CPWF Project Report

Strengthening Livelihood Resilience in Upper Catchments of Dry Areas by Integrated Natural Resources Management

Project Number 24

A. Bruggeman, F. Turkelboom, J. Porhemmat, M. Ghafouri, S.B. Moosavi, S.A. Mirghasemi, Y. Norouzi Banis, P. Milani, S. Shahmoradi, A. Ghaffari, S.H. Sabaghpour, M. Effati, M. Rafati, A. Kalaei, M. Zad, J. Anthofer, A. Aw-Hassan, M. Martini, E. De Pauw, M. Pala, H. Siadat

International Center of Agricultural Research in the Dry Areas

For submission to the

CGIAR Challenge Program on WATER & FOOD

March 28, 2010

Acknowledgements

We would like to express our sincere appreciation to the management of our respective institutes: the International Center for Agricultural Research in the Dry Areas (ICARDA), Agricultural Extension, Education and Research Organization (AEERO), Soil Conservation and Watershed Management Research Institute (SCWMRI), Rural Research Center (RRC), Forest, Rangeland and Watershed Management Organization (FRWO), Soil and Water Research Institute (SWRI), Research Institute of Forests and Rangelands (RIFR), and the Dryland Agricultural Research Institute (DARI), for allowing us to cooperate in such a different, integrated research project. We are also very grateful to the management of the Agricultural and Natural Resources Research Centers, the Extension and Agricultural Service Centers, and the offices of the Ministry of Jihad-e-Agriculture and FRWO in Kermanshah and Lorestan Provinces for their cooperation and hospitality. And while some of our active cooperators are actually part of the management themselves, we would also like to thank the many researchers and support staff of these institutes and centers, who cooperated in the research. Many of their names can be found in the list of project participants at the end of the report. We would also like to thank the more than 250 male and female farmers in Honam and Merek watersheds, who contributed to the livelihood and gender surveys and who so enthusiastically engaged themselves in participatory technology development. We would like to thank Douglas White of the Center for Tropical Agriculture (CIAT) for his helpful suggestions and comments and the CPWF management for their patience.

We would like to dedicate this report to the late Mohsen Mohsenin (AEERO) who initiated the Livelihood Resilience project together with Francis Turkelboom (ICARDA) and led us in his kind way. His sudden demise in April 2006 was a great loss. We will not forget him.

ICARDA AEERO Forest, Range & watershed Management Organization KATHOLIEKE UNIVERSITEIT LEUVEN

Program Preface:

The Challenge Program on Water and Food (CPWF) contributes to efforts of the international community to ensure global diversions of water to agriculture are maintained at the level of the year 2000. It is a multi-institutional research initiative that aims to increase the resilience of social and ecological systems through better water management for food production. Through its broad partnerships, it conducts research that leads to impact on the poor and to policy change.

The CPWF conducts action-oriented research in nine river basins in Africa, Asia and Latin America, focusing on crop water productivity, fisheries and aquatic ecosystems, community arrangements for sharing water, integrated river basin management, and institutions and policies for successful implementation of developments in the water-food-environment nexus.

Project Preface:

The Livelihood Resilience project evolved around the hypothesis that better integrated management can improve the livelihoods of poor farming communities and increase the environmental integrity and water productivity of upstream watersheds in dry areas. This hypothesis was tested by researchers from different Iranian research and executive organizations and farming communities in two benchmark research watersheds in upper Karkheh River Basin in Iran, under the guidance of the ICARDA scientists. Participatory technology development, water, soil, erosion, land degradation and vegetation assessments, livelihood, gender and policy analyses, and integrated workshops delivered a set of principles for watershed management in dry areas.

CPWF Project Report series:

A. Bruggeman, F. Turkelboom, J. Porhemmat, M. Ghafouri, S.B. Moosavi, S.A. Mirghasemi, Y. Norouzi Banis, P. Milani, S. Shahmoradi, A. Ghaffari, S.H. Sabaghpour, M. Effati, M. Rafati, A. Kalaei, M. Zad, J. Anthofer, A. Aw-Hassan, M. Martini, E. De Pauw, M. Pala, H. Siadat. 2010. Strengthening Livelihood Resilience in Upper Catchments of Dry Areas by Integrated Natural Resources Management. ICARDA and CPWF.

CONTENTS

PROJECT HIGHLIGHTS

Participatory Technology Development
Participatory Technology Development (PTD) research in Upper Karkheh River Basin (KRB) mobilized more than 30 male and female researchers, technology experts and extension staff and more than 140 male and female farmers in eight communities in Merek and Honam watersheds. Sixteen different technologies with potential for improving livelihoods and water productivity were selected and tested by farmers. Special efforts were undertaken to include technologies that attracted the poorer farmers and women. Two movies (short and long versions), in Farsi with English subtitles, entitled "*A new found wisdom*", were made by the Participatory Technology Development Team. The short version concentrated on the perceptions of different individuals who have been involved in the process under various capacities; the longer version examined in detail the stages of a PTD cycle.

Watershed management principles
Project experiences were translated into principles for managing watersheds in upper basins. All research teams contributed to the principles booklet. The project also rallied together to develop and present policy recommendations on participatory technology development, integrated watershed management, and chickpea production and marketing. The newly developed skills in integrated and participatory research, the cooperation between colleagues of different research institutes and the friendships developed during the project were truly remarkable.

Agro-ecological zoning and similarity analysis of benchmark watersheds (with PN8)
An agroecological zones map of KRB was prepared based on climate, land use, soil and land form. A similarity analysis was conducted to identify areas with similar characteristics as the benchmark research watersheds, in KRB, Iran and the Central and West Asia and North Africa region, to facilitate out-scaling of project findings.

Watershed water resources assessments
Detailed measurement and analysis of the water resources, including installation of rain gauges and data recorders for stream flow measurements, provided the needed information for water resources management and development. In Merek, total water use from wells, qanats, two irrigation diversion dams and pumping from the stream amounted to 9.98 Mm3, with about 97% used for irrigation. The annual runoff coefficient was 0.043. In Honam, total water use from spring flow and groundwater wells was 19.6 Mm^3 and the runoff coefficient was 0.53. In Merek, improvements need to come from increasing the water use efficiency in agriculture, while in Honam there is a need to develop water storage in the upstream areas for the dry summers (Porhemmat, J.et al, 2011).

Land use change analysis of upper KRB
Analysis of satellite images dating back to 1975/76 combined with analysis of 2002 images showed an increase in cropland (4.9%) at the cost of forest land (8.5%) in upper KRB. The actual reduction of forest land is likely to be higher because the cultivation of the under-story of forests could not be detected on the satellite imagery. The reduction and degradation of forest land was expected to have increased erosion rates. However, no significant time trends could be detected in suspended sediment concentrations, collected at various locations throughout the basin. Field surveys in the watersheds indicated severe biological degradation of the natural rangelands and forests. Discussions with local herders indicated that they can envision to return to the controlled grazing system of the past, provided that they receive support of the government.

Erosion assessments and modeling
The soil survey, natural vegetation assessment, land use and land use change analysis from aerial photos and remote sensing images and the erosion field surveys provided the required data inputs

for modeling and analysis of erosion in the benchmark watersheds. Spatial erosion modeling revealed trade-offs from the expansion of crop production on sloping lands. In Honam watershed cultivation has already encroached on the steeper slopes. Model results (Norouzi Banis, Y. et al. 2011) indicated that an increase in arable lands from the current 31% of the watershed area to 40% would triple water erosion and increase tillage erosion by 40%. In Merek watershed an increase in arable area from the current 62% to 71% would increase water erosion by 70% and tillage erosion by 46%

Livelihood analysis in upper KRB

Access to an irrigation water source was found to be a key determining factor of rural household income in 7 communities of the upper Karkheh River Basin. Results of the livelihood analysis were even clearer after excluding two upstream communities, that emphasized livestock and grazing systems. In Honam, the average annual income was approximately $6121 (or US$3.48 per capita per day) for the non-poor households (100% access) and $1417 (or US$0.67 per capita per day) for the poor households (86% access). In Merek watershed, where access to water resources was much lower than in Honam watershed, the incomes were also much lower. The average annual income of the non-poor households (63% access) was $4547 (or US$2.83 per capita per day)and $1145 (US$0.55 per capita per day) for the poor households (48% access). The incomes of households in the upstream livestock communities were much below these averages in Honam, whereas in Merek the incomes were comparable.

Gender analysis in upper KRB

A gender survey in upper KRB revealed an important role for women in dairy production in both watersheds. Problems and needs assessments indicated the following opportunities for improving the livelihood of the women in these upstream communities: access to loans, especially for buying livestock and milking equipment, training in livestock breeding, handicrafts, and mushroom growing, and improved veterinary services. The women also expressed the need for mechanized harvesting and weeding to reduce their workload. The lack of irrigation water was also voiced as a concern by the women from the upstream villages.

EXECUTIVE SUMMARY

Similar to other watersheds in upper catchments in dry areas, productivity and farming incomes are low in the Zagros Mountains of Iran. This mediocrity of the agricultural sector is matched by a research and executive sector that is hampered by insufficient human and financial capital and a general reluctance to change. The main goal of this project was to develop appropriate methodologies for improving livelihood strategies and watershed management in dry upper catchments. The project was a collaborative effort of an interdisciplinary group of international, national and provincial researchers, decision makers, extension staff and farmers, who tested their newly-developed skills and visions in the Honam and Merek watersheds of the upper Karkheh River Basin of Iran.

The two benchmark research watersheds differed in their level of diversity and availability of water resources. The Honam watershed, in Lorestan province, hosts approximately 19 small communities within its 140-km^2 area. Average annual precipitation over the watershed was estimated to be 690 mm, but is 440 mm at the downstream end. Mean monthly temperature is -2 ºC in January and 23 ºC in July. Honam watershed has more water resources and had more diverse crop and livestock income generating activities than the Merek watershed in Kermanshah. The Merek watershed covers 240 km^2 and contains about 40 communities. Average annual rainfall is 480 mm and mean monthly temperature is 1 ºC in January and 25 ºC in July. A similarity analysis, based on climate, land use and land form, indicated that in the region formed by Central Asia, West Asia, North Africa and the Northern Mediterranean we can find 361,569 km2 (1.6%) that are very highly or highly similar to Honam and likewise (0.8%) for Merek.

Access to an irrigation water source was found to be an important determining factor of rural household income in the downstream and midstream communities. In Honam, the average annual income was approximately $8083 for the non-poor households (100% access) and $3733 for the poor households (86% access). In Merek watershed, where access to water resources was much lower than in Honam watershed, the incomes were also much lower. The average annual income of the non-poor households (63% access) was $4371 and $998 for the poor households (48% access). The incomes of households in the upstream communities, which had important livestock and grazing systems, were much below these averages in Honam, whereas in Merek the incomes were comparable.

The gender survey confirmed the important role of women in the agricultural production process and their limited decision making power. Access to loans, training in livestock management, dairy production, handicrafts and small technologies such as mushroom growing could improve their status and contribution to the family income.

Water resources analysis in the benchmark watersheds found an important potential for increasing water storage in Honam watershed (runoff coefficient 0.54), while in Merek (runoff coefficient 0.04), judicious use of groundwater could provide relief during periods of droughts.

The vegetation survey found that biological degradation in KRB has accelerated during the last six decades, due to changing policies (nationalization of rangelands and forests in the 1960s and policies that stressed food security in the late 1970s and 1980s) and increasing population pressure (Shahmoradi, 2010). Participatory techniques are needed for effective rehabilitation of degraded areas and foster communal management of grazing rotations. Rehabilitation of rangelands requires seeding with species adapted to the different rangeland systems. In these semi-arid environments, forest systems are generally vulnerable to overgrazing and extensive wood cutting which need to be avoided. The rangelands could support rotational grazing (one year rests and two year grazing) with 5 sheep for 4 to 10 ha of rangelands, depending on the rangeland type.

The erosion and land degradation surveys found high rates of land degradation. Measurements of tillage erosion found that erosion rates exceeded 100 kg m^{-1} per tillage pass on slopes above 20%. Main causes of gully erosion within and beyond the pilot sites in Upper KRB were (i) marl formations, (ii) overgrazing, (iii) up and down slope tillage practices, (iv) road construction and pipeline projects, (v) deforestation, and (vi) stream bank erosion. Proper legislation and participatory approaches are needed to reverse the degradation trends.

Participatory technology development involved a large number of researchers, extension staff and farmers from eight communities in the two watersheds. Sixteen technologies were tested by the farmers in their fields. These included use of azetobactar (a biofertilizer) for irrigated and rainfed barley and wheat, artificial liquid inoculants for chickpea and beans, new wheat and barley varieties, communal pest management of wheat, cultivation of poplar, potato, shallot, saffron and mushrooms.

Strengthening of livelihood resilience in upper catchments of dry areas can only be achieved sustainably by combining interventions at multiple levels (i.e., field, household, watershed, community, markets, institutions, and policy). Policy recommendations on participatory technology development, integrated watershed management, chickpea production and marketing were developed and presented to decision makers.

INTRODUCTION

In the upper catchments of drylands, the options for agriculture are limited and usually dominated by rainfed agriculture and extensive livestock. Agricultural production is generally low and highly dependent on climate variation. Communities are economically remote and thereby face high transaction and input costs. When shocks and stresses occur in these areas, livelihoods can become very vulnerable, especially for the poor (Glavovic et al. 2002). Furthermore, when ecological integrity and biological diversity are reduced, natural systems become more vulnerable to sudden changes (Carpenter et al. 2001). This often leads to the downward spiral relationship between poverty and natural resources, as human and natural systems are strongly coupled and co-evolve (Norgaard 1994).

On the other hand, households in dry areas are resourceful in coping with such an unreliable environment (Campbell et al. 2002). Resilience of livelihoods is the ability to cope with and recover from stresses and shocks (Ellis 1999), and is a key component of 'adaptive capacity'. Main strategies to cope with a crisis, such as an economic shock or a drought, are livelihood diversification, agricultural intensification, and/or migration (Geran 2000). Resilience capacity of rural livelihoods depends on several factors, such as ecological, social and cultural resilience (Glavovic et al. 2002). However, strengthening livelihood resilience in dry upper catchments in practise is a very challenging task.

As water is the most limiting natural resource in these areas, any increase in water productivity will almost certainly benefit the rural livelihoods. However, as water availability depends on many stakeholders and many land uses, an integrated and participatory watershed management approach is needed to address tradeoffs. Research on past experiences has indicated that there are often losers and winners, and that it is not easy to spread the costs and benefits equally (Kerr et al. 2002). In addition, research on water flows in dry upper catchments is particularly difficult, due to the difficulty to assess groundwater resources in mountainous environments and irregular and intense overland flows (Bergkamp 1998).

The upper Karkheh River Basin of Iran is typical of the dry environments of Central Asia, West Asia, North Africa and the Northern Mediterranean (De Pauw et al. 2008). The majority of the agricultural lands is under rainfed crops: barley, wheat and legumes. Along the streams and in the plains, we find irrigated areas with water diverted or pumped from streams and groundwater. Farmers use the water for supplemental irrigation of rainfed crops or irrigation of small plots of fruit trees, sugar beet, potatoes and vegetables. Fluctuations in rainfall both within and between seasons, combined with cold winters and suboptimal agronomic management result in low yields and low water productivity (Oweis and Farahani, 2008). The natural rangelands and forests on the hillsides along the valleys are threatened by the increased cultivation of sloping lands and uncontrolled grazing. Poor vegetation cover, degraded physical and chemical soil properties and a disturbed water balance can be clearly observed across the landscape. Consequently, surface runoff is high, causing widespread erosion, regular flooding and high sediment yields. For example, 920 ton/km^2/year of sediment accumulates in the reservoir of the Karkheh dam at the downstream end of the basin (Karkheh Office, 2002). As result, the expected lifetime of the Karkheh dam has been more than halved, causing substantial economic losses for the government.

Degradation of the resource base has contributed to high poverty levels of rural communities in the region (average 230 US$/capita from agricultural activities) and to the high rural-urban migration rate (Ashrafi 2003). However, growth and migration are not evenly distributed. Villages with sufficient water continue to expand, whereas areas with water shortage tend to become ghost villages.

To address this environmental and economic challenge, the government has ambitious plans to stimulate rural development. Iran intends to increase GDP/rural capita, consolidate scattered land holdings, increase cereal yields, and reduce the small ruminant population with 50% by 2020 (Ministry of Agriculture, 1997). But there limited knowledge of household livelihood portfolios and risk coping strategies (environmental and economic) are likely to lead to ineffective project interventions. Thus, similar to many other developing countries in dry areas, it is a critical time for Iran to start examining both environmental and livelihood resilience at the same time.

This CPWF project addresses the following research hypothesis: strengthening of livelihood resilience in upper catchments of dry areas can be achieved in a sustainably by combining interventions at multiple levels (i.e., field, household, watershed, community, markets, institutions, and policy). Inquiry into this hypothesis was advanced by an interdisciplinary group of international, national and provincial researchers, decision makers, extension staff and farmers in the upper Karkheh River Basin of Iran. The main goals of this project were:

- to strengthen livelihoods in marginal dry environments in a sustainable way;

- to improve livelihood strategies and watershed management in dry upper catchments, which can be used beyond the benchmark research sites in a spectrum of dry environments.

PROJECT OBJECTIVES

The project was guided by the CGIAR's integrated natural resources management (INRM) framework and cornerstones (http://www.inrm.cgiar.org/). In short, INRM aims to help to solve complex real-world problems affecting natural resources in agro-ecosystems by fostering and improving adaptive capacity and learning of all involved stakeholders. The project implemented the following INRM cornerstones (Campbell et al 2002; 2006):

- *Merging research and development*: The project aimed to combine quality science with development impact at the field level. The project emphasized the forging effective cooperation between research agencies, development and executive organisations, policy makers, community organisations and land-users.
- *Creating a system for adapting and learning*: For sustainable impact, it is essential that the involved stakeholders will improve their own adaptive capacity to cope with the challenges in dry upper catchments. Therefore, various approaches for capacity building and communication between stakeholders were established.
- *Balancing bio-physical and socio-economic sciences*: As livelihood resilience and natural resource regeneration are interrelated, there is a need for a holistic approach. Thus, five Iranian research institutes were involved and special attention was given to improve inter-disciplinary cooperation.
- *Focusing the right type of science at the right level*: In-depth studies of two contrasting watersheds were combined with a more general analysis of the upper Karkheh basin.

The project had five main objectives:

1. Develop a framework for evaluating livelihood vulnerability and resilience in dry upper catchments.
2. Identify and evaluate watershed management principles for upper catchments in dry areas.
3. Build the capacity of communities in two upper catchments to strengthen their livelihood resilience and to manage their catchments in a sustainable way.
4. Develop an effective strategy for outscaling and upscaling of research results and lessons learned.
5. Improve coordination and process skills.

Site selection

Two representative benchmark watersheds in upper KRB were selected for in-depth study and participatory, community-based research. The watersheds were selected based on field visits, review of available information provided by the Provincial Research Centers, a preliminary agro-ecological characterization (elevation, climate, land use), and spirited discussions among an inter-disciplinary group of researchers. Factors taken in consideration included agricultural livelihoods and diversification, poverty, number of villages (10-20), availability of surface and groundwater resources, rangelands and forests, occurrence of resource degradation, institutions, cooperative community spirit, accessibility and availability of background data.

1. Objective 1: Develop a framework for evaluating livelihood vulnerability and resilience in dry upper catchments

From Rafati et al. (2010)

Methods

A livelihood vulnerability analysis was conducted in two selected watersheds in Upper Karkheh River Basin: Honam Watershed in Lorestan province and Merek Watershed in Kermanshah province (Fig. 1.1). The vulnerability analysis included a household livelihood survey, gender survey, marketing study and a linear programming analysis to examine the effect of agricultural policies on agricultural production and livelihoods. The studies used qualitative and quantitative methods of livelihoods such as informal and formal surveys, the first through PRA techniques i.e. focus group discussion and the second through questionnaire interviews. The informal surveys were used to identify the main issues and constraints. For the gender survey, local females educated in humanities (social sciences) who spoke the local dialect were trained in collecting information through the questionnaires. The studied population of the livelihood and gender surveys consisted of four villages in Merek Watershed and three villages in Honam Watershed (see Fig 1.2 and 1.3).

Figure 1.1: Location of Karkheh River Basin and the selected watersheds (Merek and Honam)

In Merek, villages were categorized into three groups according to their geographical location, access to natural resources, and production systems. These three groups included (1) villages along the valley, (2) villages near pastures, and (3) villages near the forest (see Fig 1.2). The villages in the valley have irrigated farmlands. Because the majority of the villages (23) are located in the valley, one village was selected from each group, but two villages were selected in the valley. The four selected villages in Merek consist of Bagh-e Karambayg (near the forest), Sekher-e Olya (near the pastures) and villages of Kolahjoub and Mahdiabad-e Sofla (along the valley).

In Honam, villages were categorized into upstream, midstream, and downstream villages, which varied substantially in terms of livestock and agricultural activities and access to water. Upstream villages mostly rely on livestock breeding (mainly sheep), gardening and dry farming, while midstream villages have a combination of irrigated and dry land farming and their livestock production mainly depends on cattle breeding. Downstream villages have good access to water and thereby have both irrigated and rainfed crops; their livestock production is also mainly cattle breeding. With 20 villages, Honam has fewer villages than Merek, and one village from each group was taken for sampling purposes. The selected villages were Peresk-e Olya (upstream), Chahartakhteh (midstream), and Siah Posh (downstream). The gender survey added Bardbal, a second midstream village, which was also involved in the participatory technology development.

