas for the new sites, 2006/07

Mharib		Majidyya	
Site label	Area (dunum)	Site label	Area (dunum)
MH23VSb	20.2	MJ14	26.3
MH23VSc	4.1	MJ15	55.2
MH23VSd	8.8	MJ16	41.4
MH23VSa	79.6		
MH23VSe	27.8		
MH25VS	78.2		
MH24VS	60.1		
Total	278.8	Total	122.9

10 dunum = 1 hectare

Figure 7. Intervention sites for Mharib and Majidyya, 2006/07

Database structure

The database of the *Badia* Benchmark project includes data collected from different sources, classified into different categories based on the type of data. HTML (HyperText Markup Language) was used to build the database. HTML is the predominant markup language for web pages. It allows images and objects to be embedded and can be used to create interactive forms. It provides a means of creating structured documents by denoting structural semantic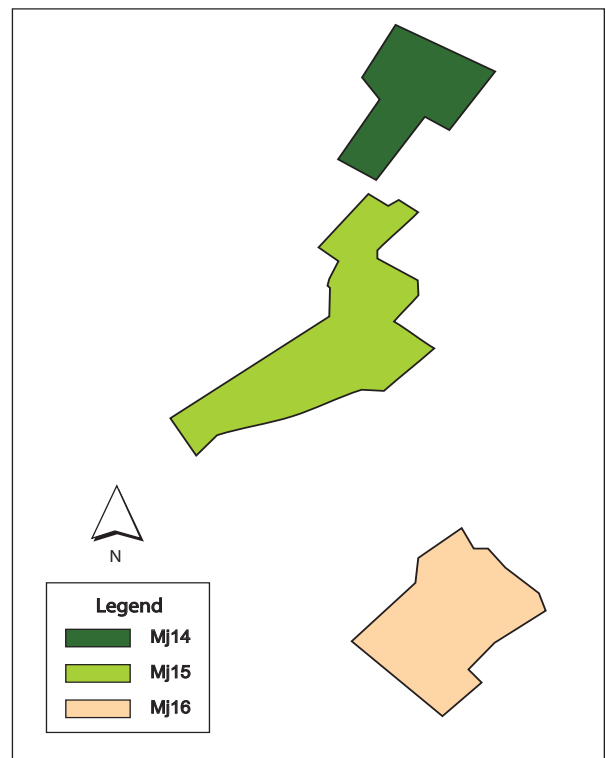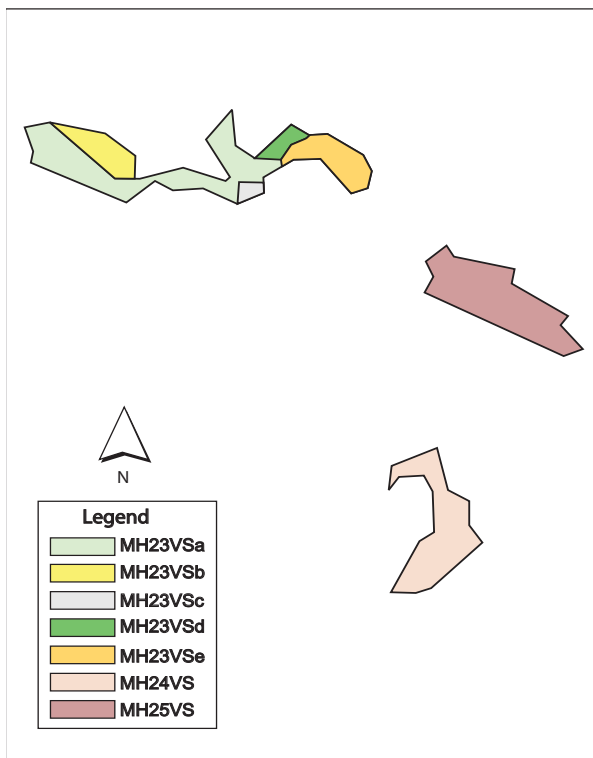s for text such as headings, paragraphs, lists, links, quotes, and other items. It can embed scripts in languages such as JavaScript which affect the behavior of HTML webpages. All related information can be accessed and displayed using the hyperlink to the main page of the project database. Therefore, all information is organized in a way that describes its content, relevant titles and documents. The structure of the database was designed to distinguish the data based on: (i) stages of the project to which the data belong; (ii) project component; and (iii) data type (reports, maps, tables, images, others). The general view of the design is shown in Fig 8. Details of the content and hierarchy for each of the database components in the figure are presented in the Appendix.

