ASSESSMENT OF WATER HARVESTING AND SUPPLEMENTAL IRRIGATION POTENTIAL IN ARID AND SEMI-ARID AREAS OF WEST ASIA AND NORTH AFRICA

Proposal submitted to

The Comprehensive Assessment of Water Management in Agriculture
led by the International Water Management Institute (IWMI)

Funded by the Netherlands Government.

by

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REVISED

OCTOBER 2003

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Total Cost of Project : US$ 259,000
Requested Funds : US$ 175,000
Duration Of Project : 20 months

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PROJECT SUMMARY

Rainfall in the arid and semi arid areas of West Asia and North Africa (WANA) is limited and highly variable, resulting in low water productivity in the rainfed areas. Supplemental irrigation and water harvesting are technologies that have shown an enormous impact on the livelihoods of smallholders in the rainfed cropping systems and steppe environments of WANA. To better target these technologies, a methodology will be developed for mapping the potential of the rainfed areas of WANA for supplemental irrigation and water harvesting. Review studies will be conducted to assess the biophysical and socioeconomic conditions that affect the adoption and impact of these technologies. Spatial databases will be constructed and suitability maps will be prepared for selected benchmark sites and for two pilot countries: Syria and Tunisia. To contribute to the comprehensive assessment Agro-Ecological Zones (AEZ) methodologies will be applied to assess actual and potential rainfed yields at the country-level. The project will be implemented by ICARDA in cooperation with the NARES of the two pilot countries and the International Institute for Applied Systems Analysis (IIASA).

PROJECT CONTEXT

This project complements the other endorsed project lead by ICRISAT on" *Water Scarcity and Food Security in Tropical Rain-fed Water Scarcity Systems: A Multi-Level Assessment of Existing Conditions, Response Options and Future Potentials*". The two projects will provide the major input into the "rainfed" component of the Comprehensive Assessment of Water Management in Agriculture. Activities of the two projects will be linked through the case studies planned for the dry areas in the ICRISAT project, participation of several principal investigators in the two projects and other joint activities planned. The duration of this project was shortened to coincide with that of the ICRISAT-lead project so the outputs will be ready at the same time for publication in the planned book on rainfed agriculture.

BACKGROUND

The arid and semi arid areas of West Asia and North Africa (WANA) are characterized by limited rainfall with highly variable spatial and temporal distribution. Although rainfall is an extremely valuable resource in these areas, its productivity is often low. In the drier environments where rainfall is not sufficient to support vegetative cover, high losses occur due to evaporation from topsoil and runoff to low-quality water bodies. Water harvesting, the practice of collecting surface runoff water for direct application to crops, storage in reservoirs, or groundwater recharge, allows the productive use of the scarce rain water resources. In rainfed cropping systems in WANA, rainfall is often not sufficient to fulfill the crop water requirements, resulting in low yields. Supplemental irrigation, the application of a limited amount of irrigation at critical times, has been shown to substantially improve yield and water productivity in these environments.

Water harvesting and supplemental irrigation are two agricultural practices with a high potential to conserve water and improve water use productivity in the dry areas of WANA. The feasibility of supplemental irrigation depends on the availability of adequate water resources, both from rainfall and irrigation water, and appropriate infrastructure and irrigation scheduling. The feasibility of different water harvesting techniques depends on local run-off characteristics, which themselves are determined by rainfall pattern, slope, land cover, and soil properties. Furthermore, socioeconomic conditions, policies, and property rights have a large impact on the successful implementation of these practices.

Whereas both practices have demonstrated their potential in terms of yield improvement, sustainable land management and income generation at various locations throughout the WANA region, a major knowledge gap concerns the extrapolation domain, those parts of the region in which the chances for impact and adoption can be optimal and to which further research could be targeted. Studies that systematically review the factors and conditions that are the basis of

the success and, even more important, the failure, of these technologies are rare. Based on the results of case studies, a methodology for mapping the zones within WANA, in which either supplemental irrigation or water harvesting or both are potentially suitable, will be developed.

The study will be undertaken in collaboration with the national agricultural research and extension systems (NARES) in Syria and Tunisia, thus increasing the capacity of these organizations in conducting similar studies. These two countries rank high on the list of water-stressed countries in the WANA region. A variety of traditional and improved water-harvesting and irrigation technologies are currently in use in these countries. Recent droughts and the growing demands of domestic and industrial water use sectors have increased political support for the implementation of technologies that improve the water productivity of rainfed agriculture. The availability of spatial databases and agro-ecological zones methodologies and models (Fischer et al., 2001) facilitates the country-level assessment of these technologies.