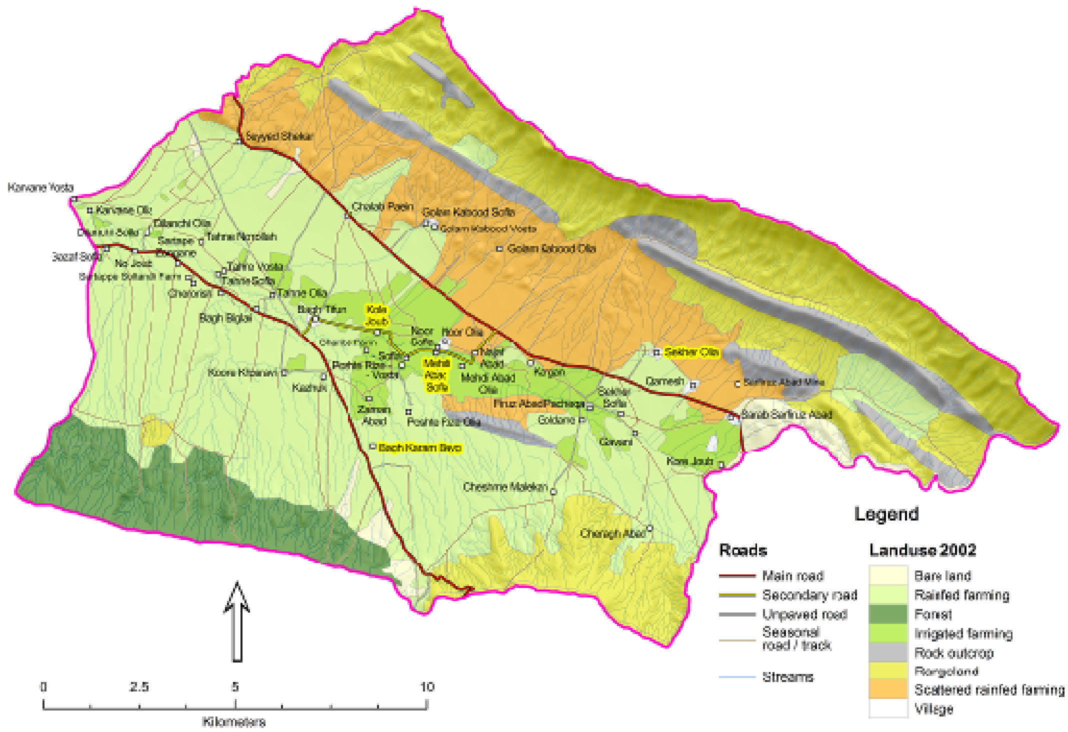

Figure 1.2: Merek watershed with the villages for the participatory research, gender and livelihood surveys are marked in yellow.

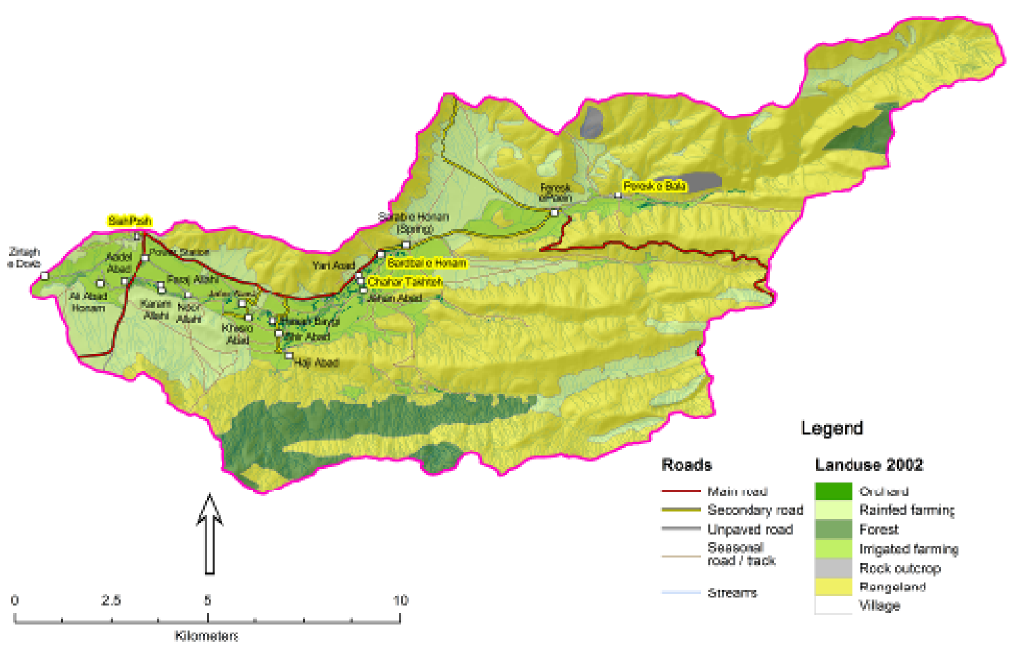

Figure 1.3: Honam watershed, with the villages for the participatory research, gender and livelihood surveys marked in yellow.

The study used a proportionate stratification sampling method. In other words, given the number of the concerned villages in the studied regions, a proportionate number of resident households was selected from each village. The actual households were selected in a simple random manner, using the names of the village households provided by the Village Islamic Council . The livelihood survey interviewed 275 household heads and the gender survey interviewed 261 women. The number of households of the surveyed villages ranged between 42 in Bagh-e Karam Baygh to 80 in Kolah Joub in Merek and between 25 in Chahartakhte and 90 in Peresk Olya in Honam.

Results and Discussion

The survey revealed contrasting population dynamics of the villages. The total population of the four villages in Merek increased from 901 in 1996 to 1069 in 2006. In Honam the number of people declined from 1154 in 1996 to 929 in 2006.

In Merek, the heads of the surveyed household were younger (48 yr average) than in Honam (56 yr) and predominantly male (97%), as compared with 84% male-headed households in Honam. The number of illiterate household heads was slightly higher in Honam (50%) than in Merek (48%). In general, illiteracy was higher in the upstream villages than in the downstream villages. The average household size was about 5 people in both watersheds. Illiteracy among women was slightly higher than among the men, according to the gender survey. In Honam 52% of the surveyed women were illiterate and in Merek 56%. The education level of the women increased with a decrease in age, indicating the increased education opportunities for rural women in recent decades.

For the livelihood survey, household income, which is not only indicative of a households' access to resources and facilities but also the success of the household in the use of these resources, was used to divide the surveyed households in two groups. The incomes of all households were analyzed and the income per capita was computed. The household were grouped into poor and non-poor using 50% of the sample mean income as the poverty line because with US$1.1 per day (using 2008 exchange rate) it was very close to the US$1 a day commonly used in poverty studies. Households with a per-capita income that was less than 50% of the sample mean were placed in the poor group and those with an income above the 50% of the sample mean were placed in the non-poor group. In both watersheds, the average household income of the non-poor families was more than four times higher than the household income of the poor. Overall, over a third (35%) of the sampled households fell in the poor category. Although, basic food products such as flour, bread and oil are guaranteed by the State at a nominal price, the poor households will certainly face food security problems.

Table 1.1 shows the fraction of poor and non-poor households in each village. The fraction of poor households was much higher in Merek (48%) than in Honam (19%). In both watersheds, the area of rainfed and irrigated land and the number of livestock is clearly much less for the poor than for the non-poor households. Interestingly, poor households in the midstream and downstream villages in Honam had more rainfed land than the non-poor households, indicating the important contribution of irrigated land to the household income.

In Merek 71% of the non-poor households had access to an irrigation water source, as compared to 46% for the poor (Table 1.2). Only 10 out of the 38 surveyed households in Sekher Olya had access to the water of the qanat for irrigation. A qanat is an ancient underground channel that accesses the groundwater table and let it flow out under gravity. But access to water is only one of the factors that determine poverty. In Honam, most households had access to an irrigation water source, except for the upstream village Peresk Olya, which also had the highest percentage of poor households.

In Merek watershed, on average 70.1% of the income of the households was obtained from cropping, 17.3% from animal husbandry, and 12.6% from other income generation activities. In Honam, 42.5% of the income was obtained from cropping, 34.3% from animal husbandry, and 23.3% from other activities.

Access to an irrigation water source was an important, although not the only, determining factor for the income of the rural households. This effect was even clearer after exclusion of the two upstream communities, Sekher Olya in Merek and Peresk Olya in Honam, with high livestock populations (more than 30 head per household). In Honam watershed, the average annual income was approximately US$6121 (US$3.48 per capita per day) for the 98 non-poor households (100%

access) and $1417 (US$0.67 per capita per day) for the 19 poor households (86% access). In Merek watershed, where access to water resources was much lower, the incomes were also much lower. The average annual income of the 82 non-poor households was $4547 (US$2.83 per capita per day) and $1145 (US$0.55 per capita per day) for the 76 poor households. The incomes of the households in the upstream livestock communities were much below these averages in Honam, whereas in Merek they were comparable. Thus, while livestock can be an important contribution to the livelihood of rural communities in upstream watersheds, the income effect of access to irrigation water was even more evident.

Table 1.1: The fraction poor and non-poor households and the average area of land and number of livestock in Merek and Honam

Village	Group	%	Irrigated land (ha)	Rainfed land (ha)	Sheep & goats (nr)	Cows (nr)
Merek						
Kolejoob	Poor	29	.73	2.30	.00	1.00
	Non-poor	71	2.74	4.58	4.00	2.12
Mahdi abad	Poor	63	.95	1.68	2.36	.77
	Non-poor	37	2.21	5.75	2.54	2.31
Sekhr olya	Poor	34	1.19	2.54	20.77	.00
	Non-poor	66	1.52	7.63	34.32	.76
Baghe karambeyk	Poor	62	.00	2.56	.45	.94
	Non-poor	38	1.00	5.41	9.95	1.26
Average	Poor	48	.58	2.27	4.42	.74
	Non-poor	52	1.88	5.89	14.39	1.54
	Total		1.25	4.15	9.59	1.15
Honam						
Siyah poosh	Poor	8	.50	2.73	.00	.00
	Non-poor	92	2.18	1.89	4.26	3.24
Chahar takhte	Poor	10	1.28	6.25	.00	1.50
	Non-poor	90	2.49	3.78	6.66	2.09
Peresk olya	Poor	32	.76	1.64	29.33	.50
	Non-poor	68	2.50	5.45	60.77	.58
Average	Poor	16	.83	2.78	18.53	.63
	Non-poor	84	2.38	3.57	20.18	2.09
	Total		2.13	3.44	19.91	1.85

Table 1.2: Access to irrigation water sources of the surveyed poor and non-poor households in Merek and Honam

	Income level	Surveyed households	Stream	Qanat	Well	Access to water
		#	#	#	#	fraction
Merek						
Kolejoub	Poor	10	0	0	8	0.80
	Non poor	25	1	0	17	0.72
Mehdiabad Sofla	Poor	22	11	0	10	0.95
	Non poor	13	7	0	9	1.00
Sekher Olya	Poor	13	1	2	3	0.46
	Non poor	25	4	8	9	0.84
Baghe Karambeg	Poor	31	0	0	0	0.00
	Non poor	19	0	0	3	0.16
Total	Poor	76	12	2	21	0.46
	Non poor	82	12	8	38	0.71
Honam						
Siyahpoosh	Poor	3	2	0	0	0.76
	Non poor	34	34	0	0	1.00
Chahartakhteh	Poor	4	4	0	0	1.00
	Non poor	38	38	0	1	1.00
Peresk Olya	Poor	12	9	0	0	0.75
	Non poor	26	21	0	0	0.81
Total	Poor	19	15	0	0	0.79
	Non poor	98	93	0	1	0.96

In both watersheds, the highest share of household expenditures was for food, ranging between 55% for the non-poor households in Peresk Olya and 72% for the poor households in Chahartakhteh, both in Honam.

All of the 261 women interviewed for the gender survey stated that they were involved in agricultural activities. However, only two of the women identified their job as tailor, while all others identified themselves as housewives. In Iran, agriculture is not considered a job for rural women, but part of their daily activities along with house activities and family care. About 13% of the women were widowed and most of these managed the family household.

Women's participation in crop production is summarized in Table 1.3. Compared to men, women had higher time shares in manual weeding and harvesting. In addition, most women are involved in traditional dairy processing, providing substantial revenues to the family. Average annual per household production ranged between a minimum production of 16 kg of ghee and a maximum production of 820 kg of yoghurt. Women were also involved in various traditional handicrafts including carpet weaving, spindle, chador making, and knitting.

Table 1.3: Agricultural activities of rural women in Honam and Merek

Activity	Honam	Merek
Cultivation (%)	9.6	10.3
Crop management (%)	30.8	33.7
Harvesting (%)	34.9	35.9
Marketing (%)	2.8	2.3
Post-harvest (%)	21.4	38.4

In rural Iran, women's have little access and control over resources. Only 3% of the surveyed women were registered as land owners. These women were household heads. Men generally had dominant shares in the household decision making process, except for decision making on selling dairy products. This was also reflected in the ownership of livestock (23% of the women). Nineteen percent of the surveyed women took part in decision making at village level; the majority of these women indicated that they participated in the Village Islamic Council. Although women may take part in meetings of the Village Councils, they are not members. Forty-nine percent of the women participated in informal, traditional collaborative activities.

The marketing study indicated that inadequate information regarding supply, demand, and price of agricultural products and lack of marketing institutions causes the farmers to sell their products to the local middlemen or wholesalers at relatively low prices. Additionally, low financial capacity of the farmers obliges them to sell their product quickly after harvest. Recent changes in export regulations that prevent an increase in domestic prices, such as in the case of chickpea, has resulted in reduced prices received by the farmers and has had a negative impact on the income and livelihood of the households.

A set of linear programming (LP) models was used to analyze the effects of policies on production decisions and farm income (Rafati, M. et al., in review). A total of 14 LP models were built for poor and non-poor households for the seven villages in the two watersheds The disaggregated models by production system and by wealth group allowed separating the effects of policy changes on different household types. The models determined optimal production activities mix for households grouped by wealth (poor and non-poor) based on income and with varying resource endowments; and allowed simulation of the effects of policies (specifically, fertilizer and pesticide subsidies and credit provision) on a number of performance indicators. These include changes in income, poverty rates, water use, food security (measured in the production of strategic crops). Production constraining factors in the models include farm resources such as water, irrigated land (spring or autumn), rainfed land, hired and family labor (male and female), machinery, fertilizer (subsidized and market price), pesticides (subsidized and market price), cash flow; access to loans; and minimum level for home consumption for major stable crops. The production coefficients were computed from the survey data.

The analysis indicated that especially for the poor households, with water resources, labor was a limiting factor. Labor saving technologies, would increase cultivated area, increase the number of livestock and thereby increase farmer's income. Price liberalization for fertilizers and an elimination of subsidies for pesticides would have different effects on the cultivated areas of rainfed and irrigated crops for the poor and non-poor households in the two watersheds. The poor households with smaller irrigated areas, hence using less subsidized inputs, will be affected much less by subsidy removal (1% and 8% income reduction for fertilizer and pesticide subsidy removal, respectively), than the better endowed farmers who use these inputs much more intensively (12% and 18% income reduction for fertilizer and pesticide subsidy removal, respectively). These results shows that such input subsidy policies cannot be justified on poverty reduction grounds as their benefits are clearly inequitable among rural households. Removal of agricultural chemical input subsidies resulted in the reduction of irrigated areas for both groups of households indicating that such policies lead to higher rates of water resources use and eventually to their depletion while at the same time are widening inequity in the rural areas. The effects of credit provision were also analyzed. In that case, the poor households in the more extensive production systems would increase their sheep flock, while the better-off farmers in the more intensive systems in the valley (with access to irrigation water) would invest in crossbred cows. Clearly the later group will have more impact on water use through cultivation of irrigated forage crops.

Conclusion

The results of the livelihood vulnerability analysis indicate the important effect of access to irrigation land on farmers' incomes'; a need for more training opportunities for women, especially in livestock management and dairy production; poor price margins for the farmers due to lack of processing and marketing support and inadequate government policies such as export restrictions for chickpea. Further integration between the livelihoods and natural resource assessments for obtaining a better understanding of the resilience of these communities and up and downstream effects is addressed in objective 2 (watershed management principles).

2. Objective 2: Identify and evaluate watershed management principles for upper catchments in dry areas

From Turkelboom et al. (2010)

Methods
The spatial and temporal dynamics of water resources in the two catchments were monitored and analyzed. Soil, erosion, nutrient balances, vegetation and land degradation surveys were conducted and results mapped. Participatory problem and needs assessments, gender and livelihood analyses (see objective 1) were conducted in downstream, midstream and upstream communities. Stakeholder meetings were organized, including SWOT analyses and priority setting exercises.

Results and Discussion
Although watershed management in Iran started in the 1950s and is a national priority, its implementation is suffering from conflicting national priorities (e.g. food self sufficiency versus natural resources conservation), uncoordinated sectoral government actions, focus on structural works, top-down approaches, and lack of community participation (Sharifi 2002). On the positive side, some important successes have been achieved; human and institutional capacity for watershed management has expanded dramatically in Iran, and many lessons have been learned (Sharifi 2002). But there are only few examples of participatory and integrated watershed management in Iran, such as in Rimaleh and Hableh Rud catchments in Lorestan and Tehran Provinces.

The principles presented below are based on international experiences (Kerr et al. 2002; ; Veale 2003; Bruneau 2005; German et al. 2005; 2006; Catacutan and Duque 2006; FAO, 2006) and those of the Livelihood Resilience Project. Some are universal, while others are tailored to the Iranian conditions of dry mountain ecosystems.

How to plan and conduct integrated watershed management projects

- Establish trust: Trust building is the basis for any successful project between different stakeholders. This requires ‘meaningful participation’ and consultation throughout the project, starting from the design to implantation and evaluation. In this process, different partners decide together on an equal basis, work together each using their comparative advantages, and share costs for the selected interventions.

- Team building: Interdisciplinary project teams contain people with different reference frameworks, objectives, incentives and characters. Team spirit can be build via joint problem analysis, field trips, retreats in a non-office environment (and with no mobile telephone connection), and targetted capacity-building events. Although it is essential to constantly stimulate critical reflection, leadership should also encourage positive thinking and avoid excessive negative thoughts.

- Learn from past lessons: There is no need to re-invent the wheel, as a vast experience with IWM approaches exists around the world (see references above), with a small but increasing number of success stories in Iran. New projects should learn from their “learned lessons”, and avoid their mistakes (see Box 1).

Box 1: Evolution of watershed management approaches

Watershed management projects have been implemented all over the world over the last 50 years and they have undergone a significant evolution (FAO, 2006). The first generation watershed management approaches were technology-driven. The objective was to find technological fixes for 'watershed problems'. The problems were usually forest degradation, erosion, or downstream sedimentation and flooding. Technological fixes were applied to fix the problems. The projects were usually led by foresters, water and irrigation engineers. These projects were popular during the 1960s up to 1980s. The disadvantage of this approach was that local farmers did not feel ownership of the interventions. Once the land management measures needed maintenance, villagers waited for government agencies to fix 'its' structures. As a consequence, many of such interventions did not survive long after the end of the projects.

The second generation watershed management approaches can be called the "participatory watershed approaches". These projects used a real bottom-up approach. Local communities were the main source of information and action. The local livelihood problems were used as an entry-point to reflect on alternative ways to use the natural resources. Solutions were found by combining local knowledge and outsider expertise and implementation was done as much as possible by the local communities. Such projects were initiated by NGOs during the 1980s. Donors and government agencies started to use this approach from the 1990s onwards. However, it was observed in some watersheds that excessive water harvesting in the upper reaches led to downstream shortages. In extreme cases, the catchment became 'closed', as no water flowed out of the catchment any more.

The third generation watershed management approaches are called 'collaborative watershed approaches'. It was realized that significant parts of natural resources management (sustainable grazing, equitable water use, payment for environmental services, treatment of sewage water) can only be achieved when agencies with legal responsibilities are involved in the process. Such projects involved multi-stakeholder processes and combined 'bottom-up' and 'top-down' approaches. This approach started around 2000 and is now being tested at many sites around the world.

- Inter-sectoral planning and stakeholder participation: No single institution can manage integrated watershed management planning alone. Therefore, planning should not be confined to one sector only. Consequently, all existing institutions that can influence the success of IWM projects should be contacted, and invited to participate in the planning and execution of the project. Stakeholders include the farming communities, catchment management authorities, governmental agencies, NGOs, local Islamic Councils, and local members of parliament (Ghafouri, 2008). A stakeholder analysis will identify their mandates with respect to watershed management, their capacities and interests, their visions about the desired future of the watershed, and their relationships with other organizations.

- Involve knowledge sources: All stakeholders should recognize the fact that all participants have knowledge and expertise that is relevant to the project. The type of knowledge is of course different, and one type of knowledge should not be treated superior than another. Knowledge can come from a range of sources: policy makers, local decision makers, researchers, extension agents, staff of the executive sector, NGO staff, community leaders and - last but not least – farmers. Especially indigenous knowledge is often undervalued and underutilized. Farmer innovations can be a potential source for development.

- Recognize household diversity and gender: It is important to consider diversity in the target communities. The less-privileged community members often need special support in negotiations (e.g. for sharing water rights), and special attention should be given to make the voice of women heard in decision making. It is also important to be flexible with respect to locally important livelihood systems (e.g. an approach for nomad communities is quite different from that for settled communities).

- Define goals: The goals of any IWM intervention should become clear in the early stages of a project. The initial diagnosis can help to sharpen and define the goals. Goals should be defined in close consultation with all the major stakeholders. A basic principle in setting goals for IWM in dry mountains is to balance rural development goals with ecological limits of dry mountains. Therefore, the success of the IWM projects should be measured both in social and environmental terms.

- Facilitate professionally: To achieve satisfactory and sustainable results, professional facilitation skills are required to guide stakeholder and community processes during the diagnostic phase, but particularly during the problem-solving phase. As such skills are often rare, they can be brought in from abroad. But at the end, outscaling of IWM projects will only be possible when local trained facilitators will be available.

- Establish local participation in monitoring and evaluation: Traditional monitoring and evaluation is usually about satisfying bureaucratic and/or donor requirements. However, when this is done in a participatory and reflective way, then such exercises can accelerate the learning curve of the involved parties and improve performance. The "Impact Pathways" approach is a useful way to plan the future project trajectory from the onset (more information at: http://boru.pbwiki.com/). The innovative aspect of this approach is that it starts with the desired outcomes and then identifies the required steps. In addition, the required institutions, their role in the different stages of the project, and the different milestones are discussed with all the partners from the onset. To aid the monitoring process, it is important to define SMART indicators.

- Identify phase-out plan: IWM projects usually mobilize substantial human and financial resources and good-will during the first few years. However, the higher the inputs, the higher the risk for collapse at the end of the project. This potential risk should be contained and planned for from the beginning of the project. Collapse can only be avoided when the ownership of the interventions lays squarely with local communities and local institutions, and when maintenance costs is within reach of these local actors.

Start-up and diagnostic phase

- Selecting target areas: Selection of target areas should take place at two levels.
    - In early stages of IWM testing and improving, target areas should represent a (problematic) socio-economic or ecological situation. Useful tools for regional analysis are agro-ecological zoning (AEZ), similarity analysis, rainfall and drought analysis, hydrological and sediment analyses.
    - In mountain regions, "watershed" areas are convenient and logical study areas, as its borders usually coincide with the borders of hydrological processes, economic activities and administrative borders. However, it is important to realize that watershed borders are not meaningful for nomad herders, as their cattle usually utilize rangelands of several catchments.
    - An important selection criterion is the interest of local communities to participate in IWM. Here it is important to get an assessment of real interests, and not interests biased by inflated expectations due to (imaginary) project funds.