Dynamic link to access available data

The main goal for establishing this link is to provide the project researchers with easy access to all available information collected during the project. For example, a researcher might want to know about the performance of various water harvesting interventions and to link them with the biophysical conditions (Tables 3-6) under which they operate and with the socioeconomic characteristics of the owners (Table 5). This would help in understanding the conditions for the success or failure of various interventions.

Two basic requirements were considered in building this link: first the system should be user-friendly, promoting the wide utilization of the available data, and, secondly, the system should guarantee the privacy and security of the database, especially when disseminated via the internet, eg. through the project website. The project's data were subdivided into two types. The first represents data collected by the *Badia* Benchmark project from previous research and from other national institutes and organizations. Further additions to these data would be very limited. The second type groups the data collected by the project from the intervention sites implemented at Mharib and Majidyya villages. These dynamic, continuously collected data had to be kept separate from the first kind of data
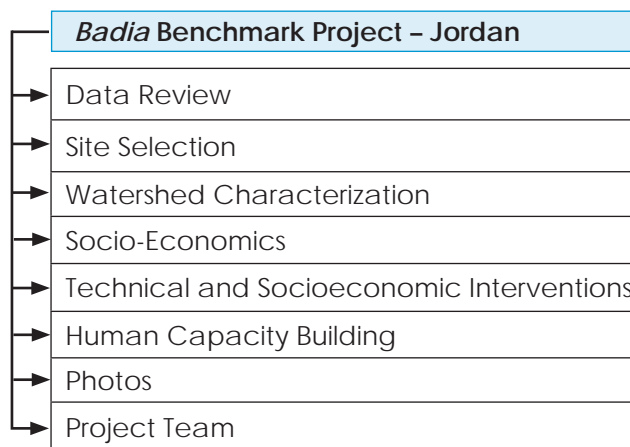
Figure 8. Database components

Fig 9 shows an example of the link between the main pages of the database, where all components are listed. The user has to press the button representing the data she/he is interested in, and the relevant data will be shown. In this example, the researcher chose 'data review' (by pressing the button), and the database has come up with all available data types under this component on the same page. The user has clicked the button labeled 'socio-economic studies' and then chose 'lessons learned'; the relevant data is presented and ready for the researcher to use in different ways. This structure together with all available information is ready for delivery to any authorized researcher.