GOAL

The overall objective of this project is to improve water productivity in the rainfed areas of WANA through effective implementation of water harvesting and supplemental irrigation.

PROJECT PURPOSE

The project purpose is to develop a methodology for identifying the agro-environments in WANA, from agroecological and production system perspectives, where supplemental irrigation can maximize water use efficiency, and where water harvesting is likely to lead to substantial increases in yield and incomes. The methodology will be developed and tested in two pilot countries: Syria and Tunisia.

OUTPUTS

The project will complete the principal outputs listed below. A logframe of the project outputs is presented in Appendix 1.

1. Report summarizing the experiences of the two pilot countries with water harvesting and supplemental irrigation.
2. Guidelines for evaluating the potential for and constraints to the adoption of water harvesting and/or supplemental irrigation practices, at the level of project sites and out scaling to the WANA region.
3. GIS-based methodology for identifying, at the level of the pilot countries, areas with potential for water harvesting and/or supplemental irrigation.
4. Enhanced capacity of NARES in two pilot countries for targeting water harvesting and supplemental irrigation activities and for conducting technology evaluation studies.

ACTIVITIES

The outputs of the project will be achieved through the activities listed below. A time frame for the project activities and milestones is given in Appendix 2.

1. Inventory of water harvesting and supplemental irrigation sites, projects, and studies in two pilot countries.

2. Preparation of report summarizing experiences with water harvesting and supplemental irrigation studies in two pilot countries.

3. Selection of water harvesting and/or supplemental irrigation benchmark sites in two pilot countries.

4. Compilation of benchmark site databases and secondary data, including satellite imagery, and their integration in a GIS framework.

5. Surveys to evaluate the adoption and impact of supplemental irrigation and water harvesting techniques at the benchmark sites.

6. Documentation of the evaluation of the potential for and impact of water harvesting and supplemental irrigation at the benchmark sites.

7. Collection and analysis of available data on climate, water resources, soil, land use, agricultural systems, socioeconomic conditions, policies and property rights at the country level.

8. Development and testing of methodologies and models for country-level identification of areas with potential for water harvesting and supplemental irrigation.

9. Ground-truthing of selected sites.

10. Preparation of maps identifying potential for water harvesting and supplemental irrigation in pilot countries.

11. Preparation of publications with methodology and guidelines for evaluating the potential for supplemental irrigation and water harvesting at the country-level.

12. Training workshop for NARES in development of spatial databases and analysis of data.

13. National workshops to discuss and disseminate results.

METHODOLOGY

A multi-scale approach will be adopted, with specific studies conducted at the level of project sites and at the level of the pilot countries.

Benchmark site studies

The first step is the selection of benchmark sites for supplemental irrigation or water harvesting in the two countries. A systematic inventory and documentation of the experience gained so far in the region with these agricultural practices will be prepared.

For the descriptions of the environments and agricultural systems at the level of the benchmark sites, specific standardized formats will be developed. Where critical data are missing, or are at an inappropriate scale to adequately describe the agro-environments and systems at the sites, additional information may be collected through targeted surveys. These descriptions and associated datasets, both spatial and non-spatial, will be the basis for establishing benchmark site databases linked to GIS.

At the research level the various supplemental and water harvesting techniques used in the project sites will be evaluated against a range of criteria related to yield enhancement, risk reduction, quality, costs and margins, technical feasibility, need for farmer training, gender impact, environmental impact and social acceptance. The main methodology for the research level evaluation will be through synthesis of the experimental results at project sites, and linking these to experiences reported in the literature.

At the farmer level the technologies will be evaluated by rapid rural appraisals and focused surveys. Questionnaires for technology evaluation will be based on those used by ICARDA in the EU-funded MEDRATE project.

The inventory and benchmark site documentation will be the basis for identifying the agroecological and socioeconomic factors at local/watershed/community level that determine the success or failure of water harvesting or supplemental irrigation practices.

Pilot country studies

The out-scaling of the evaluation from project sites to the level of the pilot countries will aim to identify areas where similar agroecological and socioeconomic conditions exist as in the project sites. This similarity assessment will be based on available datasets, supplemented with satellite imagery, for climate, soils, terrain, land cover, production systems, and socioeconomic parameters.