- Participatory appraisal: Joint visits to the target area and participatory rural appraisal (PRA) exercises are very useful to clarify the interaction between livelihoods and natural resources (e.g. coping strategies with dry spells and land degradation) and to frame problems and opportunities of the target area. This common consensus building about the situation and what needs to be done is very important, as it will provide the basis for defining the goals and the institutional roles.

- Role of research in the diagnosis phase: Not all issues can be answered during a PRA, such as bio-physical potentials and limitations of the catchments areas (e.g., sustainable water consumption rates, required ecological base flow, rangeland carrying capacity). If the understanding of these features is considered crucial for successful IWM, then expert organizations need to be involved.

Strategy to balance rural development goals with ecological limits of dry mountains

- Ecosystem services of mountainous watersheds: "Ecosystem services" are defined as "the benefits that nature and ecosystems provide to the society" (MEA, 2005). Dry mountain watersheds provide a set of ecosystem services to local communities and the Iranian society as a whole (Fig. 1.4), although many of them are not all well-documented or recognized: Besides agricultural production, which provides the main source of food and livelihood to the local communities, there is also the important role of upper catchments on the water cycle (i.e. accumulation of snow, groundwater recharge, provision of water for local and downstream users, natural control of erosion and floods, natural capacity for water purification). Other ecosystem services are food, forage and medicines derived from the rangelands, preservation of biodiversity, enchanting natural landscapes, fresh air, and potentially, ecotourism. The assessment and quantification of these services requires good understanding of agro-ecological zones, water resources, land and range capabilities, livelihood requirements of local communities, and stakeholder analysis.

• Maximizing ecosystem services: Maximizing one service on the costs of the other services will usually result in an undesirable situation for society. To avoid such tradeoffs, each intervention or project should be evaluated in terms of its impact on the other services. The challenge is to achieve multi-functional mountain catchments, where all most of ecosystem services are respected. This can be done more efficiently by actively searching for 'win-win situations': win-win situations will combine the sustainable delivery of several services, such as economic, environmental, social and cultural benefits for local communities, and environmental, educational and recreational benefits for the larger public. In practice, the challenge is usually to balance the needs of the local population (income generation, food, fuel, water, fodder and nutrients) with maintenance of the service provision of the natural resource base. To achieve such a balance, four types of interventions are required:

1. improved institutional arrangements for watershed governance,
2. integrated spatial planning,
3. development and testing of technical interventions for private land,
4. community-based management of natural resources.

Provisioning ESS	**Regulating ESS**	**Cultural ESS**
• Crop production • Forage for livestock • Meat and wool • Fish • Medicinal and edible plants • Genetic plant and animal resources • Honey • Water for local home consumption and irrigation • Water for downstream users and hydro-power • Fresh air	• Snow accumulation • Water recharge of aquifers • Natural capacity for water purification • Erosion control by natural vegetation • Natural flood control • Carbon sequestration • Pollination of crops • Biological control of agricultural diseases	• Enchanting landscapes and biodiversity • Environmental awareness and education ('outdoor classroom') • Eco- and agro-tourism • Research opportunities

CONSTITUENTS OF WELL-BEING

- Viable livelihood options
- Local employment
- Healthy living environment
- 'Sense of place'
- Relaxation and inspiration

Fig 1.4: Actual and potential ecosystem services (ESS) provided by dry mountain watersheds in Iran

Source principle: While restoration activities will be necessary for degraded areas, ongoing degradation and pollution should be as much as possible be addressed at the source of the problem, rather than at the symptom level. For example: pollution should be addressed at the its source; erosion and flooding should first look at the causes of runoff and sediment generation; and for rangelands it is important to know what are the driving factors that drive rangeland degradation.

Respecting and managing the ecological limits in dry mountains

• Respecting ecosystem thresholds: There are several possible pathways for watersheds in dry mountains, but a strategy should never jeopardize the sustenance of the natural resource base of a watershed. The ultimate bottom line for development should be to respect the ecological thresholds, beyond which ecosystem integrity breaks down and the sustainable provision of ecosystem services cannot anymore be guaranteed. A few examples of ecological thresholds are provided below. To be on the safe side to cope with whims of the climate, there should be a safety margin between the actual user levels and the ecological threshold level.

- Local people as stewards of the catchments: Securing support from local communities is essential for successful IWM. Therefore, it views communities with their traditions, as stewards of the watersheds. Management must be undertaken with and through local people, and seeks to bring benefits to local communities and contribute to their well-being through the provision of ecosystem services. Another entry-point is to use religious motives for natural resources protection.

- Land-use planning: To ensure the sustainable delivery of ecosystem services, an effective land-use plan is required, which is based on a thorough assessment of the natural resource base and economic realities. Such a plan should encourage agricultural activities, lifestyles, customary laws and traditional building practices which are in harmony with the environment; while it discourages or prohibits land-uses and activities which are inappropriate in scale and/or character. Spatial planning approaches are required to support sustainable land-use. In any case, considering the climatic variability, land-use plans cannot be based on detailed land capability maps. Under the circumstances of dry mountains, it is more appropriate to define broad land-use classes, such as irrigated land, dryland, rangelands and forests. These categories take into consideration biophysical limitations, without limiting farmers flexibility to cope with variable climate and market prices.

Land suitability in dry mountains of Iran is influenced by climate, topography, soil type, aspect and crop requirements. Two important examples:

- Slope angle: A hotspot of degradation are the foot slopes. Due to the advent of the tractor and loose legal regulations, a lot of foot slopes steeper than 12% have been taken under cultivation. Due to the narrow fields, up-and-down plowing is the norm. This does not only results in tillage erosion but also in accelerated rill and gully erosion. Therefore, the necessary measures should be taken to avoid annual cultivation of this land. These lands should be reseeded with appropriate species and returned to rangelands. Alternatives would be to develop water harvesting systems with fruit trees if the soils are deep to store the rainfall-runoff, conservation tillage practices or perennial crops that do not require plowing.
- Erodible parent material: Marl ($CaSO_4$) is a soft rock, and especially sensitive to rill and gully erosion. After clearing the natural vegetation, marl areas usually develops into "badlands" and become a major source of sediment. This can result in filling up of hydropower dams with sediments. Therefore, it is important to reduce arable agriculture in this type of land, and stimulate sustainable rangeland management.

- Water – The most critical natural resource in dry mountains: To assess sustainable water extraction levels, it is important to take into account the water balance of the watershed and the required environmental flows to fulfill the ecosystem services of the catchment and that of downstream areas. Groundwater resources need special attention, as extraction rates and groundwater reserves are not easy to monitor.

Concepts such as water productivity, which looks at agricultural production in terms of the yield or economic return per unit of water instead of per unit of land area, can assist decision making on water resources allocation. Similarly, considering the benefits of both blue water (streams and groundwater) and green water (the soil moisture that returns back to the atmosphere as evaporation and evapotranspiration) is an important issue for dryland watersheds. Maximizing the use of green water through optimal rangeland cover and supplemental irrigation of rainfed crops during dry spells are important strategies for upland watersheds.

Dry mountains of Iran are characterized by high spatial and temporal variability of water resources. This makes rigid water-use regulations not so useful, but rather dynamic water-use regulations and drought early-warning systems are recommended. Spatial drought analysis for Upper Karkheh River has shown that droughts can be pervasive. Increasing water storage with small dams, groundwater dams and through managed aquifer recharge, and judicious use of groundwater is needed to store sufficient water for drought periods. Water harvesting in deeper soils along the foot slopes can also provide water storage especially for fruit trees.

• Rangelands and forests – These are important sources of biodiversity and biomass for grazing. Deforestation and destruction of rangelands has occurred for centuries, and it continues today with a myriad of ecological consequences, including habitat devastation and decreased diversity and expiration of plants and animals; erosion, landslide, and mudflows; siltation of rivers and streams; flooding, and local climatic changes. Rangelands and forest ecosystems in Karkheh River Basin (KRB), have been under high pressure of over grazing by sheep, goat, and cattle; woodcutting for fuel by herders and villagers; and plowing for rainfed agriculture by local farmers, during last several decades.

Tremendous losses of desirable range plant species and forest tree species have occurred and have resulted in a considerable reduction of biodiversity in the basin. Continuous damages to the rangelands and forests have resulted in hardship for the people of the basin. Destruction of these resources, as the major part of the watershed, is considered the main cause of difficulties for the livelihood of herders and villagers, particularly. Participatory development of techniques for rehabilitation and management of these resources, such as various ways of range seeding or reforestation, is needed as a part of sustainable watershed management. Communities need to agree among themselves to manage grazing cooperatively. "Opportunistic grazing" or "dynamic carrying capacity" could be more appropriate to cope with the fluctuating rangeland resources in the dry areas than a fixed carrying capacity. In practice, this can be managed by "resting rotational grazing" practices (e.g. 2 years grazing, 1 year resting) and "flexible starting date" in function of the rangeland condition. This can only work if communities can agree among themselves. To tackle deforestation of rangelands, alternative energy sources need to be identified.

Some rangelands are important erosion hotspots and sediment sources. These are usually located in steep and concave foot slopes. To avoid further degradation, they could to be planted with unpalatable plants, so they are self-secured versus overgrazing. However, such interventions should be targeted on very specific areas and should not cover more than a few % of the total rangeland.

• Rural infrastructure: Rural roads are essential for marketing and general welfare, but regulations need to be put in place to minimize the effects of road construction on gully erosion and land degradation.

Improve income, food security and secure livelihood resilience

• Consider local aspirations: Try to find out what really matters to local people. It might be that it is not simply "yield increase". In mountainous areas, where livelihoods depend strongly on the climate, other aspirations might be: more diversification options, resilient and climate-proof production systems, local job opportunities, less drudgery.

• Comparative advantage versus risk prevention: While choosing new enterprises or technologies for livelihood, there are generally two major strategies. One strategy is to make use of the local comparative advantage of the area. Such a strategy result in profit maximizing activities, but they are usually quite risky, especially if these activities can be affected by the climate or market prices. Diversification strategies are aiming to reduce the risk in order to be prepared for fluctuating precipitation of market prices. Such a strategy usually results in less profit, but is more resilient. A healthy balance between these strategies is recommended (both at individual household and at community level).

• Develop adapted technologies and increase local expertise: Farmers constantly require new sustainable technological options that support livelihood resilience and strengthen the natural resource base. A proven methodology to develop new and useful technologies in Iran is 'participatory technology development' (PTD). It showed to be a useful approach to link expertise from local people, with the expertise of researchers and staff of extension and executive sectors (see objective 3). A good way to incorporate indigenous knowledge is to search for local innovations and innovators. With this approach, development will come from within the local communities and participating farmers will have the ownership of the 'new' technologies. Potential options for dry mountains are: biofertilizers for barley and wheat (e.g., azotobacter), improved agronomic management options and crop varieties (e.g., new chickpea varieties and early planting of chickpea), high-value crops (e.g. saffron, mushrooms and shallots), rangeland rotations, water harvesting and supplementary irrigation.

- Special attention for women needs: To make sure that women also benefit from an IWM project, it is not sufficient to have a separate (and usually small) 'women programs', but to provide women with opportunities to participate in planning and decision making. Technology fairs in the villages served as an equalizer through their easy access by all village men, women and children. Women requested their own technologies such as handicraft and mushrooms, but also participated in the other activities such as shallots and saffron. Special activities or PTD groups can be set-up to address the concerns or ambitions of women, and improve their skills. There is a large potential for special micro-credit programs, and livestock activities and marketing.

Legal framework and governance for integrated watershed management

- Co-management / Collaborative watershed governance: Kerr et al. (2002) compared the performance of different watershed management approaches. Top-down technocratic approaches showed the poorest performance. Participatory approaches were much more effective. But with combined participatory and technocratic solutions were found to be superior. The need of such approach became clear when it was realized that significant parts of natural resources management (sustainable grazing, equitable water use, payment for environmental services, treatment of sewage water) can only be achieved when agencies with legal responsibilities are involved in the process. Such projects involved multi-stakeholder processes and combined 'bottom-up' and 'top-down' approaches.

- Multi-stakeholder governance: Effective IWM depends on the presence of transparent decision-making structures, which seeks communities' and concerned stakeholders' active involvement in the shaping of watersheds. Multi-stakeholder discussions and interactions will enable the identification of the diverse ecosystem services that are expected from the concerned watersheds, which can lead to the development of a commonly-agreed desired state (or 'vision'). Multi-stakeholder governance will increase communication, trust, linkages, ownership and joint commitment to the shared vision and desired impacts.

On the other hand, multi-stakeholder governance also requires enforceable rules (based on legally-backed standards, regular inspections and spot checks) and when conflicts over resource management arise, the responsible governance agency needs to mediate and/or intervene to resolve conflicts. This will require strong 'Catchment Management Authorities' (CMA). Multi-stakeholder forums can be organized at catchment or basin levels (see Box 2).

Box 2: Essential features of multi-stakeholder forums for watershed management (Figure 1.5):

- A multi-stakeholder forum facilitates linkages and enhances communication between stakeholders. It can assist in bridging the gap between research, policy and executive agencies.
- It requires effective facilitation, coordination and negotiation at different levels.
- A multi-stakeholder forum should be a legitimate and accepted forum for dialogue, conflict resolution and planning.
- The decision-making process should be clear.
- A clear and shared vision, goals, objectives and actions should be developed at an early stage.
- Planning should be proactive and include a solid and participatory monitoring and evaluation system.
- A reflective approach (e.g. share 'lessons learned') accelerates the learning curve of all involved.
- There should be sufficient time and resources to find acceptable social arrangements.

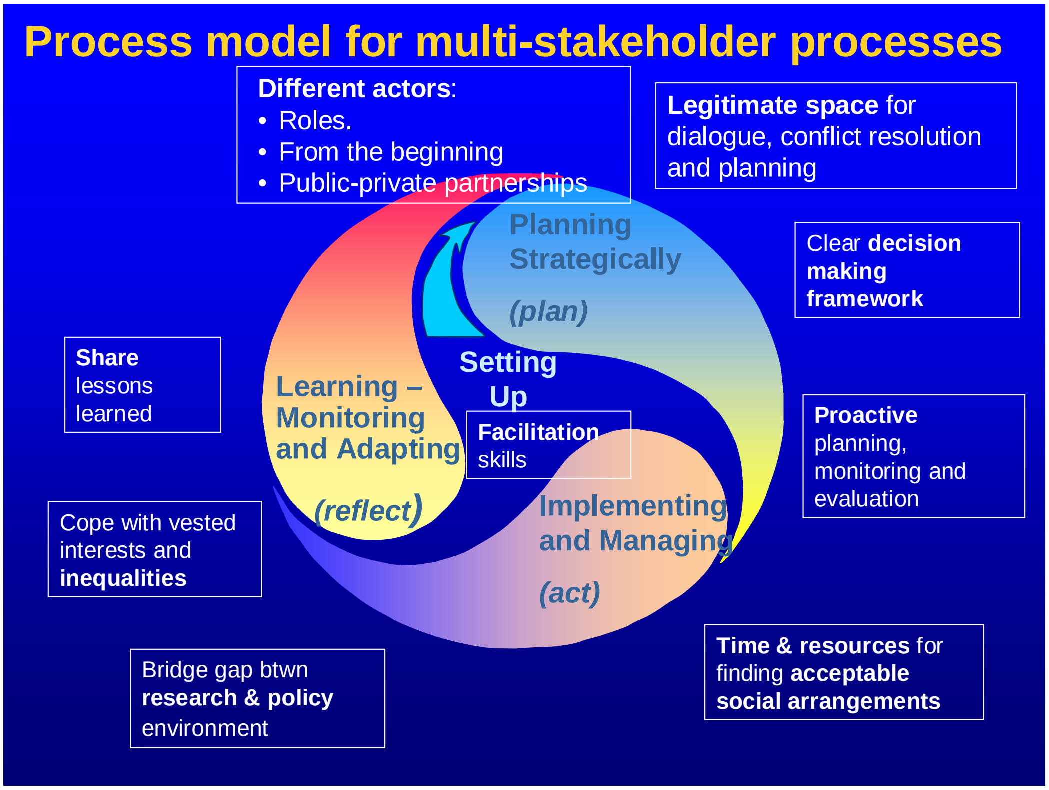

Figure 1.5: Features for successful multi-stakeholder forums at catchment or basin level

- Legal frameworks: As there is an extensive framework already available in Iran, IWM can operate within the existing laws and guidelines. However, if they are not conducive, steps should be taken to update or revise them (e.g. rights of communities to control and manage 'their' common-pool resources). Catchment Management Authorities can develop regulations and bylaws, which are applicable for a specific catchment. When traditional and conventional systems and user rights for natural resources are resulting in sustainable land use, they should be integrated in local regulations as much as possible.

- New roles for Government: In collaborative watershed governance, the role of Government agencies needs to shift from 'delivering and implementing solutions' to 'providing an enabling environment'. Examples of ways to do this include:
  - Overcome disciplinary planning and fragmented mandates.
  - Minimize bureaucracy.
  - Better and reliable government services, such better education opportunities, better health services, develop markets for buying inputs and selling of agricultural products
  - Provide political endorsement of multi-stakeholder forums and their decisions.
  - Devolve authority so that decisions are made at the lowest possible level.
  - Develop enabling legislation.
  - Provide sustainable funding for watershed management institutions and their programs.
  - Replace 'input subsidies' (such as those on fertilizers and pesticides) by 'smart subsidies' and economic instruments that enable sustainable farming practices.
  - Ensure land tenure or land-use security (private or communal).
  - Strengthen capacity building and increase awareness on sustainable management of watersheds.

- New roles for research: Technical expertise and analytical skills make research agencies useful and attractive partners for a multi-stakeholder watershed management forum. However, in order to fulfill such expectations, the traditional approach of research agencies needs to evolve as well by adopting a more demand and problem-oriented action research approach. This requires stronger interdisciplinary interaction, participatory methods and use of nested scales. New research topics that will be required include:

- Development of common language and approaches.

- Consistent data-sets.
- Risk mapping and risk assessment.
- Practical decision support tools.
- Best management practices.
- Benefits of integrated watershed management.
- Indicators to monitor progress
- Understanding the relationship between livelihood (and poverty) and natural resources.
- The role of women in natural resources management.
- Power relations between stakeholders.
- Legal, economic, social and communication tools.

• Capacity of local institutions: Participatory watershed management needs credible local institutions. Potential local community organizations in Iran are the 'Islamic Councils', or established traditional community-based organizations. However, many of these local institutions are ill-equipped to deal with the challenges of designing, negotiating, monitoring, and sanctioning for natural resources management. Therefore, local institutions need to be strengthened to enhance their decision-making capacity and their capacity to initiate community-initiated change. External assistance and supervision is often required, especially at the start.

• Community-based management for common pool resources: Common-pool resources (such as range, groundwater and surface water) usually suffer from the "tragedy-of-the-commons syndrome", especially if these resources are nominally the property of the state. Degradation of common pool resources is very common in the mountainous watersheds of Iran (e.g. rangelands, biodiversity, surface water, groundwater) and often important for the poorest of the local communities.

Successful interventions are mostly based on collective action and control by the local communities, and a certainty that their efforts to take care of the natural resources will benefit them in the long run (FAO 2006). However to be successful, the benefits of the interventions for local communities should be substantial and attractive, while the transaction costs for designing and implementing solutions be manageable and cost-effective (e.g. mechanisms for upstream-downstream cost and benefits sharing, social fencing).

3. Objective 3: Build the capacity of communities in two upper catchments to strengthen their livelihood resilience and to manage their catchments in a sustainable way

From Moosavi et al. (2010)

Methods

Objective 3 aims to strengthen livelihood resilience, by better management practices, alternative land use and farm enterprises, and communal and institutional arrangements. Options were selected based on the local knowledge and preferences, and based on socio-economic and bio-physical insights of the local system. Special attention was given to the needs of vulnerable groups, especially women and the poor. Thus, socio-economic considerations will be at least as important as the technical considerations, in the selection of technologies/options to be tested. The testing and evaluation of the options will follow the cycle of participatory technology development (PTD). An chronologic overview of the activities implemented by the PTD teams in Upper KRB is presented in Figure 1.6. The PTD project was preceded by training and a survey of innovative farmers in the two watersheds (Norouzi Banis et al. 2009). Some of the staff and farmers that participated in the innovator survey became active participators in the PTD project. It should be noted that the PTD was facilitated by social scientists and that the reporting is rather descriptive. However, some quantitative results of the technologies provided by scientists that led the technology testing are provided.

Resource and problem identification

In November and December 2007, two provincial PTD teams conducted, a relatively comprehensive participatory resource and needs assessment in the eight project villages – Upper Peresk, Bardbal, Chahartakhte and Siahpoosh in Honam Watershed of Lorestan Province (Fig 1.3), and Kolah Joob, Upper Sekher, Lower Mehdi Abad, and Bagh Karam Beyg in Merek Watershed of Kermanshah Province (Fig 1.2). The teams were briefed on the participatory methodology, as well as some PRA tools and techniques that could be used in the field. Almost all the field work was conducted in separate sessions with men and women. Some of the techniques were carried out with both groups. The following techniques were used:

- Social and resource mapping
- Household well-being rankings
- Historical time lines
- Seasonal calendars and daily routines
- Card collection (or Delphi's technique) of problems and needs
- Pair-wise and ranking matrices (separate for problems and needs)
- Problem trees

Technology selection

Prior to the autumn cultivating season in Honam and Merek in 2007, the provincial PTD teams organized two technology fairs in Upper Peresk village in the Honam district of Lorestan and in Nojoob village in the Merek district of Kermanshah in September. They also provided transportation for the farmers of the other project villages to come to the fair.
For the spring season, the PTD group decided to hold separate fairs in the eight pilot villages, thus spending a half-day in each in the first half of March 2007. For all the fairs, the group tried to facilitate programs that could include:

- Open, visual presentation of technologies;
- Reversed roles of researchers and experts (from conveners of technologies to resource persons) and farmers (from passive recipients of technologies to active decision-makers on the choice of options); and
- An enabling environment for the farmers to better interact with the experts as well as with other farmers from their community and other villages, and for mutual learning for all involved.

Technology experimentation and evaluation
Experimenting farmers co-hosted cross visits. Therefore, the technical expert was no longer the only resource person for the technology. Interaction amongst the farmers was relaxed and informal. Experimenting farmers would relate the technology to the local context in very familiar discourse. Ample opportunity was available for experimenting and non-experimenting farmers to raise issues related to the technical and particularly the non-technical aspects of the technology.

A combination of methodologies was used for the evaluation of the technology experiments. For technologies such as autumn chickpea, walnut blight control, wheat sunn pest management and Azetobacter bio-fertilizer inoculants, the corresponding scientists and researchers carried out conventional quantitative experiments to compare parameters like yield, changes in soil quality, and changes in the extent of infection. On the other hand, the participatory evaluation process, which was carried out for all the experiments, was designed to give farmers the chance to reflect upon their experiment, together with the respective scientist and the PTD team: the preparation, implementation and harvest stages; comparative strengths and weaknesses; farmers' suggestions and recommendations; and the scientists' responses to some of the ambiguities. Different visualization tools (color cards, flip charts, etc) were used.