Figure 9. Example of database link to various components and data formats

Data collection forms for water-harvesting sites

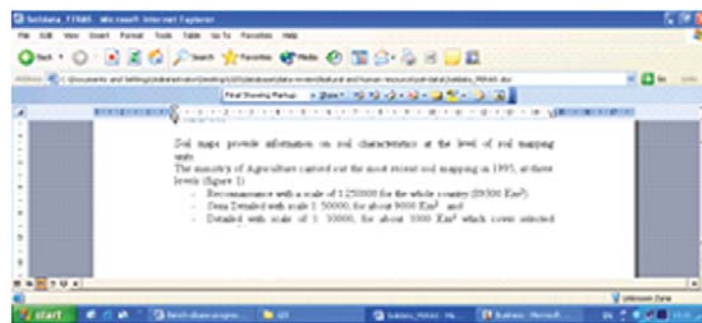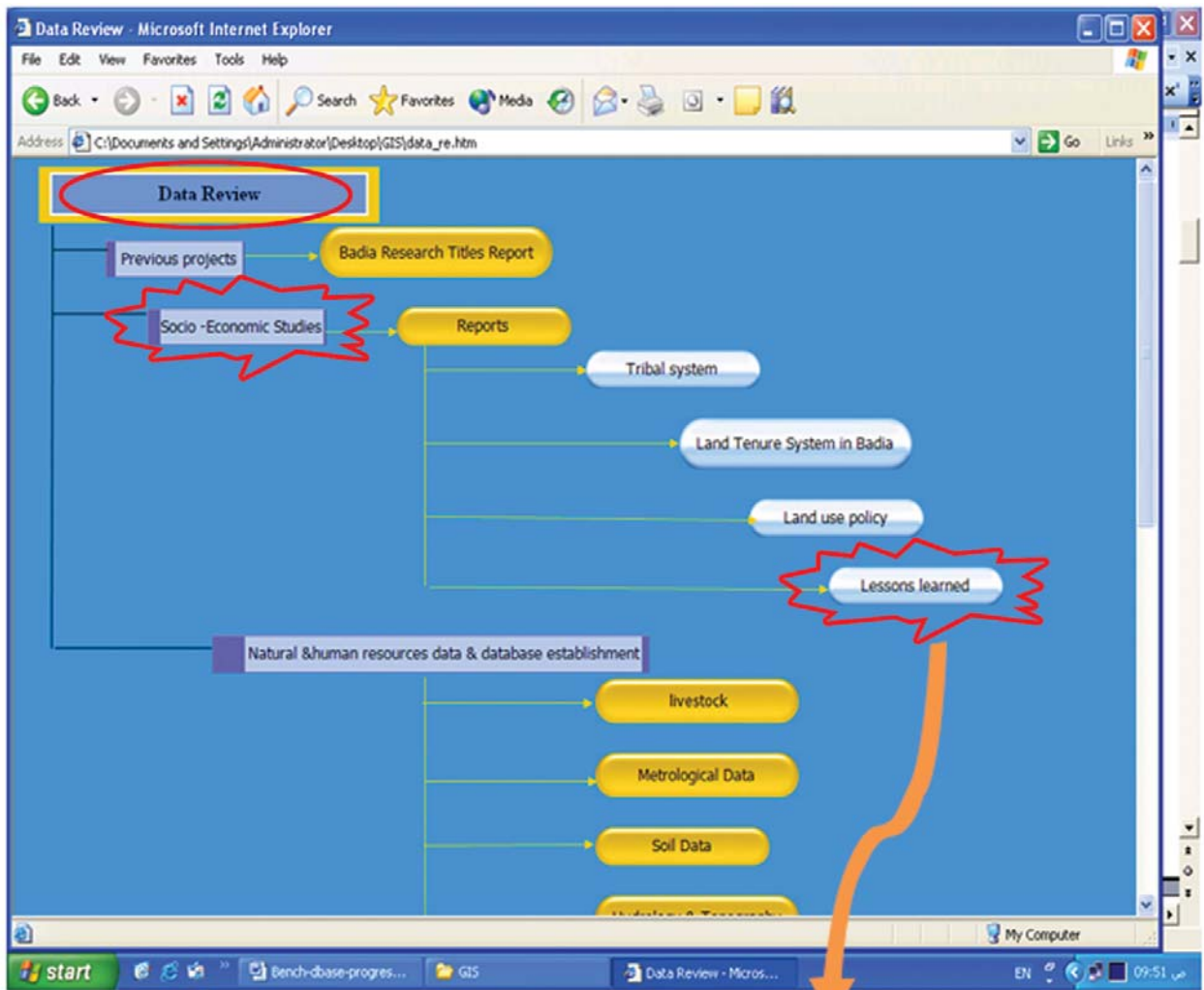These forms aim to bring together all project teams and components through a unified data collection and organization procedure. This facilitates data retrieval by researchers within or outside the project, as well as the analysis and understanding of project findings. The project team is multi-disciplinary; plant specialists work with soil scientists, GIS specialists, socio-economists, and others. Organization of the database facilitates communication between these teams and better use of project results.

It was agreed to design the database using the Microsoft Excel worksheet format, because of its ability to carry out various database functions (entry, storage, retrieval and analysis) and its wide use and familiarity among team-members.
We anticipate that the findings and approaches developed by this project will be implemented by future similar development projects. A short-term objective of establishing such a database is to facilitate modeling tools for use by the project or others.

The key parameter linking all types of information for each site is the site label identified in the field (explained in the previous section). This label is unique for each site and used by all researchers to document any data about the intervention sites. An Excel file was generated for each intervention site. The data recorded in this file were subdivided into two main categories.

i.   The first presents the site characteristics, collected at the beginning of the implementation (biophysical and socio-economic characterization of the site). These data are collected for one time, and therefore no updating is expected for this type of information.
ii.   They were grouped together on one sheet in the Excel file (sheet name: 'site characterization', Fig 10).

Figure 10. Data collected at each intervention site

iii. The second category includes data that were collected during the growing season to monitor the progress and performance of the intervention site. These were organized on two types of sheets.

- One for each of the successive visits undertaken by team members to each intervention site. This sheet records the data collected while in the field (sheet name: 'visit', Fig 10). The number of visits is unlimited. If more than one visit is undertaken, the researcher has to copy the sheet and use it to add additional visits.
- The second type of data are the data collected to describe the natural vegetation and barley crop status for each site (sheet names: 'nat. vegetation' and 'barley', Fig 10). These data were sepa-

rated because of the specificity of the data collected; these parameters were not collected by the other teams. These data were used to compare the performance of the intervention site (barley or forage shrubs) with that of the natural vegetation. The parameters collected for each site are explained in Tables 3–6.