To assess suitability for either water harvesting or supplemental irrigation, again a multi-scale approach will be used. The first step will be to mask those parts of the pilot countries that are obviously unsuitable for either water harvesting or supplemental irrigation, because the rainfall criteria are not met, or irrelevant to either practice in view of current land use (e.g. irrigated areas). This task will be accomplished by creating for each country a 1-km resolution interpolated precipitation surface, using the method of Hutchinson (1995), and national climatic datasets, and preparing a current land cover map.

The next step will be to assess at a much finer resolution (30-90 m) the surface characteristics that determine suitability for water harvesting, using an adaptation of the methodology by Oweis et al. (1998). The criteria to be used in the suitability evaluation will include land cover, terrain characteristics, precipitation, soil depth and crops. A model will be developed that matches these criteria in a hierarchical decision tree against land characteristics. The land characteristics will be assessed using a combination of land cover maps, derived from Landsat or ASTER imagery, digital elevation models (DEM), and soil maps at national or sub-national level. The data-layers will be analyzed to provide homogeneous terrain units with similar hydrological characteristics.

Within the areas that meet the rainfall criteria for supplemental irrigation, Landsat and ASTER imagery, DEMs, and soil maps will be used to identify the land areas where the soil resources are optimal for supplemental irrigation. Also the available renewable water resources will be assessed. In combination with a simplified crop growth simulation model and AEZ methodologies, this information will allow estimation of the potential production increase and water productivity due to supplemental irrigation.

IMPLEMENTATION AND MANAGEMENT

ICARDA will coordinate and manage the project. The budget required for implementation of the project is presented in Appendix 3. In each pilot country, a national agricultural research institution will be contracted to undertake a national review study. Benchmark sites will be selected in consultation with ICARDA. The selected institutes will conduct the necessary studies, compile the required baseline data and develop a database for the benchmark sites. Compilation and analysis of country-level databases will be undertaken either by the selected NARS or ICARDA staff. ICARDA will provide technical guidance for all activities by preparing guidelines, procedure manuals, questionnaires, support missions, and training.

The project will link with the other activities of the Comprehensive Assessment on rainfed agriculture. Where applicable similar methodologies and models will be used. AEZ methodologies will be applied at the country level in cooperation with IIASA.

DISSEMINATION STRATEGY

The methodology will be developed and tested in cooperation with the NARES in two pilot countries. The results will be presented and discussed with researchers and policymakers at national workshops in the pilot countries. The methodology will be disseminated through presentations and distribution of reports to scientists and decision makers of the WANA region at regional meetings and conferences. Results of this study will be presented to a wider audience at international conferences and in journal articles. All project documents will be made available on a project web page. The final product of the project will be published in the book on rainfed agriculture planned by the Comprehensive Assessment on Agricultural Water Management.

REFERENCES

Fischer G., Shah M., Van Velthuizen H., Nachtergaele F.O. (2001). Global Agro-ecological Assessment for Agriculture in the 21st Century: Methodology and Results (March 2002). IIASA Research Reports RR-02-02, FAO and IIASA, Laxenburg, Austria.

Hutchinson M. (1995). Interpolating mean rainfall using thin plate smoothing splines. Int. J. Geographical Information Systems 9: 385-403.

Oweis T., Oberle A., Prinz D. (1998). Determination of potential sites and methods for water harvesting in Central Syria. Advances in GeoEcology 31,83-88

APPENDIX 1: LOG FRAME

Narrative Summary	Measurable Indicators	Means of Verification	Important Assumptions
GOAL Improve water productivity in the rainfed areas of WANA through effective implementation of water harvesting and supplemental irrigation.	Improved rainfed productivity, increased incomes of small-holders	National statistics	Supportive policies implemented and dissemination activities provided
PURPOSE Develop and test a methodology for identifying the agro-environments in WANA, where supplemental irrigation can maximize water use efficiency, and where water harvesting is likely to lead to substantial increases in yield and incomes.	Suitability maps for Syria and Tunisia	Review of scientists and decision makers	Data available and suitable, all activities successfully and timely completed
OUTPUTS 1. Report summarizing the experiences of the two pilot countries with water harvesting and supplemental irrigation.	Report produced and disseminated	Citation and request for report	Timely and quality contribution of authors, publication permission granted by authorities
2. Guidelines for evaluating the potential and constraints for adopting water harvesting and/or supplemental irrigation practices, at the level of project sites.	Databases, reports and maps	Requests for reports, citation	Scientists and data available, farmers cooperative
3. GIS-based methodology for identifying, at the level of the pilot countries, areas with potential for water harvesting or supplemental irrigation.	GIS-linked databases, maps, report and journal article produced and disseminated	Interest at workshop requests and use of maps and report, journal article accepted	Data and software available and suitable
4. Enhanced capacity of NARES in two pilot countries for targeting water harvesting and supplemental irrigation activities and for conducting technology-evaluation studies.	Involvement in meetings and workshops	Authors of reports and publications	Basic analytical capacity available, conducive working environment