Recording and assessing experiments
PTD focuses not only on technology development but also on strengthening local capacities to innovate. The monitoring and evaluation activities should cover both of these aspects from the start. The emphasis is to support farmers in their own efforts to record and assess the results of their experiments. This does not exclude the possibility that outsiders collect and record additional data. This may have the dual purpose of (1) helping to verify results of farmers' experiments in discussions with farmers and (2) meeting requirements set by the outsiders' professional organization.

Farmers' criteria
What is most significant is that the whole experiment process be influenced by the farmers' criteria: They will vary between households – depending on the resources controlled and social status - but also within households. This means that different household members will evaluate a technology according to different criteria, which are related to their role and functions in the household. Criteria to assess a specific technology must be made explicit when screening the technical options prior to experimentation, and can be used again when defining what to record and how to assess the results of the experiments.

Training
Ideally, training of farmers on certain technical aspects of a technology or innovation would be planned and designed according to the type of technology and the training requirement of the targeted farmers. The training itself would be done in the field in a farmer field school mode rather than in classroom session. Examples in this project included the short training the farmers in Merek received for hygienic preparation of potato bulbs before planting, or that one conducted for the mushroom growing experimenters on how to prepare their rooms. In Honam, specific field training was conducted for the experiment on urea fertilizer application based on soil tests.

Apart from these specific trainings sessions, the technology experts and researchers continuously provided guidance and on-the-spot training as the experiments progressed and as issues arose.

Tests and controls
For each new option to be tested, there needs to be a control for comparison. In this PTD project, the farmers had control plots next to plots where a new technology was tested, e.g. Azetobacter was applied to wheat as the test treatment with untreated wheat as control plot. Likewise, untreated trees served as control next to trees treated for walnut blights. The controls for some of the other technologies did not adhere so much to conventional 'standards'. For autumn chickpea, the control with which the farmers could compare their findings from the experiment was the farmers' own practice of local chickpea varieties cultivated in spring. For potato cultivation, the control was the yield and market performance of sugar beet from previous years, because ultimately this was the crop it was meant to replace in that area. For mushroom and saffron growing, the control was the fiscal or even non-fiscal cost of the opportunity if they had not implemented these ideas.

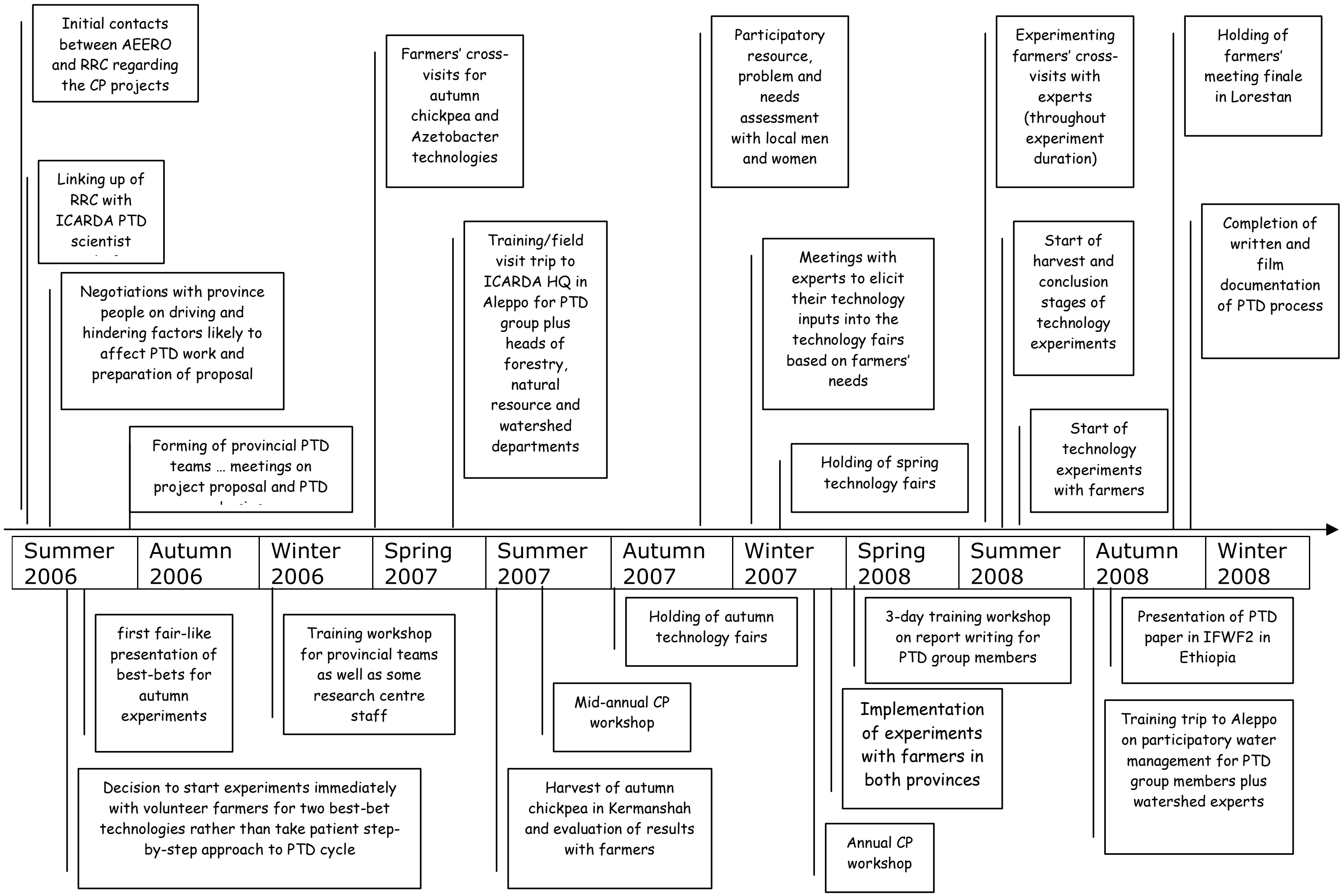

Fig 1.6: Overview of Participatory Technology Development process in KRB

Having a control allows the farmer to draw conclusions on the effect of the technology: on their farming system, the relevance of the idea to local needs and conditions, the socio acceptance, economic viability, environmental friendliness, and also sustainability of the new idea based on his or her own priorities and criteria. Reaching reliable conclusions may take more than one season. Therefore, it is preferable to continue experiments over several seasons, which would allow an examination of the technology under different weather conditions and under a varying economic environment where prices could change.

Cross-visits
Conventional 'field days' are often used to promote ready technologies for dissemination, where the main actors are researchers and extension workers trying to explain 'their' technologies. Participating farmers are often the more advanced and connected ones and are hardly representative of the whole farming community. They would remain rather passive recipients of information (Rogers, 2003).

Such classic field days with the aim to promote readily available technologies shift, in a PTD process, towards farmer-to-farmer cross visits, where the research team facilitates open discussions among farmers and where technologies are viewed as options rather than final solutions. Within the PTD process, farmer cross visits have a double function: (1) to have a critical feedback from average farmers which is taken seriously and may affect further experimentation; (2) to provide the basis for out-scaling successful technologies to other farmers and farming communities.

Farmers' evaluations
The different types of views emerging from the evaluations and recommendations in each of the two project areas (Honam and Merek) were clustered, regardless of the positive or negative weight of the view, to see on what topics and aspects of life and livelihood the evaluations converged.

Results and discussion

Resource and problem identification
An example of a well-being ranking for Upper Peresk community is presented in Table 1.4.

Table 1.4: Well-being ranking of households in Upper Peresk, Honam

Least wealthy	*Middle*	*Wealthy*
• Less than 2 hectares of agriculture land • Small, mud house • Little or no literacy • Large family, around 7 • No livestock • Works as seasonal labor • Some are covered by welfare organization	• Owns maximum 5 hectares of rainfed land • Brick and/or stone house • Owns up to 4 cows • Has some farming equipment • Almost one farming equipment for every three households • Around 2 million tomans annual income (approx. US$2000) • About a third of these households have houses in town • Children attend school up to 9th grade and high school diploma • Only one bread-winner in each household	• Owns at least 7 hectares of irrigated land • House in relatively good condition • Owns light and heavy equipment and machinery • Mechanized farming • Owns house in town • Children are educated to high school and diploma level

The results and analyses from the participatory techniques described above were integrated to give a comprehensive picture of the socio-economic situation, priority needs and problems, and farmers' criteria.

- One of the criteria that characterized poorer farming households in well-being analyses in both Merek and Honam was 'working as seasonal labor in other areas'. This criterion, as well as 'unemployment' being cited as one of the problems in the area, seems to justify the farmers' pursuit of adding to and diversifying their sources of livelihood. At the same time, for farmers who do not own land and work on other farmers' land, there is a need for options that can show returns in a shorter time span. It might be difficult for the poorer farmers to take up activities or ideas that require more than one season to show significant results.

- In the historical time line analyses in Honam, farmers recalled the 'abandonment of the traditional alternate cultivation of land' as a direct reason for the decrease in productivity. This is credible evidence of the farmers' endogenous mechanisms for the management of their local natural resources. Giving their analysis of the consequences with a sense of regret is further reason to acknowledge local people's awareness of the inter-linkages affecting their long-term livelihood. A very common need expressed by farmers was 'improved cultivation'. Ideas such as Azetobacter bio-fertilizer inoculant, pea and bean inoculants, and integrated wheat pest management, were all ideas that had the potential to respond to this particular need while conserving the natural resources and protecting the environment at the same time.

- Stressing 'loss of fisheries in the river' and 'destruction of rangeland' as pressing issues testifies to the fact that even poorer farmers can be concerned about the environment on a wider scale.

- Male farmers focused on 'no or little land owned/ need to rent land for agriculture'; 'rain-fed nature of agriculture'; 'lack of access to agricultural equipment and machinery'; 'lack of technical skills'; 'lack of money'; and 'illiteracy' as the root causes of their agricultural and livelihood problems and difficulties. Such realities emphasize the importance of seeking ideas and options that require little land - any new technology or activity taken up by the poorer farmers would have to be implemented and be effective on relatively smaller plots - and capital, are simple to implement, and do not require much equipment or machinery.

- Issues such as 'lack of water for agriculture' and needs such as 'more agriculture water' also emphasized the need for ideas that are more sparing on water resources.

- Prioritizing 'inadequate fertilizer portions' as a problem and 'increase of fertilizer portion' as a need emphasized the need for ideas that either reduce the need for chemical fertilizers, or at least make their use more optimal.

- Another priority problem was the 'lack of diversity of agricultural products'. It seems the farmers were well aware of the risk of concentrating on one or two products, and of the value that diversification of farming activities can add to their livelihood resilience. (This was definitely one of the incentives for the 22 farmers in Merek who pursued the idea of substituting sugar beet with potato cultivation for the first time in their area.)

- Contrary to the general beliefs that farmers' priorities, especially the poorer ones, are always guided by immediate personal benefits, farmers will always value and have time for what is best for the whole community.

- Local farmers have recognized the need to learn and develop new skills and capacities to be able to change aspects of their livelihood. This is a rich potential source of motivation to participate in experimentations with new ideas.

- 'Reducing agricultural losses', 'employment generation', 'health', 'commonality' and 'learning new activities' were some of the criteria that both men and women referred to for prioritizing their needs. This does show that both genders are jointly engaged in, and equally aware of, many aspects of local livelihood.

- Some of the women farmers' criteria for prioritizing needs – e.g. generating hope for the future; family use and consumption; easing of work; independent or direct income for women; filling leisure and idle time; indoor nature of activity – are not necessarily or solely of an economic nature, and some of them are definitely not immediately short term. In fact, many of the ranking matrices showed that non-material and non-economic criteria and concerns had priority over material and economic items. The criteria also show a holistic outlook towards their livelihood and living environment.

- Options that combine farmers' needs and their criteria were priorities. Mushroom and saffron growing were two ideas presented that responded to needs while also satisfying local criteria for prioritization.

Technology selection

Of the 27 technologies and innovations on display and 'on offer' throughout the autumn and spring fairs of 2006 and 2007, 485 men and women farmers from Honam and Merek volunteered to experiment with 26 of them (Table 1.5). Experiments were implemented for only 16 of these, however. The other ten were abandoned, at least for this particular project, for a variety of reasons, including:

- The innovation being replaced with another one on the farmers' own initiative (e.g. replacing sugar beet with potato rather than improving techniques for its cultivation);
- Missing the appropriate time for implementation (e.g. planting fruit trees on slopes);
- Failure to coordinate with the respective outsider scientist or local innovator (e.g. enriching hay, and cultivating potatoes in barrels); or
- Loss of interest of volunteering farmers after details of the innovation or technology made clearer in subsequent meetings after the fairs.

Table 1.5: The technologies and innovations selected by farmers for experimentation

Nr	Technology/innovation	Number of volunteers	Selected but not implemented (*)
	Autumn		
	Kermanshah		
1	New wheat and barley varieties	8	
2	Improved techniques for sugar beet cultivation	11	*
3	Autumn chickpea cultivation	3	
4	Azetobacter inoculants on wheat/barley	10	
	Lorestan		
5	Vetch fodder plants	41	
6	Growing shallots on private plain land	39	
7	Simultaneous wheat pesticide application	8	
8	Chemical and biological fertilizers	-	
9	Walnut tree blight control	7	
	Spring		
	Lorestan		
10	Enriching quality of hay using urea fertilizer	11	*
11	Thyme cultivation	16	
12	Prescribing phosphor chemical dosages based on soil tests	1	
13	Liquid inoculation of beans (rhizobium legominozarum)	3	
14	Liquid inoculation of chickpeas (rhizo-chickpea)	16	
15	Adapting saffron cultivation to local conditions	23	
16	Rainfed planting of grape and almond trees on slopes	18	*
17	Cultivation of potatoes in barrels (local innovation)	29	*
18	Vegetative propagation of trees through buds	29	*
19	Using animal fat for compost	1	*
20	Production of dye plants	3	*
21	Cross breeding local goats with foreign breeds in order to increase milk production	17	*
22	Double-queen bee keeping	3	
	Kermanshah		
23	Replacing sugar beet with potato cultivation	8	
24	Growing mushrooms	35	
25	Planting poplar trees around farm land	40	
26	Handicraft training (sewing, carpet weaving, etc)	95	*

Farmers' evaluations
There is plenty of evidence that the perceived strengths and weaknesses of the experiment process by the farmers can be quite diverse in nature. The topics were clustered as follows:

- Demand on human resources
- Demand on water resources
- Outsiders' behavior and performance
- Technical adaptability of technology to available resources
- Technical simplicity and flexibility
- Inputs required
- Production aspects
- Added value for household economy – new source of livelihood
- Economic value and issues
- Skills/knowledge/training/insights gained
- Institutional aspects
- Direct benefit for women
- Added value for household nutrition
- Something new in the community
- Byproducts and additional impacts of technology

As was evident in the overall picture of the resource and problem identification findings, here too it can be seen that farmers take a very holistic and multi-dimensional approach towards evaluating the potential of new technologies in the farming systems. Looking at the strengths and weaknesses the farmers stated for each of the technologies, it is possible to understand their criteria of choice and the key topics they aim to address: food security; employment; income; learning; new experience, etc. Therefore, any technology claiming to be useful for farmers, would have to satisfy, not only technical requirements, but also, and usually more importantly, the many other aspects of farmers' criteria and priorities.

Measurements and sampling for some of the technologies indicated an 18% increase in irrigated wheat yield and a 16% increase in rainfed barley yields as a result of azetobactor application; a 13% reduction in walnut blight with appropriate insecticide use; a 30% increase in wheat yields as a result of timely, communal application of pesticide, among others.

Did we actually manage to reach the poorer farmers?
For each of the technology experiments, the farmers who ultimately participated were classified according to the well-being analyses carried out by the local people themselves in the resource and problem identification stage of the process. This classification makes it possible to assess which of the technologies have been better able to reach the poorer and more marginalized farmers (Table 1.6 shows the socio-economic make-up of the farmer-experimenters for some of the innovations and technologies implemented in this project).

Experiments of Azetobacter, integrated wheat pesticide application and urea and phosphorus fertilizers seem to have attracted mainly the poorer farmers. Walnut blight treatment, shallot, saffron and mushroom growing, and double queen beehives for honey making, all have an even distribution of farmers involved. Potato cultivation was new to Merek watershed and requires irrigation. Thus, it was expected that the smaller farmers would not be inclined to take the risk to invest in this technology. Even though this technology was dominated by better-off farmers with more resources, it is noteworthy that seven farmers from the middle and less wealthy sections of the community also participated till the end of the experiment.

Table 1.6: Number of farmers of the different socio-economic groups experimenting with the various technologies.

Technology/innovation	*Farmer category*			
	Least wealthy farmers N (% of total)	*Medium level farmers N (% of total)*	*Wealthy farmers N (% of total)*	*Total N*
Planting Poplar trees	18 (35.3%)	18 (35.3%)	15 (29.4%)	51
Simultaneous wheat pesticide application	19 (61.3%)	7 (22.6%)	5 (16.1%)	31
Azetobacter inoculant for wheat and barley	12 (50%)	6 (24%)	6 (24%)	24
Potato cultivation (as substitute for sugar beet)	3 (13%)	4 (17%)	16 (70%)	23
Saffron	8 (44.4%)	5 (27.8%)	5 (27.8%)	18
Shallot growing on private plain land	7 (38.9%)	6 (33.3%)	5 (27.8%)	18
Walnut tree pest management	4 (23.5%)	6 (35.3%)	7 (41.2%)	17
Artificial liquid inoculant for chickpea and beans (rhizo-chickpea and rhizobium legominozarum)	5 (62.5%)	1 (13.5%)	2 (25%)	8
New wheat and barley varieties	1 (12.5%)	6 (75%)	1 (12.5%)	8
Double-queen bee keeping	3 (50%)	2 (33.3%)	1 (12.7%)	6
Mushroom growing	1 (25%)	1 (25%)	2 (50%)	4

Farmers and resource persons from different government organizations and institutes have been involved in an interactive process of learning and action. There has been a constant dialogue with relevant departments and individuals, which has facilitated inter-disciplinary interaction amongst experts from different departments around local needs and interests. Based on their field experiences, the experts have developed technology flyers with explanations for the farmers.

Conclusions

The search for potential options was based on separate participatory problem identification and needs assessments in each of the villages. At the same time, these had to be options to which the farmers could relate, and therefore apply and adjust them as they see fit. The technologies - (technology intended here to include new ideas and inputs, and existing ones that can be managed and applied differently and that have the potential to adapt to local conditions) - were meant to 'be simple to understand', 'not require changes in major parts of the existing farming system', and 'rely on few external inputs and labor resources'.

Participatory approaches and the farmer-first paradigm are still evolving, but some process elements seem to be increasingly supporting each other. One is the potentially synergic combination of enhancing the adaptability of farmers and that of the outsiders, through widening the choices and knowledge of both. "For farmers, the choices are of practices and plants; for outsiders, of behavior, approaches and methods. For farmers, the adaptability is to uncertain climatic and economic conditions; for outsiders, it is to needs, opportunities and insights as they arise" (Chambers 1993). Such a process can, with adequate decentralization and reversals of authority to those below, empower farmers to analyze, choose, experiment and evaluate, and empower outsiders to use their initiative and choose methods that are fitting for local conditions.

The project compromised on an initial insistence that the technologies be related to issues of water and natural resources, to instead be guided by the argument that diverse needs require diverse technologies. Therefore, the project adopted a strategy of seeking options that show potential in terms of adapting to local conditions and needs and contributing to an improved and more resilient livelihood, and to better management of resources. However, considering the

Over the two years duration of the project, there have been 16 technologies for which experiments have been conducted, with the range, diversity and flexibility of the technologies and experiments gradually increasing. More important than the actual technology has been the characteristics of the experiments from a PTD perspective, each of which could be a point for reflection and entry when it comes to working on technological change with local communities. The technologies at this stage could actually be viewed as starting points in a long-term process of analyzing farmer issues and seeking appropriate and relevant options and solutions, with the initiative being handed over more and more to the local people.

4. Objective 4: Develop an effective research strategy for outscaling and upscaling research results and lessons learned

Methods

The strategy for upscaling and outscaling involved the selection of two representative watershed for in-depth biophysical and socio-economic characterization and technology testing, the biophysical characterization of the basin, and a similarity analysis to assess the agro-ecological similarity between these watersheds and the larger Central and West Asia and North Africa region. The watershed selection considered agricultural diversification and agro-ecological characteristics (aridity and elevation). The selection involved field visits and meetings with farmers and local research and development staff, a rapid agro-ecological characterization of the basin, and interdisciplinary discussions.

The characterization of the upper basin involved the following activities:

- Agro-ecological characterization and similarity analysis, together with CPWF project PN8 (Improving On-farm Agricultural Water Productivity in the Karkheh River Basin),
- Assessment of upper basin hydrology,
- Spatial drought analysis,
- Analysis of land-use change and time trends in sediment concentrations.

Stakeholder meetings, a conference and workshops were held during the project to support the upscaling of the project. A policy meeting was held to present policy briefs to research managers and decision makers at the end of the project (with PN8).

Agro-ecological characterization

The agricultural environments of the KRB were mapped using the concept of agroecological zones (AEZ), integrated spatial units arising from the integration of climatic, topographic, land use/land cover and soil conditions (De Pauw et al. 2008). The AEZ were derived by the following six-step procedure:

- Generating raster surfaces of basic climatic variables through spatial interpolation from station data;
- Generating a spatial framework of agroclimatic zones (ACZ);
- Simplifying the relevant biophysical themes (agroclimatic zones, land use/land cover and landform/ soils);
- Integrating the simplified frameworks for agroclimatic zones, land use/land cover and landforms/ soils (soilscapes) by overlaying in GIS;
- Removal of redundancies, inconsistencies, and spurious mapping units;
- Characterization of the spatial units in terms of relevant themes.

The similarity in conditions between the benchmark watersheds and different out-scaling targets (KRB, Iran and Central and West Asia and North Africa) was assessed based on a similarity index, computed as the product of a temperature, precipitation, landform and land use/cover similarity index. The four indices were multiplied without any weighting. For temperature a calibration factor of 7.0 was used, which corresponds to a drop in similarity by 20% under a temperature difference (between two sites) of 2 ºC and of about 50% under a difference of 5 ºC. The calibration factor for precipitation was set to 3.0, which corresponds to a drop in similarity of 50% under a precipitation difference of 20 mm and a drop of about 80% under a difference of50 mm

Upper KRB hydrology

There are 75 hydrometery stations in Upper KRB and 4 in lower KRB. A total of 28 stations with sufficient long-term data were analyzed (Porhemmat et al. 2010). The main physiographic parameters area, perimeter, main river length, elevation classes and range and slope) of these subbasins were extracted using the SRTM DEM and GIS analysis. The 30-year average annual flow of the 28 stations was computed. Regression equations between the 30-year average annual flow and maximum daily flow and instantaneous flow for return periods of 2, 10, 25, 50 and 100 years for were developed. A review of the groundwater resources and their exploitation was conducted based on Jamab (1999).