Finally, all the data collected are available to project researchers in two forms. First, as Excel files in the format described above. Second by the generation of a summary Excel file. This file includes the whole data for all intervention sites (Fig 11). Each intervention site is presented as one row (record) in the summary file, where all collected data are organized in columns (fields). The purpose is to facilitate comparison among intervention sites.

Table 3. Parameters recorded at each intervention site (Excel sheet 'site characterization').

Excel sheet	Parameters
Site Characterization	Site code Area Site description Slope Surface crust Soil depth Stone cover Rock outcrop Infiltration rate Bulk density Field capacity Wilting point pH Electrical conductivity Organic matter Nutrients: N,P, K $CaCO_3$ Soil texture: sand%, silt%, clay%, texture class

Table 4. Parameters recorded at each intervention site (Excel sheet 'natural vegetation')

Excel sheet	Parameters
Natural Vegetation	Species per quadrate Count Total Frequency Abundance Density Proportion SDI

Table 5. Parameters recorded at each intervention site (Excel sheet 'visit')

Excel sheet	Parameters
Visit	Date
Soil and water parameters	Wetted depth Location details Vegetation and rangeland management
Fodder shrubs parameters	Catchment/cultivated area Plant density Dry matter (kg/ha) Survival% Browse (kg dm/ha) Herbage (kg dm/ha) Forage (kgdm/ha) Stocking rate (sud/ha)
Natural vegetation parameters	Total no. of families Total no. of plant species Vegetation cover % Vegetation biomass Stone cover % Root mat characteristics
Barley Parameters	Crop stage Grain yield (kg/ha) Straw yield (kg/ha) Dry matter (kg/ha) Average plant height No. of tillers per plant
Livestock parameters	No. of grazing days Dry matter intake of livestock Dry matter production Barley equivalents of dry matter production for each No. of animals grazing the plots by age Time of grazing Area of barley stubble grazing Area of Atriplex grazing No of plants grazed per hectare Hand feeding Change in the livestock number in the community Animal performance and stoking rate Rangeland productivity and biomass Rangeland species richness Livestock watering

Machinery parameters	Returns (JD/dunum or JD/hr) Running cost (JD) Annual cost of fuels Annual lubricates cost Annual repairs and maintenance cost annual spare parts Annual operator costs Seasonal operators Fixed costs (depreciation, garage cost, insurance cost, interest rate on invested capital, operator cost)
Socio-economic parameters	Return (JD) Quantity of production (grain, hay, biomass) Prices or estimated values of outputs Variable cost: Seedling and/or seeds, compound chemical fertilizer, organic fertilizer, pesticides, electricity, fuel, maintenance, sacks, water, hired machinery, tillage costs, cost of spraying, manual hired labor Interest on variable cost Gross margin, fixed cost, family labor, total cost, net profit, costs of water, return to water, construction cost, land acquisition, operation and maintenance costs

JD = Jordanian dinar

Table 6. Parameters recorded at each intervention site (Excel sheet 'barley')

Excel sheet	Parameters
Barley	Barley variety Seeding rate Planting date Planting depth Planting method Previous crop Experimental design No. of treatments No. of replicates Plot size Distance between rows Length of row No. of rows Fertilizer (type, quantity, date of application) Growth stage Harvesting (date of harvesting, method, harvested area)

Conclusions

The systematic procedure followed in collecting and organizing these data has led to the establishment of a comprehensive and dynamic database for the whole project. To achieve this, the collaboration of all project components and researchers was necessary to deliver the data as they become available. The database has been used successfully by different researchers within the project. It provides easy access to uniformly formatted spatial and non-spatial data, which can easily be viewed and explored. It also facilitates the navigation of data and components, which has helped in exploring new database applications.