APPENDIX 2: SCHEDULE OF ACTIVITIES AND MILESTONES

Activity	Month 1-5	Month 6-10	Month 11-15	Month 16-20
Output 1				
1. Inventory of water harvesting and supplemental irrigation sites, projects, and studies in two pilot countries.	xxxxxxxxxxx			
Milestone	list of sites and studies			
2. Preparation of report summarizing experiences with water harvesting and supplemental irrigation studies in two pilot countries.	xxxxxxxxxxx	xxxxxxxxxxx	xxxxxxxxxxx	xxxxxxxxxxx
Milestones			country reports	final report
Output 2				
3. Selection of water harvesting and/or supplemental irrigation benchmark sites in two pilot countries.	xxxxxxxxxxx			
Milestone	sites selected			
4. Compilation of benchmark site databases and secondary data, including satellite imagery, and their integration in a GIS framework.	xxxxxxxxxxx	xxxxxxxxxxx	xxxxxxxxxxx	
Milestones		all data collected	database completed	
5. Surveys to evaluate the adoption and impact of supplemental-irrigation and water-harvesting techniques at the benchmark sites.		xxxxxxxxxxx	xxxxxxxxxxx	
Milestone			surveys completed	
6. Documentation of the evaluation of the potential and impact of water harvesting and supplemental irrigation at the benchmark sites.			xxxxxxxxxxx	xxxxxxxxxxx
Milestone				reports
Output 3				
7. Collection and analysis of available data on climate, water resources, soil, land use, agricultural systems, socioeconomic conditions, policies, and property rights at the country level.	xxxxxxxxxxx	xxxxxxxxxxx	xxxxxxxxxxx	
Milestones		all data collected	database completed	
8. Development and testing of methodologies and models for country-level identification of areas with potential for water harvesting and supplemental irrigation.	xxxxxxxxxxx	xxxxxxxxxxx	xxxxxxxxxxx	
Milestone			methodology developed	
9. Ground-truthing of selected sites.			xxxxxxxxxxx	
Milestone			sites checked	

Activity	Month 1-5	Month 6-10	Month 11-15	Month 16-20
10. Preparation of maps identifying potential for water harvesting and supplemental irrigation in pilot countries.			xxxxxxxxxxxx	xxxxxxxxxxxx
Milestone				maps prepared
11. Preparation of publication with methodology and guidelines for evaluating the potential for supplemental irrigation and water harvesting at the country-level.		xxxxxxxxxxxx	xxxxxxxxxxxx	xxxxxxxxxxxx
Milestones		draft report		publication
Output 4				
12. Training workshop for NARES in development of spatial databases and analysis of data.		xxxxxxxxxxxx		
Milestone		workshop		
13. National workshops to discuss and disseminate results.				xxxxxxxxxxxx
Milestone				workshops

APPENDIX 3: BUDGET

Line Item (in US$)	Year 1			Year 2			Total
	ICARDA	**NARES[1]**	**IIASA**	**ICARDA**	**NARES[1]**	**IIASA**	
Personnel	40,000	36,000	6,000	40,000	35,000	5,000	162,000
Consultants	5,000	0	0	5,000	0	**0**	10,000
Travel	6,000	6,000	2,000	6,000	6,000	2,000	28,000
Research Supplies & Services	20,000	9,000	0	4,000	6,000	**0**	39,000
Workshops	2,000	0	1,000	0	6,000	1,000	10,000
Publications & Dissemination	2,000	0	1,000	5,000	0	2,000	10,000
Total	75,000	51,000	10,000	60,000	53,000	10,000	259,000
Own Contribution	35,000	11,000	0	25,000	13,000	0	84,000
Donor contribution	40,000	40,000	10,000	35,000	40,000	10,000	175,000

[1] Equal contribution to NARES of Syria and Tunisia