Drought analysis

For drought analysis the Standard Precipitation Index (SPI) of McKee et al. (1993) was used (Porhemmat et al. 2010). This index has been designed to quantify precipitation deficits for various time scales. These time scales relate to the required times for the precipitation deficit impact on various sources of water supply. The soil moisture condition reacts to short-term abnormality of precipitation, whereas groundwater, surface water and water supply sources react to long-term abnormalities. The SPI indices for 1, 3, 6, and 12 months were computed.

Monthly precipitation data for 45 stations in the region were obtained from the Iranian Water Resources Institute and the Iranian Meteorological Organization. The randomness of the annual data sets was investigated through tests for homogeneity, absence of artificial trends and spurious temporal autocorrelation. Following Hessel and Hirsch (1992), a set of non-parametric tests was applied: the Mann-Whitney homogeneity test, the Mann-Kendall trend test and the Kendall's autocorrelation test. These tests were performed for all stations as described by Paulo et al. (2003) using software developed by Matias (1998). The test results led to discard 17 stations having low quality data and/or more than 5% missing values. The remaining 28 stations cover 35 hydrological years, from October 1965 to September 2000, and constitute a well-distributed network throughout upper KRB. Missing values for each station were estimated using the MOVE4 technique (Maintenance of Variance Extension), which develops a linear equation such that a reasonable and unique extended record is generated, while the variance of the data series remain unchanged (Vogel and Stedinger, 1985).

Land use change
LandSAT MSS imagery of 1975 or 1977 and LandSAT ETM+ image of 2002 were geo-referenced and also radiometrically corrected. Different techniques were used for land use map extraction including:

- Un-supervised classification methods (clustering) with trial and error (10, 15 and 20 classes)
- Normalized Difference Vegetation Index (NDVI) for differentiation of irrigated farming, orchards and also good and poor vegetation cover classes.
- Visual interpretation (looking at image tone, pattern and texture) for differentiation of irrigated farming, orchards and good forest cover.
- Field checks.

For comparison of land use changes, the extracted land use/land cover (LULC) classes of both image sets were generalized and a common land use/land cover (LULC) map was produced. Then by using GIS overlaying techniques, the changes in land use were determined.

Suspended sediment samples have been taken at the outlets of a number of subbasins on a regular basis, (one to three times per month), during the past 40 years. Suspended sediment and runoff data of the subbasins were plotted over time and average monthly sediment concentrations were computed for seasonal trend analysis. A series of non-parametric techniques (Gilbert 1987; Hirsch et al. 1991) were used to analyze for the occurrence of time trends.

Results
The two benchmark research watersheds contrasted in their level of agricultural diversification and availability of water resources. Honam watershed, in Lorestan province, hosts about 19 small communities within its 140-km^2 area. Average annual precipitation over the watershed was estimated to be 690 mm, but 440 mm at its downstream end. The mean monthly temperature is -2 ºC in January and 23 ºC in July. Honam watershed has more water resources and is more diversified than the second watershed: Merek in Kermanshah. Merek watershed covers 240 km^2 and has about 40 communities. Average annual rainfall is 480 mm and mean monthly temperature is 1 ºC in January and 25 ºC in July.

Agro-ecological characterization
A total of 46 agro-ecological zones were identified in Karkheh River Basin (Figure 1.7). Six zones cover 60% of the basin. On the basis of major differences in climatic conditions, land use patterns and terrain-soil characteristics, three major agricultural regions, the Northern, Middle and Southern Agricultural regions can be distinguished.

The agro-ecological zones of the Honam and Merek benchmark sites (see Figure 1.1.) were highly representative of the KRB. However, the badlands, which occupy substantial areas in the Middle and Southern Karkheh Agricultural Regions, and the sand dunes of the Southern Karkheh Agricultural Region are not present in the benchmark sites; and only small patches of oak forest, which is characteristic of the Middle Karkheh Agricultural Region, occur in Merek.

A similarity analysis, based on precipitation, temperature, land use and land form, indicated that in the region formed by Central Asia, West Asia, North Africa and the Northern

Mediterranean 361,569 km2 (1.6%) is very highly or highly similar to Honam and likewise 0.8% for Merek.

Upper basin hydrology and drought analysis

The 30-year means of the 40 precipitation stations varied between 251 mm (Bale sarugh) and 1196 mm (Tangepanj–bakhtiyari). The mean rainfall of KRB upstream from the dam was 490 mm. The average rainfall was 556 mm for the Kashkan river subbasin upstream of Pol Dokhtar (21-183), as compared with 484 mm for the Saymareh subbasin upstream of Holayan (21-147). Figure 1.8 shows the main sub-basins and the climate.

The Kashkann and Saymareh subbasins have considerable differences in runoff (Table 1.7). This is not only due to the differences in rainfall, but also to the fact that the Saymareh subbasin has also larger agricultural plains with more water returning to the atmosphere as evapotranspiration, as compared to the Kashkan basin. Kashkan at Pol-e Dokhtar has 21.8% of KRB at Payepol, just downstream of the dam, and 24.7% of sum of Kashkan and Saymareh at Pol-e Dokhtar and Nazarabad. Kashkan has 35% of the annual volume of sum of this two sub basin and 1.7 times the runoff depth of Saymareh. Upper KRB receives 88.3% of Karkheh at Payepol from the above two sub basins.

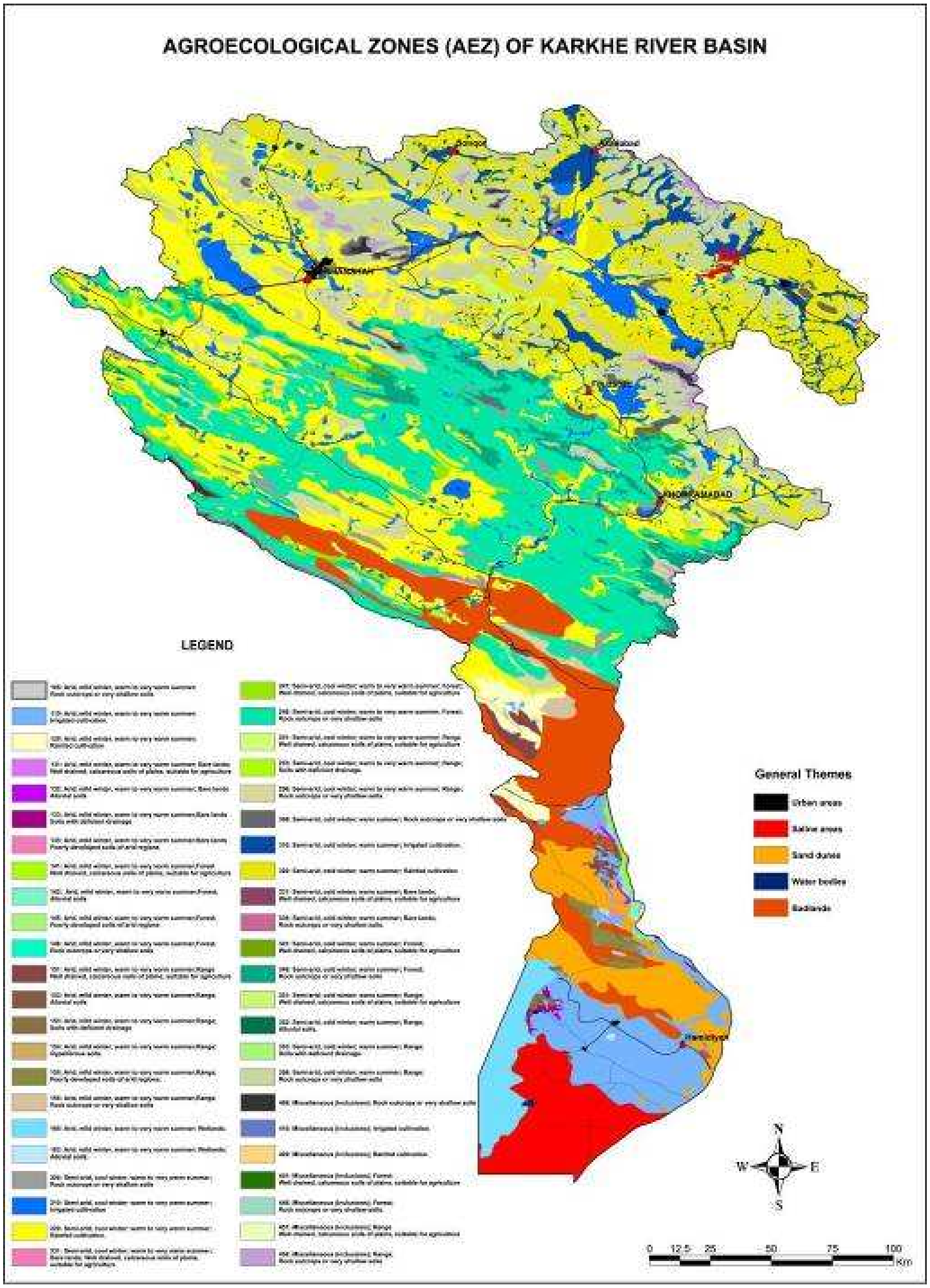

Figure 1.7: Agro-ecological zones of the Karkheh River Basin (De Pauw et al. 2008)

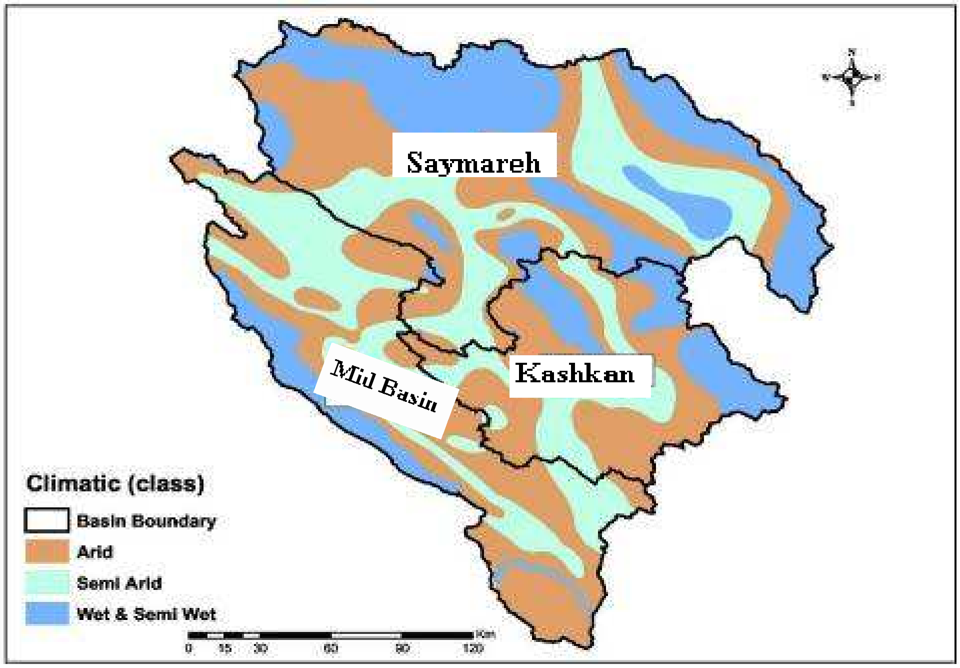

Figure 1.8: Main subbasins and climate of Upper KRB from the rain gauge data, with the higher elevations

Table 1.7: Main subbasins and average 30-year discharges in Upper KRB.

Station	River	Station Cod	Area (km2)	Discharge (Mm^3/s)	Runoff depth (mm)	Area (% of subbasin)	Area (% of Payepol)
Polchehr	Gamasiab	21-127	10,208	36	111.2	65.8	24
Ghoorbaghestan	Gharesoo	21-143	5,309	24.1	143.3	34.2	12.5
Holaylan	Saymareh	21-147	19,977	81.3	128.4	68.3	47
Nazarabad	Saymareh	21-411	28,281	103.7	115.6	75.3	66.5
Cham-e Anjir	Khorram Abad	21-175	1,630	11.5	222.9	19.2	3.8
Afarineh-Kashkan	Kashkan	21-177	6,842	48.2	222.1	80.8	16.1
Pol-e Dokhtar	Kashkan	21-183	9,267	55.9	190.4	24.7	21.8
Paye Pol	Karkheh	21-191	42,191	203.2	151.9	100	100

The 30-year minimum average annual flow of the Kashkan at Pol-e Dokhtar was 21.5 m^3/s, which is less than half the average flow (55.9 m^3/s). For the Saymareh at Holaylan, the low flows are even more dramatic; with 19.2 m^3/s, the 30-year minimum average annual flow was 25% of the long-term average. Monthly flows are generally lowest in August and September, with observed 30-year minima of 3.7 m^3/s for the Kashkan and 1.2 m^3/s for the Saymareh.

Coefficients of determination of the different regression models between the 30-year average flow and the maximum daily peak flows for different return periods ranged between 0.80 and

0.96 (n=21). The maximum daily flow for a 100-year return period for Upper Seymareh basin (3rd order) was estimated as 3134 m^3/s, and the maximum instantaneous flow 3579 m^3/s. For the 3rd order Kashkan basin the 100-year daily peak flow was 1198 m^3/s and the instantaneous peak was 1486 m^3/s.

There are 1410 qanats (subterranean tunnels that tap the groundwater by gravity) and 2746 springs, the majority karstic, in KRB. Aquifer thickness, transmissivity and water quality decreases southwards. The complete water balance is presented in Figure 1.9. Clearly agriculture is the main water use in the basin with 94% of the demand, with domestic and industrial water demand covering a mere 6%. A total of 66% of the precipitation goes to evapotranspiration. Thus, increasing the currently low water productivities of agriculture could have a substantial impact. The alluvial aquifers show a negative water balance, indicating that pumping for irrigation need to be reduced. However, overall the demands are a little more than 50% of the blue water resources of the basin. Considering the hot climate and the salinity problems of the downstream areas, it is likely that overall agricultural productivity in the basin could be improved by increased allocation of water resources for irrigation in the upstream basins.

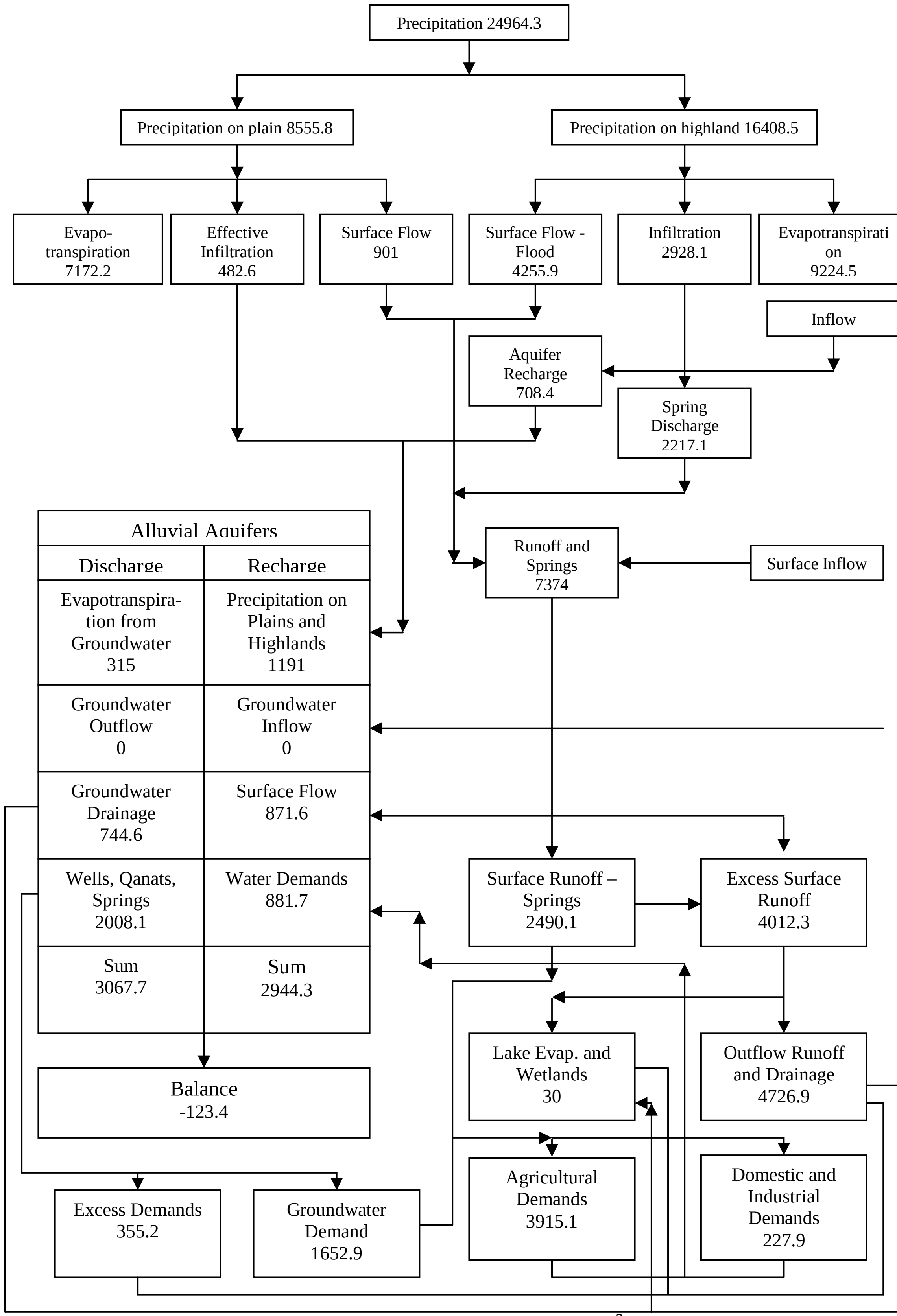

Figure 1.9: Hydroclimatological water balance of KRB (million m³), after Jamab (1999)

Drought analysis

Time series of 6-month Standardized Precipitation Index (SPI) for Kermanshah and Alashtar stations are presented in Figure 1.10. Main droughts occurred in 1970, 1983 to 1985, 1999 and 2000 in Honam. In Merek droughts occurred, based on 6 month SPI, in 1974, 1979 to 1980, 1984, 1991, 1996, 1999 and 2000. Comparison of drought years showed 1999 and 2000 are common in both of catchments. The 1999 drought was pervasive for Upper KRB (Figure 1.11).

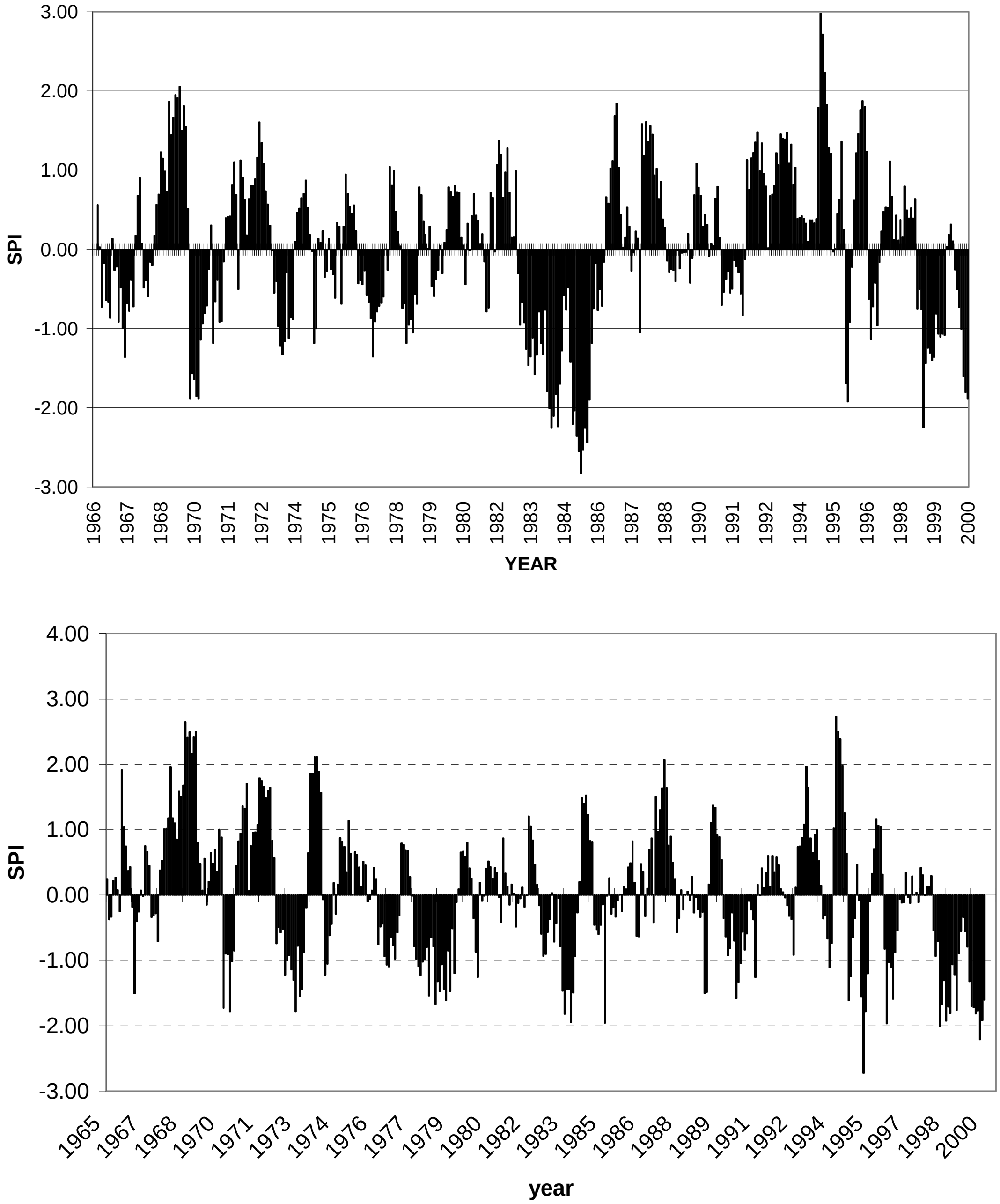

Fig 1.10: Time series of 6-month SPI at Alahstar station at the downstream end of Honam watershed (top) and at Kermanshah station near Merek watershed (bottom)

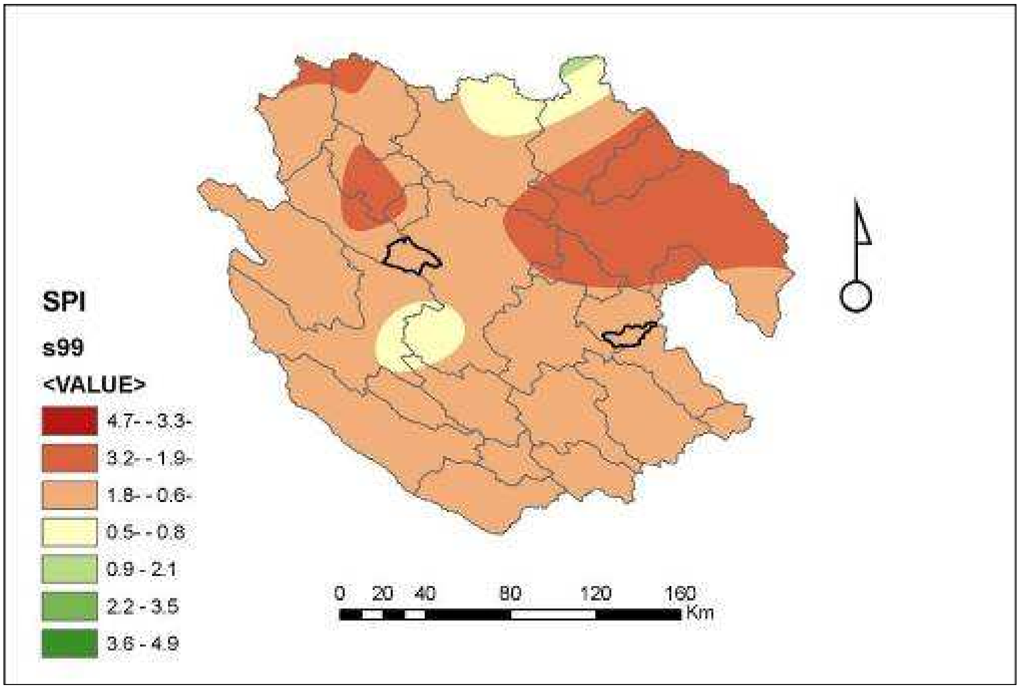

Fig 1.11: Spatial distribution of SPI-12 in Upper KRB in September 1999.