The benefits go beyond the use within this particular project to providing a comprehensive database for the whole *Badia* region in Jordan, which is representative of the arid regions of WANA. It is anticipated that any future research and/or development project will use this database and continuously develop the structure and content to benefit the efforts of land resources management in the dry areas.
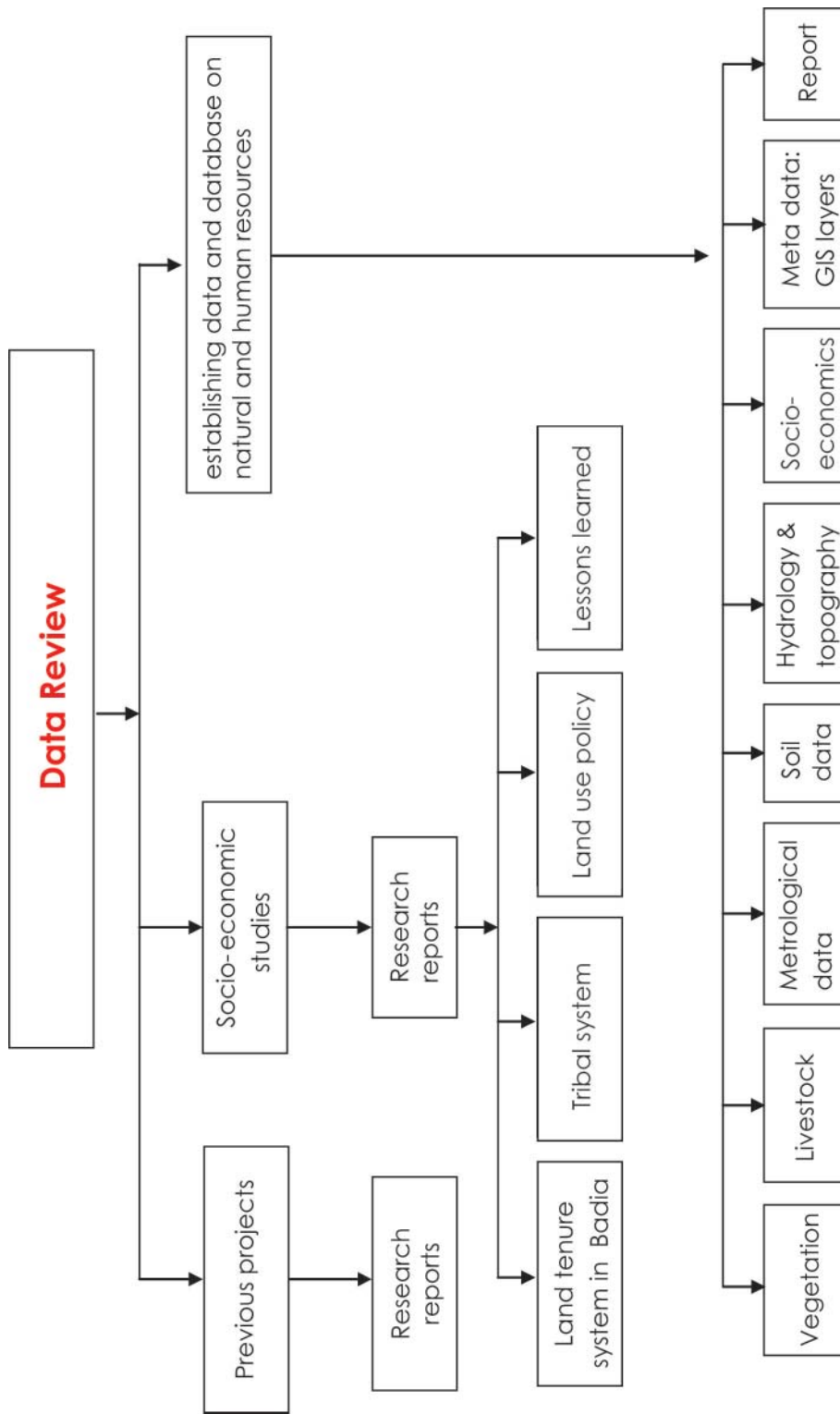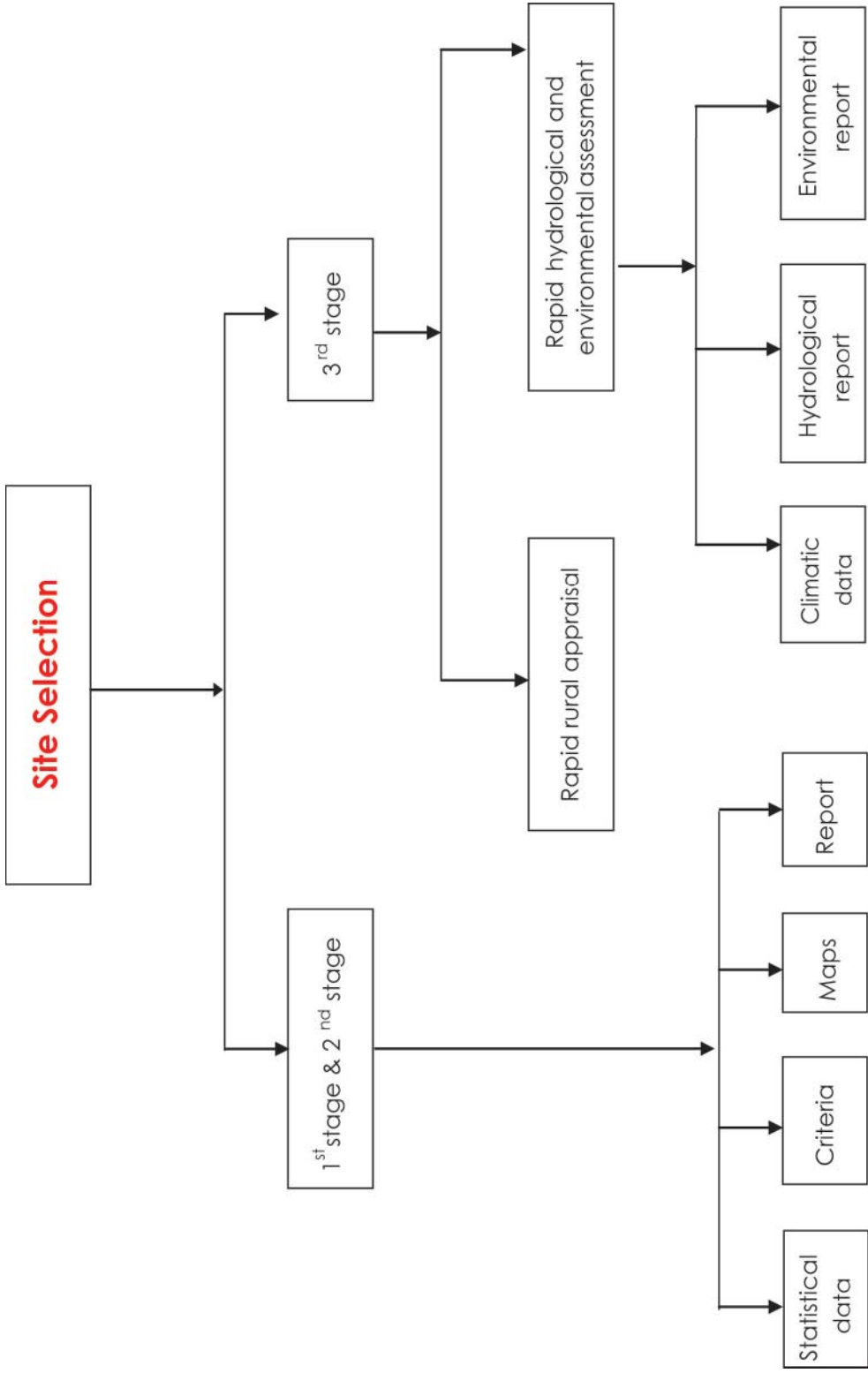
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Figure 11. Example of summary file, which includes all intervention sites