Land use change
The 2002 land use in upper KRB and the change from forest and rangeland to arable land are presented in Figure 1.12. The analysis indicated an 8.5% reduction in forest cover (Table 1.8), which amounts to 355,000 ha. Cultivation in the under-stories of forests, which has been estimated to amount to approximately 300,000 ha in KRB (about 7% of KRB) cannot be distinguished from the satellite image analysis. Field surveys also provided evidence of severe biological degradation of the rangelands and remaining forests. Therefore, the actual loss of forests lands is expected to be much higher.

Table 1.8: Coverage of land use classes in KRB

Land Use Class	Year		Land use change %
	1975/1977	2002	
Arable lands	25.0	29.9	4.9
Bare lands (rock)	1.7	0.4	-1.3
Forest	25.5	17.0	-8.5
Mix range, forest, cultivation	10.7	12.9	2.2
Range	37.0	38.6	1.6
Urban area	0.1	0.8	0.8
Water body	0	0.3	0.3
Grand Total	**100.0**	**100.0**	-

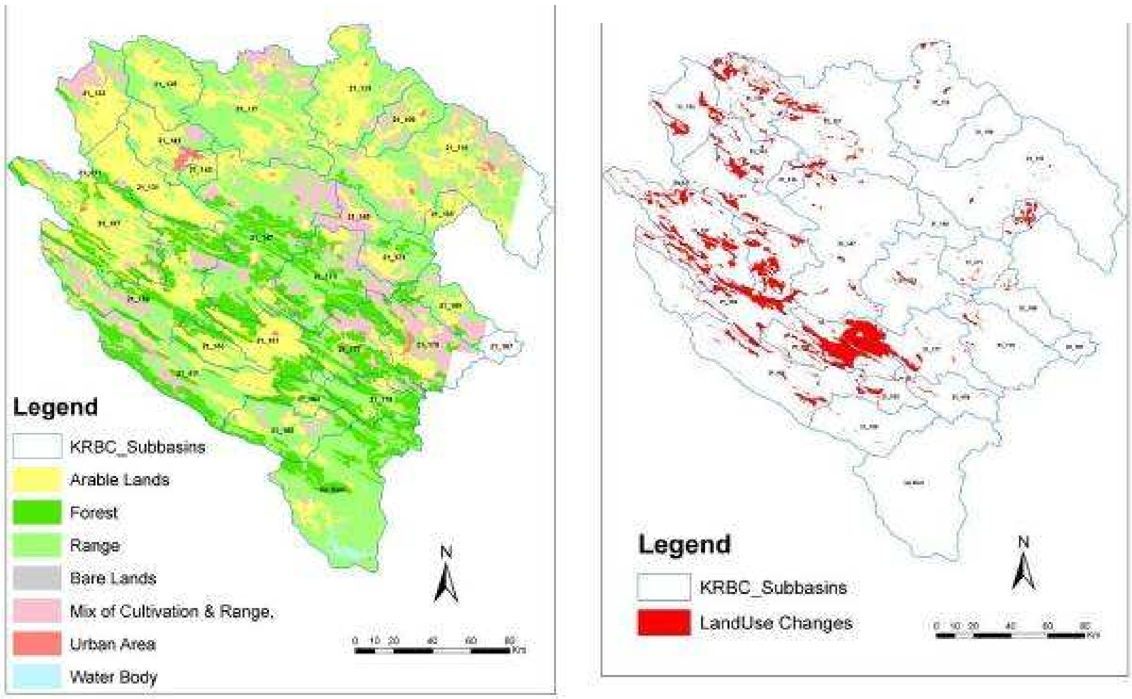

Figure 41.12: Land use map of upper KRB extracted from LandSat ETM+ 2002 images (left) and land converted from forest and rangelands to arable lands between 1975 (as extracted from LandSAT MSS imagery) *and 2002 (right)*

Observed sediment and flow rates at the different subbasin outlets were highly variable. At station 21-185, near the outlet of upper Karkheh River Basin, zero sediment concentrations were observed even at the highest 1% of the observed flow rates (flow rates exceeding 1000 m^3/s). But also for the smaller subbasins no clear relations were found between sediment concentrations and flow rates. This indicates that erosion and contribution of sediment is not uniform over the basin and subbasins.

Non-parametric trend analyses of the monthly average sediment concentrations for the period 1969 to 2006 did not show statistically significant time trends at the different subbasins. Similarly, linear regression of all measured suspended sediment concentrations and flows with time did not show any relations. The sediment concentrations and the corresponding flow rates for station 21-181, the outlet of the subbasin with a very high conversion of forest and rangelands to arable lands (see Figure 1.12), are presented in Fig. 1.13. Only the highest 50% of the flow rates were plotted. Except for the event of February 1975 (2079 mg/L), the top 5% observed sediment concentrations (all exceeding 800 mg/L) all occurred after November 1981.

Sediment concentrations and corresponding flow rates for station 21-85, near the outlet of upper KRB are presented in Fig. 1.14. Again, only the top 50% of the flow rates were plotted. No time trends were found. However, the irregular manual sampling is likely to have influenced the analysis. It would be recommended to add automated sediment samplers that take samples at pre-set stage changes.

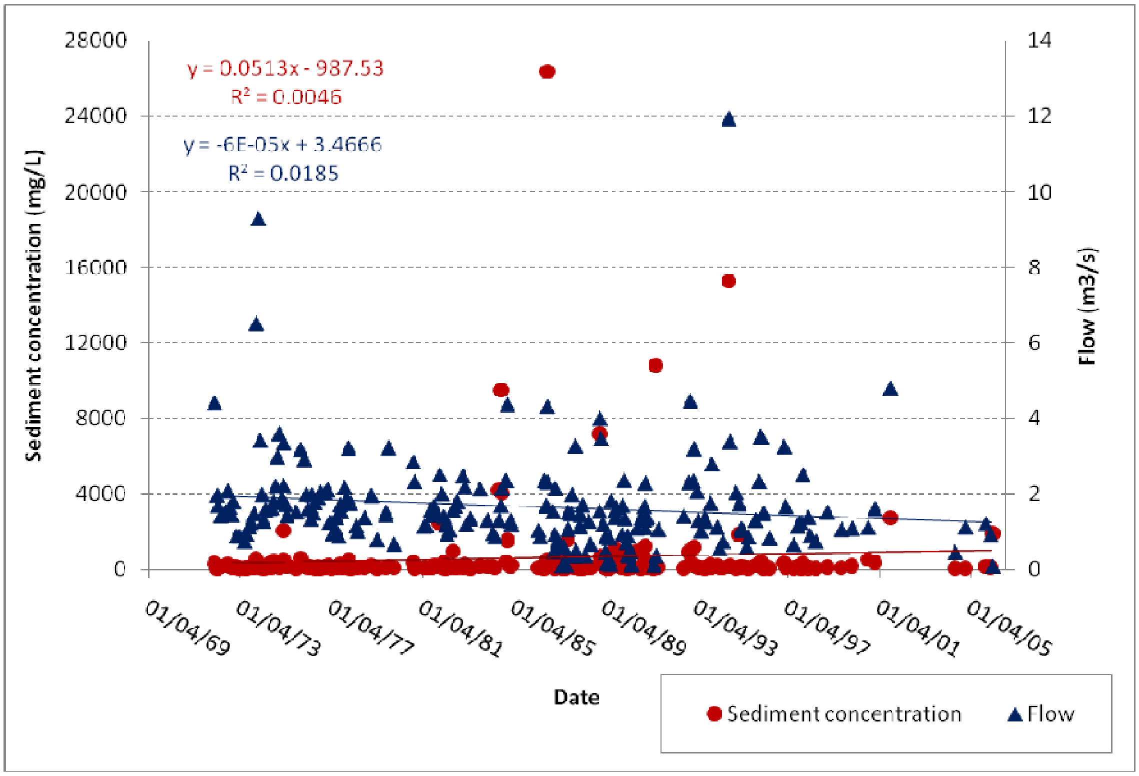

Figure 1.13: Suspended sediment concentration and stream flow at the outlet of the subbasin with highest conversion of forest and rangeland to arable land (station 21-181) in upper Karkheh River Basin, between September 1971 and March 2006

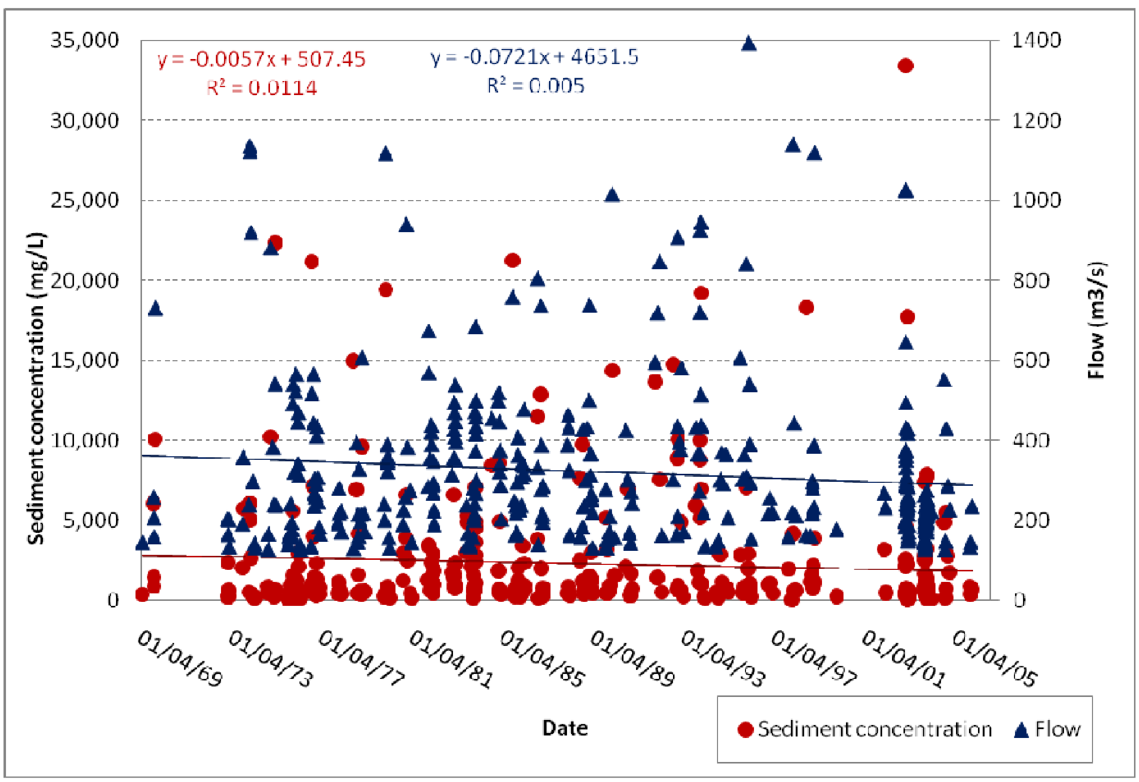

Figure 4.14: Suspended sediment concentration and stream flow at station 21-185, near the outlet of upper Karkheh River Basin, between April 1969 and December 2005

Conclusions
A rapid selection of benchmark watersheds, based on climate information, field visits and expert knowledge helped the project to get quickly established. Agro-ecological characterization confirmed the representativity of the selected sites to the region, nevertheless, important agro-ecosystems (badlands, forests) of KRB were not or poorly represented. Representation of all agro-ecosystems of the basin would have required the inclusion of a third watershed, which was outside the scope of this project. The result of the large scale upper basin assessments were supported or confirmed by detailed field surveys, mapping and modelling of the resources (water, soils, nutrients, erosion, vegetation) at the benchmark watersheds. Active involvement and capacity building of national and provincial researchers, as well as agricultural development and extension staff throughout the project laid the ground for further outscaling and upscaling of the project approach in Iran. Provincial and national scientific workshops and a policy meeting with participation of scientists and policy makers provided additional support and interest for the project and its findings.

5. Objective 5: Improved institutional capacity to coordinate INRM projects with involved stakeholders, and to tackle livelihood improvement and resource degradation in a more holistic way

Methods
The INRM approach emphasized process tools. Process tools are the 'oil' that will keep the project machine active, transparent and responsive. Process tools include the cross-disciplinary approach, capacity building, envisioning, participatory action research, multi-stakeholder cooperation, participatory monitoring and evaluation, and effective communication and facilitation. It is the role of the coordinators to safeguard that the process tools are properly used, mainstreamed and supported. This will include: keeping the process tools on the agenda, raise awareness about the need and usefulness of these tools, and organize training workshops when and where necessary.

Capacity building workshops and on-the-job training continued throughout the project. This objective involved the following main activities:

- Setting up of Steering Committee and Provincial Coordination Committee and Coordinators
- Consideration and inclusion of gender in all steps of the research
- Training activities and workshops, field days and on-the-job training
- Integrated workshops and activities for researchers
- Capacity building of farmers and communities throughout the PTD process (participatory problem analyses, technology fairs, field visits, farmer cross-visits, farmer evaluations)
- Basin stakeholders' meeting
- Development of database and webpage, sharing of reports and data
- Transparent coordination and decision making

Results and Discussion
A long list of capacity building activities and communication activities was given in the Completion Report. Training in INRM concepts and tools at the early stages of the project paved the way for the research activities. However, some of the jargon got lost in translation and logistic uncertainties, such as changes in team leaders and allocations of budgets hampered implementation. Smaller capacity building activities with direct field implementation such as the tillage erosion measurements, PTD training activities and various data analyses methods were more successful. However, a more telling tale of the increased capacity were the workshops that were organized by the project researchers and teams in Iran.

- A scientific workshop with results of all research activities in Tehran in September 2007.
- A two-day basin stakeholder workshop in Kermanshah (October 2007), where more than 50 stakeholders analyzed and prioritized watershed management strategies.
- An integrated watershed management workshop in Kermanshah (December 2008), where the project scientists presented and discussed their finding with the provincial researchers and executive staff.
- A final Farmer Participatory Technology Development Fair in Khoramabad (December 2008), attended by 115 male and 28 female farmers and a large number of researchers and extension staff. The farmers presented the technologies in which they had participated with field materials and self-made posters.

The final evaluation of the project indicated the appreciation of the participating researchers for the process tools.

Conclusion
The action oriented approach of the project, with research activities in watersheds in two provinces, exposed a large group of diverse stakeholders to integrated natural resource management and participatory research. Workshops and exposure to international research activities improved the leadership skills of the local researchers throughout the project's implementation stages. One of the project's principle investigators moved on to lead the GEF-sponsored INRM project (MENARID) for Iran.

OUTCOMES AND IMPACTS

Problem and objective trees and network maps developed during the CPWF Impact Pathway workshop in May 2006 guided the project.

A participatory project evaluation was conducted with the key researchers of the project in July 2009. The evaluation requested the researchers to rate the status (achieved – not achieved) and relevance of the different project activities and outputs, as planned in the original project proposal. Interestingly, most researchers rated the activities and outputs in which they took part but refrained from commenting on the outputs of others.

Visions for the future indicated a clear interest in continuing the research activities, especially modeling and GIS analyses. But the vision also showed a desire to continue team work, organize policy meetings, and to develop INRM and PTD projects for other areas. The importance of international support was mentioned by many. A new GEF-sponsored INRM project (MENARID) for Iran has adopted the livelihood projects approach and is currently using similar process tools.

A number of technologies was adopted by farmers, extension staff and scientists, including the use of azetobactor for both rainfed and irrigated barley and wheat, fall planting and improved varieties of chickpea, shallot cultivation, mushroom cultivation, saffron cultivation, improved soíl nutrient management, cultivation of fast growing trees, and communal pest management of wheat.

6. Proforma

Summary Description of the Project's Main Impact Pathways

Actor or actors who have changed at least partly due to project activities	What is their change in practice? I.e., what are they now doing differently?	What are the changes in knowledge, attitude and skills that helped bring this change about?	What were the project strategies that contributed to the change? What research outputs were involved (if any)?	Please quantify the change(s) as far as possible
Male and female farmers	Farmers are taking the initiative to experiment with new options that improve water productivity and resilience through diversification (e.g., change in date of sowing, use of improved varieties, new crops, improved nutrient and pest management).	Believing more in self-initiated change; more informed on options and possibilities and available resources; farmers saw that their needs and conditions were influencing the search for technologies; cooperation with researchers.	Constant interactions among farmers, researchers and extension agents; cross-visits and evaluations based on farmers' views; farmer-to farmer assessment and evaluations.	Four communities in 2 watersheds (8 total), 20% at community level, 80% of involved farmers in the project.
Extension staff	Arguing farmers' cases and limitations more vis-a-vis outside researchers rather than merely mediating the transfer of technologies.	Researchers ideas can be negotiated; facilitating participatory needs assessments, cross visits, and evaluations	Change of role of extensionists to facilitator of Participatory Technology Development process.	60%

Technology researchers	Seeking to expose their ideas to more direct experimentation with farmers in local conditions; more flexibility regarding technical aspects of their ideas; communicating their technologies in a simpler way; accepting the necessity of discussing rural women's situation and problems in international meetings.	Acknowledging local knowledge (also from poor farmers); how to present their ideas in a more accessible way; listening to farmers; reflecting repeatedly on the process; change in attitude toward international studies on women.	Basing the search for ideas on the needs assessment with local people; presentation of options in open fairs from which farmers could choose; the constant action and reflection throughout the project; involving farmers actively through experiments and evaluation; convinced researchers (somehow) that women's issues are not political, private and confidential.	70%
Researchers	Using participatory approach. Team work and integration, more consideration of gender issues, awareness of research methods.	Understanding of integrated natural resource management concepts and participatory approaches	Training activities, integrated workshops and field activities, participatory approach, exposure to international research projects.	60% of the behavior of the 120 researchers that were involved in the project
Management (research and executive sector)	Interest in integrated research	Understanding of a need for integrated and participatory research	Steering committee meetings, conference, workshops	Very mild

Of the changes listed above, which have the greatest potential to be adopted and have impact? What might the potential be on the ultimate beneficiaries?

Participatory Technology Development has the greatest potential for improving the livelihood of farming communities and increasing the work pleasure and enthusiasm of researchers and extension staff.

What still needs to be done to achieve this potential? Are measures in place (e.g., a new project, on-going commitments) to achieve this potential? Please describe what will happen when the project ends.

The Provincial Research Centers need to have sufficient budget and decision power and support of the researchers in Tehran. Various outscaling materials were developed (flyers, newsletter article, report, movies) but continuing international support (technical and financial) is needed to gain unconditioned acceptance of PTD at the higher management level and to extract original, high quality scientific outputs.

Each row of the table above is an impact pathway describing how the project contributed to outcomes in a particular actor or actors.

Which of these impact pathways were unexpected (compared to expectations at the beginning of the project?)

The PTD mobilized an unexpected large number of researchers and farmers.

Why were they unexpected? How was the project able to take advantage of them?

PTD was unknown in Iran. Teams in two provinces worked with eight farming communities on sixteen different technologies. A large number of researchers got trained in PTD. Extension staff and farming communities gained direct access to researchers, while researchers found new ways to adapt and fine tune their knowledge and technologies.

What would you do differently next time to better achieve outcomes (i.e. changes in stakeholder knowledge, attitudes, skills and practice)?

In hindsight it is often easy to say that we could have done things differently. In reality, we did try many things in many different ways, but many of them simply did not succeed within the current research system. Integrated natural research management research is new to Iran and our project basically started from scratch. Even though we had the support of the CPWF, it still takes time to change the system and the mind of the people. Changes and uncertainties at the local research management level also affected the research progress. Furthermore, finding the right people that can contribute and commit themselves to the project. Some of the people only joined after the project started blooming, and so they also missed some of the foundations of the project.

However, next time, we could let the project be less driven by pre-defined research tools and methods and more by a strongly-led integrated international science basis and the knowledge, knowledge gaps and demands of the local stakeholders. Due to the experience and interests of local scientists and the conventional research system the tools (e.g., land degradation assessment, watershed modeling) sometimes seemed to become an end by itself, instead of a contribution to the larger integrated research project.

7. International Public Goods

1.1 Tools and Methodology

- Integrated watershed management principles for dry mountain watersheds.
- Agro-ecological characterization and similarity analysis for outscaling of technologies tested in benchmark watersheds.
- Spatial erosion modeling to understand trade-offs between production increase and erosion for expanding farming onto sloping lands.
- Farmer innovator survey, for discovering and outscaling local knowledge and best-bet technologies.
- Implementation of participatory technology development.
- Practice of planting chickpea in fall instead of spring, with high water productivity.
- New chickpea varieties that are tolerant to cold and terminal drought.

1.2 Project Insights

- Assessment of water resources at the watershed level can provide important insights in the water potential of the watershed. The two upstream benchmark watersheds had very different water resources situations.
- Improving water productivity in upstream watersheds in the dry areas does not necessarily come from optimizing irrigation, but from maximizing the productivity of the people and the land, by supporting sustainable agricultural technologies that require little or no additional water, such as improved varieties of rainfed crops (barley, wheat, chickpea, lentil), fruit trees, bee keeping, saffron, mushrooms, poultry, dairy processing, improved nutrient management, collective pest management.

- The integration of gender research, and a mix of male and female researchers, farmers and children created an overall very positive, accessible and sustainable feel to the project. More attention and support (training) of rural women in livestock management, dairy production, handicrafts and selected agricultural technologies such as mushroom growing, could have an important effect on the livelihood and water productivity of rural communities in upstream areas.

- Soil surveys, land use mapping and field measurements of erosivity and tillage erosion combined with spatial erosion modeling could provide important insights in the trade-offs between expansion of crop lands and production versus land degradation and downstream sediment.

8. Partnership Achievements

The value of bringing a CGIAR challenge program research project to Iran, supported by international donors, scientists and funds cannot be overlooked. The research sector in Iran is relatively isolated and set in its ways. Through its global nature and significance, the CPWF had established a certain respect. This helped us to bring researchers from many different institutes together and to develop a truly integrated project. Capacity building activities and interactions with international scientists in Iran, training workshops and trips abroad such as to the International Fora on Water and Food, to ICARDA's cooperative research activities in Syria, and to the International Institute of Rural Reconstruction in the Philippines helped Iranian researchers to think differently. Some of the Iranian researchers also grabbed the opportunity to improve their English skills and to collect new international research publications and many learned new research methods and tools. It can be said that as a whole, the project greatly improved the experience, cooperation and coordination skills of both the Iranian and the international scientists.

The sharing of data between the researchers from the different institutes and the development of an integrated spatial databases for Honam and Merek watersheds allowed the erosion and land degradation and suitability analyses and the development of provisional watershed management plans. Cooperation with Leuven University provided the researchers with new spatial erosion modeling and decision support tools, which were implemented for the watersheds.

Researchers from the Rural Research Center (AEERO) learned new facilitation and participatory research skills and developed close cooperation with the researchers of the Agricultural and Natural Resource Management Centers, and the staff of the Extension and Agricultural Service Centers in the Provinces. For many of these researchers it was the first time that they tested and fine-tuned their knowledge and technologies in close cooperation with farmers. Both the researchers and the farmers gained a new level of confidence in demand-driven agricultural research.

Flyers of most of the technologies tested in the two watersheds were developed and distributed in Farsi and English (see Moosavi et al. 2010). The use of the biofertilizer azetobactor for rainfed and irrigated wheat and barley and the early planting and management of new chickpea varieties have been presented in international research articles. However, the scope and duration of the project did not allow a full scale scientific analysis and publication of the adaptation of the large number of successful technologies.

9. Recommendations

Transform supply-driven agricultural research to demand-driven research and technology development by enabling farmer participation

Participatory research in Honam and Merek watersheds (Participatory Technology Development as well as Participatory Plant Breeding) revealed great response of both male and female farmers to work with researchers on the adaptation of technologies that could solve their own problems. The linear process of development of technologies by researchers and transfer of results by extension staff to farmers has not been able to adequately respond to complex development challenges, especially in marginal environments. A more integrated and participatory approach that involves local communities and their indigenous knowledge can more efficiently contribute to the improvement of productivity and income of farming communities. This implies inter-disciplinary interaction between research, extension and farmers.

Proposed policy measures include the following:

1. Institutionalize farmer-participatory approaches in agricultural research and extension programs by mainstreaming PTD and inter-institutional cooperation.
2. Create mechanisms for cooperation between researchers, extension staff and farming communities.
3. Involve male and female farmers in setting the research agenda.
4. Provide appropriate incentives for participatory research for researchers, such as adjustment of promotion criteria.
5. Enhance allocation of resources for provincial research centers to support participatory technology development.
6. Mainstream Participatory Plant Breeding to improve production in marginal lands and cope with climate change.
7. Increase the number of female research and extension staff and start up a participatory research program specifically targeted to women farmers.
8. Improve agricultural micro-credit systems that support investment of both male and female farmers in promising and sustainable income generating technologies.
9. Document indigenous knowledge to enhance innovation.

Balance rural development and food security goals with ecological limits in upstream catchments of dry mountains

Sound planning of natural resource use and interventions at the watershed level can improve the quality of life of rural communities, and increase resilience of livelihood options in face of drought. Uncontrolled use of natural resources, such as over-grazing and out-of-season grazing, conversion of rangelands and forests into rain-fed croplands, cutting of trees and over-harvesting of high-value plants have caused degradation of the vegetation and diversity of plant species in many watersheds in the country. Erosion due to inappropriate land use and management, irrigation without proper drainage systems, over-exploitation and pollution of water resources not only affect local communities, but also affect downstream end resource users. In mountainous areas interactions between socio-economic activities and utilization and conservation of land and water resources can best be managed at the watershed level.

Proposed policy measures are as follows:

1. Develop mechanisms that facilitate effective stakeholder cooperation and a holistic approach at the initial stage of watershed management planning.
2. Enable the practical realization of the mandates of new and existing community-based watershed management organizations (like village Islamic councils) for sustainable use and management of natural resources.
3. Develop land use plans based on agro-ecological characteristics, soil and water resources, land degradation, vegetation assessments and livelihood needs.

4. Define criteria and indicators for participatory monitoring and evaluation of watershed resource management.
5. Design plans for additional income-generating activities and sustainable management of rangelands and forests based on the dynamic carrying capacity of the vegetation together with pastoralists communities.
6. For slopes above 12%, encourage sustainable use of natural rangelands and development of rainfed orchards and high-value medicinal and herbal plants in degraded lands.

Promote chickpea production and marketing to increase farm income

Chickpea production is profitable and farm income can be increased if supported by local markets and a clear export policy. Production of chickpea is well adapted to the agro-ecological conditions of upper Karkheh River Basin, particularly in Kermanshah and Lorestan Provinces, a region with pockets of high rural poverty. Project research showed that chickpea production with improved varieties, fall planting, mechanized planting and harvesting and proper use of fertilizers and mechanized weed control resulted in high water productivities and good farm incomes. Chickpea cultivation makes farm production more sustainable by encouraging legume-cereal rotation in the farming system.

There is strong demand for chickpea in the Gulf countries. Iran has a proximity advantage in this growing market. But chickpea producers face risks when exports are suddenly curtailed with the objective of stabilizing domestic consumer prices. Project research showed that chickpea production is more sensitive to price fluctuations than stable food crops because of its relatively higher supply price elasticity (Rafati et al., 2010).

Proposed policy measures are the following

1. Encourage use of improved chickpea varieties for fall planting to increase yields and ensure high water productivity.
2. Support cooperative use of mechanized planters, cultivators and harvesters through Agricultural Service Centers.
3. Encourage investment in post-harvest management and value added activities (cleaning, sorting, packaging and labelling) to establish a high-value brand with strong customer loyalty.
4. Develop and support local markets to increase the benefits for farmers.
5. Support chickpea export with a clear and stable export policy that shifts the policy goal from consumer price stabilization to rural poverty reduction through higher and more stable farm income.

10. Publications

Research Reports

De Pauw, E., A. Mirghasemi, A. Ghaffari, and B. Nseir. 2008. Agro-ecological zones of Karkheh River Basin. ICARDA, Aleppo, Syria.

Farahani, H. Oweis, T., H. Siadat, F. Abbasi, A. Bruggeman, J. Anthofer, F. Turkelboom, (ed.). 2008. Proceedings of the international workshop on improving water productivity and livelihood resilience in Karkheh River Basin, 10-11 September 2007, Karaj, Iran. ICARDA, Aleppo, Syria.

Ghafouri, M., (ed.) 2007. International workshop on improving water productivity and livelihood resilience in Karkheh River Basin. Extended abstracts. 10-11 Sep 2007, Tehran, Iran. Soil Conservation and Watershed Management Research Institute.

Milani, P.M. K. Eftekhari, S.H. Fatehi, and M. Sepahvand. 2010. Semi-detailed soil surveys of Merek and Honam Watersheds, Karkheh River Basin. ICARDA, Aleppo, Syria.

Moosavi, S.B., J. Anthofer, M. Moazzami, S.M. Mobarakian, P. Garavand, Z. Rashno, S. Moradi, M. Moradi, M.R. Farhadi, M. Fakhri, T. Babaei, H. Azizi, S. Rahmani. 2010. Gathering Wisdom from the Field: Participatory Technology Development with Farming Communities in Honam and Merek Watersheds in the Karkheh River Basin. ICARDA, Aleppo, Syria.

Effati, M., M. Martini, A. Abbasi, and S. Soltani. 2010. Gender and Livelihoods in Upper Karkheh River Basin, Iran. ICARDA, Aleppo, Syria. (in review)

Norouzi Banis, Y., S.A. Mirghasemi, R. Bayat, A. Jafari Ardakani, D. Nikkami, B. Ghermezcheshmeh, H.R. Masoumi, T. Farhadinezhad, Y. Parvizi, M. Ghaitouri, D. Lotfollah Zadeh, P.M. Milani, F. Turkelboom, Z. Masri, and A. Bruggeman. 2010. Erosion and Land Degradation in Karkheh River Basin. ICARDA, Aleppo, Syria. (in review)

Porhemmat, J., B. Chermezchesmeh, S Rahimi-Bondarabadi, T. Razee, P.D. Arrasteh, A. Bruggeman. 2010. Water Resources and Drought Analysis of Karkheh River Basin. ICARDA, Aleppo, Syria. (in review)

Porhemmat, J., M. Heydarizadeh, I. Veyskarami, H. Hessadi, B. Ghermezcheshmeh, A. Bruggeman. 2010. Water Resources and Runoff Modeling of Merek and Honam Watersheds, Karkheh River Basin. ICARDA, Aleppo, Syria. (in review).

Rafati, M., M. Zad, A. Kalaei, K. Noori, A. Aw-Hassan, P. Valipour, M. Farhadi, F.Jahannama, A. Nemati. 2010. Livelihoods and Agricultural Policies in Merek and Honam Watershed in Karkheh River Basin. ICARDA, Aleppo, Syria. (in review)

Sabbaghpour, S.H., A. Ghaffari, A. Shahmoradi, M.Ghaitori, S. Ahmadi, A. Tavakoli, K. Nadermahmoudi, M. Pala. 2010. Agricultural Production, Rangeland and Forest Systems in Karkheh River Basin. ICARDA, Aleppo, Syria. (in review)

Turkelboom, F., M. Ghafouri, A. Bruggeman, and H. Siadat (eds.). 2010. Integrated Watershed Management Principles for Upper Catchments of Dry Mountain Environments, with examples from Karkheh River Basin, Iran. ICARDA, Aleppo, Syria. (in review)

Journal Publications

Sarreshtehdari, A., A. Van Rompaey, M. Ghaffouri. 2010. Modelling the trade-off between wheat production and soil erosion in the Karkheh River basin, Iran, Catena (in preparation)

Masri, Z., Y. Norouzi Banis, D. Lotfollahzadeh, M. Ghaitouri, T. Farhadinezhad, P.M. Milani, A. Bruggeman and F. Turkelboom. Assessment of tillage erosion in the marginal hilly slopes of Karkheh River Basin, Iran. Soil and Tillage Research (in preparation)

Ghafouri, M. and J. Van Orshoven. 2010. Spatial Decision Support Systems for Sustainable Rainfed Farming in Karkheh River Basin, Iran. (in preparation).

Proceedings Papers

Alireza, S.J.S., P.M. Milani. 2008. Land suitability evaluation in Merek Watershed, pilot watershed of Karkheh River Basin. Proceedings of the CGIAR Challenge Program on Water and Food 2nd International Forum on Water and Food, 10-14 Nov. 2008, Addis Ababa, Ethiopia, Vol 2: 174-177.

Bruggeman, A., F. Turkelboom, J. Anthofer, A. Aw-Hassan, J. Porhemmat, B. Moosavi, M. Ghafouri, S.A. Mirghasemi, Y. Norouzi Banis, P. Milani, S. Shahmoradi, K. Noori, A. Ghaffari, S.H. Sabaghpour, M. Moazami, H. Siadat, E. De Pauw, M. Martini, and M. Pala. 2008. Integrating watershed management while strengthening livelihood resilience. Which bottom up? Proceedings of the 2nd International Forum on Water and Food, 10-14 Nov. 2008, Addis Ababa, Ethiopia.

Moosavi, S.B., S.M. Mobarakian, M.R. Farhadi, and J. Anthofer. 2008. Gradual evolution of a participatory process of technology development. Proceedings of the CGIAR Challenge Program on Water and Food 2nd International Forum on Water and Food, 10-14 Nov. 2008, Addis Ababa, Ethiopia, Vol 3: 184-188.

Norouzi Banis, Y., M. Heshmati, K. Khademi, S.A. Heydarian, S.B. Moosavi, F. Turkelboom and J. Anthofer. 2008. Promoting farmer innovations in Karkheh River Basin A promising process to improve rural livelihoods. Proceedings of the CGIAR Challenge Program on Water and Food 2nd International Forum on Water and Food, 10-14 Nov. 2008, Addis Ababa, Ethiopia, Vol 3: 189-192.

Sabaghpour, S.H., P. Pezashkpour, I. Kerami, A. Ghaffari, M. Pala, J. Anthofer , F. Feri, A. Nemeti, F. Mahmoodi, H. Azizi, A. Hasanvand. 2008. Evaluation of agronomic management practices for enhancing chickpea yield in Karkheh River Basin in Iran. Proceedings of the CGIAR Challenge Program on Water and Food 2nd International Forum on Water and Food, 10-14 Nov. 2008, Addis Ababa, Ethiopia. Vol 2: p.170-173.

Ghaffari, A., E. De Pauw, S.A. Mirghasemi. 2008. A land suitability study under current and climate change scenarios in the KRB, Iran. Proceedings of the CGIAR Challenge Program on Water and Food 2nd International Forum on Water and Food, 10-14 Nov. 2008, Addis Ababa, Ethiopia, Vol 1: 177-180.

Ghafouri, M., A. Sabziparvar. 2008. Iranian climate change mitigation strategies for agriculture water demands. Proceedings of the CGIAR Challenge Program on Water and Food 2nd International Forum on Water and Food, 10-14 Nov. 2008, Addis Ababa, Ethiopia, Vol 1: 181-183.

Milani, P.M. and J. Anthofer. 2008. Effect of Azotobacter and Azospirillum on the yield of wheat (Triticum aestivum L.) and barley (Hordeum vulgare L.) in Kermanshah and Lorestan, Iran. Proceedings of the CGIAR Challenge Program on Water and Food 2nd International Forum on Water and Food, 10-14 Nov. 2008, Addis Ababa, Ethiopia, Vol 2: 178-181

Newsletters

Moosavi, B. 2008. Participatory Technology Development. Newsletter of the Rural Research Center 20: 4-5.

Policy flyers

Transform supply-driven agricultural research to demand-driven research and technology development by enabling farmer participation

Balance rural development and food security goals with ecological limits in upstream catchments of dry mountains

Promote chickpea production and marketing to increase farm income

Website
http://www.karkheh-cp.icarda.org/karkheh-cp/default.asp

BIBLIOGRAPHY

Adato, M. and R. Meinzen-Dick. 2002. Assessing the impact of agricultural research on poverty using the sustainable livelihoods framework. EPTD Discussion Paper 89/FCND Discussion Paper 128. International Food Policy Research Institute (IFPRI), Washington, D.C.

Anthofer J., S.B. Moosavi, M. Moazemi, M. Efati, and F. Turkelboom. 2007. Participatory Technology Development - Challenges and opportunities. In: Extended abstracts of the International workshop on improving water productivity and livelihood resilience in Karkheh river basin. Karaj, Iran, 10-11 September, 2007. MoJA-AREO, CPWF, ICARDA.

Ashrafi, S. 2003. Overview of Karkheh river basin. Presented at the Karkheh basin kick-off workshop. Karaj, Iran, Februari 2003.

Bergkamp, G. 1998. A hierarchical view of the interactions of runoff and infiltration with vegetation and microtopography in semiarid shrublands. *Catena* 33: 201-220.

Blaschke, T. and J. Strobl. 2003. What's wrong with pixels? Some recent developments interfacing remote sensing and GIS. GIS 6/2001, Heidelberg: Hüthig GmbH & Co. KG.

Bruneau, R. 2005. Watershed Management Research: A review of IDRC Projects in Asia and Latin America. IDRC Rural poverty and environment working paper series No.18. IDRC, Canada.

Campbell, B.M., S. Jeffrey, W. Kozanayi, M. Luckert, M. Mutamba and C. Zindi. 2002. Household livelihoods in Semi-Arid Regions. Options and Constraints. Indonesia: CIFOR.

Carpenter, S., B. Walker, J.M. Anderies, and N. Abel. 2001. From metaphor to measurement: resilience of what to what? *Ecosystems* 4: 765-781.

Catacutan, D. and C. Duque. 2006. Challenges and opportunities in managing Philippine watersheds: the case of Manupali watershed in the southern Philippines. Paper presented to the Conference on Watershed Management in the Philippines, Don Mariano Marcos Memorial University, La Union, Philippines, 16-18 May 2006.

Celis, D., and E. De Pauw. 2003. 'Hot spot' assessment of land cover change and land degradation in CWANA using AVHRR satellite imagery. Paper presented at the 7th International Dryland Development Conference, Tehran, Iran, 14-17 September 2003.

Chambers, R. 1993. *Challenging the Professions: Frontiers for rural development.* London: Intermediate Technology.

Cools, N., E. De Pauw, and J. Deckers. 2003. Integrating conventional land evaluation methods and farmers' soil suitability assessment: Case of Northwestern Syria. *Agriculture, Ecosystems and Environment* 95: 327-342.

De Pauw, E., A. Mirghasemi, A. Ghaffari, and B. Nseir. 2008. Agro-ecological zones of Karkheh River Basin. ICARDA, Aleppo, Syria.

De Pauw, E. 2002. An agroecological exploration of the Arabian Peninsula. Aleppo, Syria: ICARDA.

De Pauw, E., A. Ghaffari, and V. Ghassemi. 2003. Agroecological zoning in Northwest Iran. NRMP Annual Report 2002. Aleppo, Syria: ICARDA.

DFID. 1999. *Sustainable livelihoods guidance sheets.* http://www.livelihoods.org/info/guidance_sheets_pdfs/section2.pdf

Ellis, F. 1999. Rural livelihood diversity in developing countries: Evidence and policy implications. Overseas Development Institute No.9.

FAO, Rome. LADA - Land Degradation Assessment in drylands. Rome: FAO. http://www.fao.org/ag/agl/agll/lada/default.stm

FAO. 2006. The new generation of watershed management programmes and projects. FAO Forestry Paper 150. FAO, Rome.

Farahani, H. and T. Oweis. 2009. Agricultural water productivity in Karkheh River Basin. In: *Improving on-farm agricultural water productivity in the Karkheh River Basin*. Research Report no 1: A Compendium of Review Papers, ed. Oweis et al., 3-17. Aleppo, Syria: ICARDA.

German L., H. Mansoor, G. Alemu, W. Mazengia, T. Amede, and A. Stroud. 2006. Participatory Integrated Watershed Management Evolution of Concepts and Methods. African Highlands Initiative (AHI) Working Paper 11.

German L.A., B. Kidane,. and K. Mekonnen. 2005. Watershed Management to Counter Farming Systems Decline - Toward a Demand-Driven, Systems-Oriented Research Agenda. African Highlands Initiative (AHI) Working Paper 16.

Geran, J.M. 2000. Growth, crisis and resilience: Household responses to economic change in rural Southeast Asia – evidence of Northern Thailand. Madison, WI: Department of Agricultural & Applied Economics. http://www.aae.wisc.edu/coxhead/projects/lamyai/WP2.pdf

Gilbert, R.O. 1987. *Statistical methods for environmental pollution monitoring*. New York: John Wiley and Sons.

Hirsch, R.M., R.B. Alexander, and R.A. Smith. 1991. Selection of methods for the detection and estimating of trends in water quality. *Water Resources Research* 27(5): 803-813.

Glavovic, B., R. Scheyvens, and J. Overton. 2002. Waves of adversity, layers of resilience – Exploring the sustainable livelihoods approach. Palmerston North, N.Z.: Institute of Development studies, Massey University.
http://devnet.massey.ac.nz/papers/Glavovic,%20Overton%20&%20Scheyvens.pdf

Grootaert, C., and T. van Bastelaer. 2002. Understanding and measuring social capital. A multidisciplinary tool for practitioners. The World Bank, The International Bank for Reconstruction and Development, Washington, D.C.

Guttman, N.B. 1999. Accepting the Standardized Precipitation Index: a calculation algorithm. *J. Amer. Water Res. Assoc*. 35(2): 311-322.

Hessel D.R., and R.M. Hirsch. 1992. *Statistical methods in water resources.* Amsterdam: Elsevier.

Jamab Co. 1999. Comprehensive water resources plan of Iran. Karkheh River Basin Reports. Tehran, Iran.

Jones P.G., P.K. Thornton, W. Diaz, and R.W. Wilkens. 2003. Marksim. A computer tool that generates simulated weather data for crop modelling and risk assessment. CIAT, Cali, Colombia.

Karkheh Office for Watershed Management. 2002. Wateshed Project in Karkheh Dam Basin. RFWO.

Kerr J., G. Pangare, and V.L. Pangare. 2002. Watershed development projects in India – An evaluation. IFPRI research report No.127.

Matias, P.G. 1998. Análise de Frequência de Séries Hidrológicas Anuais. Dep. Engenharia Rural, Instituto Superior de Agronomia, Lisboa.

McKee, T.B., N.J. Doesken, and J. Kleist. 1993. The relationship of drought frequency and duration to time scales. In: Proceedings of the 8th conference on applied climatology, 17–22 January, Anaheim, CA, Am Meteor Soc, Boston, MA, 179–184

Millenium Ecosystems Assessment (MEA). 2005. Ecosystems and their services. Washington DC: World Resources Institute.

Ministry of Agriculture. 1997. Long Term Agricultural Development Plan for 2020. Tehran: Planning and Agricultural Economics Research Institute.

Norgaard, R.B. 1994. *Development betrayed: the end of progress and a coevolutionary revisioning of the future.* New York: Routledge.