Appendix: Details of content and hierarchy for each of the database components in Figure 8

Site Selection

1st stage & 2nd stage
- Statistical data
- Criteria
- Maps
- Report

3rd stage
- Rapid rural appraisal
- Rapid hydrological and environmental assessment
  - Climatic data
  - Hydrological report
  - Environmental report

Watershed Characterization

- Biophysical characterization
  - Field observations
  - Maps
  - DEM
  - Report
- Socio-economic characterization
  - Cadastral - Owners
- Suitability - water harvesting techniques
  - Criteria
  - Maps
  - Report

Socio-economics

- Community baseline information
- Participatory diagnosis
- Gender analysis

Project team

- 2004/05
- 2005/06
- 2006/07

Technical and Socio-economic Interventions

- Site assessment and monitoring (database 63 sites)
- Cost assessment
- Implementation
  - Monitoring
    - Experimental sites
      - Majidyya
        - Data
        - Map
        - Report
      - Mharib
        - Data
        - Map
        - Report
  - Potential interventions
    - Year 06/07
      - Map
      - Report
    - Year 05/06
      - Map
      - Report

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Meetings

- Tech. committee meetings
- Team meetings
- Field meetings
- General meetings
  - Regional
  - Local
- Steering committee meetings

Photos

- Regional
- Local

Capacity Building

- Workshops
  - Regional
  - Local
- Training
  - Regional
  - Local
- Public awareness program
  - Brochures
  - Media
    - TV
    - Press
  - Reports
  - Field visits
    - Regional
    - Local
  - Calendar

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