Ostrom, E. 1990. *Governing the commons – The evolution of institutions for collective action*. Cambridge University Press.

Paulo, A.A., L.S. Pereira, P.G. Matias. 2003. Analysis of local and regional droughts in southern Portugal using the theory of runs and the Standardised Precipitation Index. In *Tools for Drought Mitigation in Mediterranean Region*, ed. G. Rossi, A. Cancelliere, L.S. Pereira, T. Oweis, M. Shatanawi, and A. Zairi, 55–78. Dordrecht: Kluwer.

Rakodi, C. 1999. A capital assets framework for analysing household livelihood strategies: Implications for policy. *Development Policy Review* 17: 315-342.

Rogers, E.M. 1983. *Diffusion of innovations.* Third Edition. New York: The Free Press.

Shahmoradi, A. M. Ghaitori, S. Ahmadi, A. Tavakoli. 2008. Vegetation assessment and recommendations for rehabilitation and sustainable management of rangelands and forest ecosystems of Merek and Honam Watersheds in Upper Karkheh River Basin. Project report. Research Institute of Rangelands and Forests.

Salmen, L.F. 1995. Participatory poverty assessment. Incorporating poor people's perspectives into poverty assessment work. Environment Department Papers-Social Assessment Series. Paper No. 024.

Sharifi, F. 2002. Watershed management experiences and rural livelihoods in Iran – An introductions to G-Wadi pilot sites at Taleghan and Hashtgerd. FRWO, Ministry of Jihad-Agriculture, Iran, and UNESCO.

Veale, B.J. 2003. A review of watershed planning and management best practices, legal tools and next steps. Grand River Conservation Authority/Conservation, Ontario, Canada.

Vogel, R.M., and J.R. Stedinger. 1985. Minimum variance streamflow record augmentation procedure. *Water Resour Res* 21:715–723.

PROJECT PARTICIPANTS

Name	Institution	Coord	Water	Erosion	IWM	Soil	Range	Agron	AEZ	Socioec	Gender	PTD
Coordination & Support												
Mohsen Mohsenin(1)	AEERO-Tehran	x								x		
Jahangeer Porhemmat	AEERO-Tehran	x	x		x							
Mohammad Ghafouri	SCWMRI-Tehran	x			x							
Francis Turkelboom(2)	ICARDA-Aleppo	x		x	x	x	x					x
Juergen Anthofer(2)	ICARDA-Aleppo	x				x		x				x
Adriana Bruggeman	ICARDA-Aleppo	x	x	x	x	x		x				x
Hamid Siadat	ICARDA-Tehran	x			x	x		x				x
Theib Oweis	ICARDA-Aleppo	x										
Ahmed Amri	ICARDA-Tehran	x										
Mohammad Roozitalab	ICARDA-Tehran	x										
Zieaodin Shoeai	AEERO, ICARDA-Tehran	x										
Saeed Nazari	ANRRC-Kermanshah	x										x
M. Noori	ANRRC-Kermanshah	x										x
Nader Heydari	AERI-Tehran	x										
Water and Drought												
Majid Heydarizadeh	SCWMRI-Tehran		x									x
Bahareh Yousefipanah	SCWMRI -Tehran		x									
S. Rahimi-Bondarabadi	SCWMRI-Tehran		x									
T. Raziei	SCWMRI-Tehran		x									
Iraj Vayskarami	ANRRC-Lorestan		x									x
Kianfar Peymani	ANRRC-Lorestan		x							x		
Homayoun Hesadi	ANRRC-Kermanshah		x									x
Mohamad Ahmadi	ANRRC-Kermanshah		x	x								
Erosion and Land Degradation												
Yaghoub Norouzi Banis	SCWMRI-Tehran			x	x							x
Amir Sarreshtehdari	SCWMRI -Tehran			x	x							
Dadvar Lotfollahzadeh	SCWMRI-Tehran			x	x							
B. Ghermez Cheshmeh	SCWMRI-Tehran		x	x	x							
R. Bayat	SCWMRI-Tehran			x								
A. Jafari Ardakani	SCWMRI-Tehran			x								
H.R. Masoumi	SCWMRI-Tehran			x								

Davood Nikkami	SCWMRI-Tehran			x	x							
Mosayeb Heshmati	ANRRC-Kermanshah			x								
Yahya Parvizi	ANRRC-Kermanshah			x								
Taher Farhadinezhad	ANRRC-Lorestan			x								
Allahyar Mohammadi	FRWO-Kermanshah			x	x							
Hossain Pirhayati	FRWO-Lorestan			x	x							
Zuhair Masri	ICARDA-Aleppo			x								
Jean Poesen	KUL-Leuven			x								
Anton Van Rompaey	KUL-Leuven			x								
Integrated Watershed Management												
M. Roughani	SCWMRI-Tehran				x							
M.R. Tabatabaei	SCWMRI-Tehran				x							
Mir Masoud Kheirkhah	SCWMRI-Tehran				x							
Esmaeil Sharifi	SCWMRI-Tehran				x							
Jos Van Orshoven	KUL-Leuven					x						
Soil and Nutrients												
Parviz Mohajer Milani	SWRI-Tehran			x	x	x		x				x
K. Eftekhari	SWRI-Tehran					x						
Ghaderi Jalal	SWRI-Tehran					x						
Seyed Alireza S. Jalali	SWRI-Tehran					x						
S. Fatehi	ANRRC-Kermanshah					x						
Morad Sepahvand	ANRRC-Lorestan					x						x
Seppe Dekker	KUL-Leuven						x					
Rangelands and Forests												
Amrali S. Shahmoradi	RIFR-Tehran				x		x					
Shahla Ahmadi	AEERO-Lorestan						x					
Mohamed Ghaithouri	AEERO-Lorestan				x		x			x		
Ahmad Tavakoli	AEERO-Kermanshah						x					
Agronomy												
Seyed H. Sabaghpour	DARI-Kermanshah							x				x
Mustafa Pala	ICARDA-Aleppo							x				
Vahid Ghasemi	SWRI-Kermanshah							x				
Iraj Karami	DARI-Kermanshah							x				
Peyman Pezeshkpoor	DARI-Kermanshah							x				
Hasan Peerdadeh	MoJA-Lorestan							x				
Agroecological Characterization and GIS												

Eddy De Pauw	ICARDA-Aleppo					x			x			
Abdulali Ghaffari	DARI-Maragheh					x				x		
Seyed A. Mirghasemi	FRWO-Tehran			x	x	x	x		x			
Bashar Nseir	ICARDA -Aleppo								x			
Farhad Feri	DARI-Kermanshah							x				
Farshid Mahmoodi	DARI-Kermanshah							x				
Socioeconomics												
Aden Aw-Hassan	ICARDA-Aleppo									x		
Keyomars Noori	RRC-Tehran									x		
Mohsen Rafati	RRC-Tehran									x		
Mohammad Zad	RRC-Tehran									x		
Ali Kalei	RRC-Tehran									x		
Adel Nemati	RRC-Tehran							x		x		
Fahimeh Jahannama	RRC-Tehran									x		
Safoura Karimi	RRC-Tehran									x		
Manuchehr Rahmani	RRC-Tehran									x		
Mohammad E. Hooshmand	RRC-Tehran									x		
Mohammad Reza Touraji	RRC-Tehran									x		
Hassan Alipour	AEERO-Tehran									x		
Parvin Valipour	ANRRC-Lorestan									x	x	
Alirahm Hassanvand	ANRRC-Lorestan									x		
Mir Moh. Beyranvand	ANRRC-Lorestan									x		
Zahra Amiri	ANRRC-Lorestan									x		
Gender												
Malika Martini	ICARDA-Aleppo										x	
Mohammad Effati	RRC-Tehran										x	x
Shohreh Soltani	RRC-Tehran										x	
Mitra Moazzami	RRC-Tehran										x	x
Vida Roshani	ANRRC-Lorestan										x	
Participatory Technology Development												
Seyed Babek Moosavi	RRC-Tehran				x							x
Akram Abbasi	RRC-Tehran										x	x
Nastaran Moosavi	RRC-Tehran											x
Shahryar Rahmani	Indep.-Tehran											x
Moh. Reza Jamalifard	Indep.-Tehran											x

Moh. Reza Farhadi	ANRRC-Kermanshah									x		x
Masoumeh Fakhri	MoJA-Kermanshah											x
Teymoor Babaei	RRC-Kermanshah											x
Hamid Azizi	ASC-Kermanshah							x		x		x
Fardin Khodadoost	ASC-Kermanshah											x
Nargess Azimi	Extension-Kermsh.											x
Heydar Zonnourian	ANRRC-Kermanshah											x
Yahya Khoda Karami	ANRRC-Kermanshah											x
Reza Haq-parast	DARI-Kermanshah											x
Katayoon Moomivand	Indep.-Kermanshah											x
S. Majeed Mobarakian	RRC-Lorestan											x
Parviz Garavand	RRC-Lorestan											x
Ziba Rashno	ANRRC-Lorestan											x
Manoochehr Kalhor	ANRRC-Lorestan					x						x
Nader Azadbakht	ANRRC-Lorestan											x
Dariush Mubaraki	ANRRC-Lorestan											x
Karim Ghorbani	ANRRC-Lorestan											x
Mir-Reza Jamshidi	ANRRC-Lorestan											x
Shahla Ahmadi	ANRRC-Lorestan											x
Karim Khademi	ANRRC-Lorestan									x		x
Firooz Derekvandi	ANRRC-Lorestan									x		x
Morad Azizollahi	Extension-Lorestan					x				x		x
Ain-Ali Amiri	ASC-Lorestan											x
Mahmoud Moradi	Indep.-Lorestan											x
Saba Moradi	Indep.-Lorestan										x	x
Nasim Moradi	Indep.-Lorestan										x	x
Sattar Hashemi	Indep.-Lorestan											x
Maryam Rahmaniam	CENESTA-Tehran											x
Kasem Al Ahmad	ICARDA-Aleppo											x

(1) Deceased April 2006
(2) Left February 2008

Institutions
AEERO: Agricultural Extension, Education and Research Organization
AERI: Agricultural Engineering Research Institute
ANRRC: Agricultural and Natural Resources Research Center

ASC: Agricultural Service Center
CENESTA: Centre for Sustainable Development (NGO)
DARI: Dryland Agricultural Research Institute
FRWO: Forest, Rangeland and Watershed Management Organization
ICARDA: International Center for Agricultural Research in the Dry Areas, Aleppo, Syria
Indep.: Independent
KUL: Catholic University Leuven, Belgium
MoJA: Ministry of Jihad-e Agriculture
RIFR: Research Institute of Forests and Rangelands
RRC: Rural Research Center
SCWMRI: Soil Conservation and Watershed Management Research Institute
SWRI: Soil and Water Research Institute

Notes
The Iranian research centers and research institutes are under the umbrella of AEERO.
The researchers at the Agricultural and Natural Resources Research Centers in Kermanshah and Lorestan are affiliated with the different research centers and institutes in Tehran (e.g., SCWMRI, SWRI).

Appendix A: Abstracts of Key Research Reports

De Pauw, E., A. Mirghasemi, A. Ghaffari, and B. Nseir. 2008. **Agro-ecological zones of Karkheh River Basin.** Aleppo, Syria: ICARDA.

The two Challenge Program projects working in the Karkheh River Basin (KRB), "Improving livelihood resilience by integrated natural resource management in upper catchments of dry areas" and "Improving on-farm agricultural water productivity in the Karkheh River Basin", have research objectives that require the agroecological characterization of the KRB, and the identification of the recommendation domains for the research conducted at benchmark sites within the basin. To achieve these objectives within a limited period of time and with limited resources, new GIS-based methodologies, applicable world-wide, were developed or fine-tuned.

This study has several major components: an assessment and mapping of the agricultural environments in the entire Karkheh River Basin (KRB); the setting of the selected benchmark sites for the two Challenge Program projects in relation to these environments; and the mapping of the possible out-scaling domains (from a biophysical perspective) at the level of the Karkheh River Basin, Iran and the CWANA region.

The agricultural environments of the KRB were mapped using the concept of agro-ecological zones (AEZ), integrated spatial units arising from the integration of climatic, topographic, land use/land cover and soil conditions. The AEZ were derived by the following six-step procedure:

- Generating raster surfaces of basic climatic variables through spatial interpolation from station data;
- Generating a spatial framework of agroclimatic zones (ACZ);
- Simplifying the relevant biophysical themes (agroclimatic zones, land use/land cover and landform/soils);
- Integrating the simplified frameworks for agroclimatic zones, land use/land cover and landforms/soils (soilscapes) by overlaying in GIS;
- Removal of redundancies, inconsistencies, and spurious mapping units;
- Characterization of the spatial units in terms
- of relevant themes.
- Using this methodology, the entire Karkheh River Basin (50,764 km2) was classified into 46 unique AEZ, of which only five occupy nearly 60% of the basin.

On the basis of major differences in climatic conditions, land use patterns and terrain-soil characteristics, three major agricultural regions, the Northern, Middle and Southern Agricultural regions, are distinguished and described. In addition, an overview is provided of the biophysical conditions that prevail in the four benchmark sites selected in the basin. The AEZ present in the benchmark sites occupy 90% of the KRB. Hence on this criterion, the benchmark sites are highly representative, even though some of the AEZ may occupy only a small area in the benchmark sites. On the other hand, with the exception of a few small areas in Merek, the oak forest belt, which is characteristic of the Middle Karkheh Agricultural Region, is not present in the benchmark sites. Neither are the badlands, which occupy substantial areas in the Middle and Southern Karkheh Agricultural Regions, and the sand dunes of the Southern Karkheh Agricultural Region.

In the last section of the report, a methodology is developed to assess whether the technological, institutional and policy options for the farmers and communities developed in the benchmark sites, have possibilities of application in areas outside these sites. The methodology is based on assessing the similarity in conditions between each of the benchmark sites and different target areas for out-scaling (the KRB, Iran and CWANA). The approach taken is confined to the biophysical domain only and involves several stages of assessment. In a first stage climatic similarity in biophysical conditions is assessed using temperature and precipitation as indicators and similarity indices for quantification. In further stages, the climatic similarity index is combined with a landform similarity index and a land use/cover similarity index. Soils, a potentially important indicator, were not considered in the light of inadequate soil information, but can be brought into the similarity assessment at a later stage, once better data become available.

Irrespective of the out-scaling domain and the way similarity is defined, the areas similar to Azadegan and Sorkhe, the two irrigated viii benchmark sites, are small, as they contain homogeneous environments and irrigated areas are always a minority land cover. On the other hand, a much higher degree of similarity is found in the three out-scaling domains with the upper catchment benchmark sites, Honam and Merek, due to the fact that in both sites the presence of different topographic conditions and land uses allow covering a larger outscaling domain.

Moosavi, S.B., J. Anthofer, M. Moazzami, S.M. Mobarakian, P. Garavand, Z. Rashno, S. Moradi, M. Moradi, M.R. Farhadi, M. Fakhri, T. Babaei, H. Azizi, S. Rahmani. 2010. **Gathering Wisdom from the Field: Participatory Technology Development with Farming Communities in Honam and Merek Watersheds in the Karkheh River Basin.** ICARDA, Aleppo, Syria.

In mid-2006, a sub-project on "Participatory Technology Development" (PTD) was initiated within the Livelihood Resilience Project in the Upper Karkheh River Basin, Iran. Its aim was to facilitate a participatory approach to developing agricultural technologies and improving resource management, thus adapting the process of change to the diverse livelihood of the local people and the complex, agro-ecological systems prevailing in dry mountainous areas and watersheds. Adopting such an approach would entail a shift from the linear transfer of technologies from research stations to farmers through extension staff currently being practiced in Iran, to a more interactive collaboration between researchers, farmers and extension staff.

In Iran, agricultural research and their implementing institutes are considerably fragmented and follow the conceptual distinction of crops, livestock, trees, soils and socio-economics. This conceptual break-down structures skill development, institutes within the agricultural research organization, research objectives and discipline-specific methodologies, and planning and evaluation processes. Researchers have to submit a research proposal to the scientific committee of their respective research institute which evaluates the proposal from a disciplinary point of view. This set-up impedes the promotion of integrated and sustainable land and water management approaches. The structure of government line ministries also reflects this fragmentation of the natural world.

The conventional agricultural research approach in Iran may have produced high-quality scientific outputs within agricultural disciplines. However, for complex, heterogeneous agro-ecological systems prevailing in dry mountainous areas and watersheds, alternative ways for research and development are required. In addition to disciplinary biases which shape agricultural research, there is a bias towards plot and farm-level research and a focus rather on individuals than on common resources such as water or rangeland. There is also an emphasis on agricultural production in isolation from other aspects of livelihoods and in the failure to consider social consequences of farming activities beyond the plot and household boundaries. A consequence of the disciplinary structure of the agricultural sector is a lack of coordination between research institutes as well as links to other stakeholders in the agricultural sector to achieve wider scale impact.

The Livelihood Resilience Project in the Karkheh River Basin in Iran tries to address these issues following a multi-stakeholder INRM and participatory approach. Since the PTD component was initiated rather late trying to overcome some of the previous shortcoming of the conventional research approach, it did not follow the chronological steps of PTD, namely problem and needs assessment, group formation, planning, experimentation, and monitoring and evaluation (van Veldhuizen et al, 1997). Rather, it tried to shift on-going activities into a more participatory direction attempting to integrate activities of different partners and other stakeholders. Rather than adhering strictly to the chronological steps of the methodology from the outset, the PTD group had to adapt itself to seeking, and iteratively building upon opportunities for instigating methodological, attitudinal and perhaps even institutional change with respect to participatory research.

This report is meant to describe the evolution of the PTD process that unfolded over its 30-month lifespan. Chapter 2 provides an overview of the philosophy of adopting a participatory approach to technology research and development, as well as describing the path we intended to follow for this project. Chapters 3 to 6 describe and reflect upon different stages within the PTD cycle: resource and problem identification; technology selection; experimentation process; and technology evaluations. A natural follow-up to a PTD cycle would be outscaling the process principles, methods, findings and learnings. Chapter 7 seeks to know what outscaling of PTD entails, and whether the project did enough to expect promising outcomes in the future. To complement the outscaling of the process, chapter 9 discusses what is required to upscale and mainstream the approach at various planning and policy-making levels. In between, Chapter 8 looks at the individual and group capacities needed to facilitate and contribute to the effective implementation of a PTD process. Finally, chapter 10 tries to summarize some of the lessons learnt.

Milani, P.M. K. Eftekhari, S.H. Fatehi, and M. Sepahvand. 2010. **Semi-detailed soil surveys of Merek and Honam Watersheds, Karkheh River Basin.** ICARDA, Aleppo, Syria.

The study of soils is important for land use planning, agriculture, and natural resource development programs. Determination of soil characteristics and limitations is one of the most important duties of soil researchers. It is hoped that the report will be great value to all who are interested in the optimum use of the land and water resources of Iran. This report presents a semi-detailed soil survey of Merek watershed in Kermanshah Province and Honam watershed in Lorestan Province.

The Merek watershed is located southeast of Kermanshah, the provincial capital. Its area is 24,200 ha. Its climate is cold semi-arid. Soil temperature and moisture regimes are thermic and xeric, respectively. Lithological composition is mainly limestone, dolomite, marl, claystone and sandstone.

The Honam watershed is located south of Alashtar city and has an area of 14,200 ha. It has a wet climate as a result of high mountains. Soil temperature and moisture regimes are mesic and xeric, respectively. Lithological composition comprises limestone, dolomite, marl, quartzite, shale, sandstone, and conglomerate.

Interpretive map units were produced for both watersheds using a geopedologic approach. Soil morphology, physical and chemical characteristics studied included color, soil structure, rock fragments, voids, roots, clay cutans, soil reaction, soil salinity, soil alkalinity, $CaCO_3$, organic carbon, cation exchange capacity, soil texture, field capacity and permanent wilting point were determined in each map unit.

In Merek, three landscapes, seven reliefs or moldings and twenty one land units were distinguished. Three soil orders were identified: Entisols, Inceptisols and Vertisols. Entisols are found in the mountains and hilly areas. Textures in the soil profiles are clay or silt clay. A subangular blocky structure is the dominant soil structure. The amount of subsurface gravel (fine and coarse) in the profiles dug on mountains and hilly areas varies between 25 to 60%. The pH varies between 7.3 and 7.9, electrical conductivity varies between 0.4 to 0.8 ds m^{-1}, organic carbon varies between 1 to 3% and the amount of $CaCO_3$ in surface horizons varies between 17 to 32%.

In Honam, four landscapes, ten reliefs or moldings and 37 land units were distinguished. Two soil orders were identified: Entisols and Inceptisols. Entisols are found in the mountains and hilly areas and Inceptisols in the piedmonts and valleys. Textures in the soil profiles are clay or silty clay and the dominant soil structure is subangular blocky. The amount of subsurface gravel (fine and coarse) in the profiles dug on mountains and hilly areas varies between 0 to more than 75%. The pH varies between 7.3 and 8.0, electrical conductivity varies between 0.2 to 7.6 ds m^{-1}, organic carbon varies between 1 to 3.7% and the amount of $CaCO_3$ in surface horizons varies between 1.7 to 43.42%. Topography, soil depth, stoniness, water erosion, heavy soil texture, especially in the surface horizons, are the main limiting factors in the study area.

Turkelboom, F., M. Ghafouri, A. Bruggeman, and H. Siadat (eds.). 2010. **Integrated Watershed Management Principles for Upper Catchments of Dry Mountain Environments, with examples from Karkheh River Basin, Iran.** ICARDA, Aleppo, Syria. (in review)

The Livelihood Resilience Project was implemented in the Karkheh River Basin in Iran, in the period between June 2004 to June 2009. The project has as its overall goal to strengthen livelihood resilience of the rural poor and to improve environmental integrity in upper catchments of the dry areas (Turkelboom et al., 2004). One of the specific objectives of the Livelihood Resilience project was to amalgamate the findings and experiences of the studies and activities in the two benchmark watersheds into watershed management principles for upper catchments of dry mountainous environments. The results of this work are summarized in this report.

Integrated watershed management should be pursued for people's livelihoods and for the ecosystem. It can be achieved when all stakeholders agree on a joint vision and action plan. Scientists should support the process with information about the limits of exploitation of ecosystems, efficient and sustainable methods to use natural resources, mechanisms for cooperation, and provide indicators of progress. (Turkelboom).

Priority issues for integrated watershed management were identified in a workshop with 70 stakeholders from Honam and Merek watersheds. These include:

- Stakeholder coordination before and after implementation of projects is essential.
- Participation of women needs to be encouraged.
- A holistic system of resource management is required; teamwork is an essential feature.
- Community participation during implementation of projects is essential.
- Criteria and indicators for integrated watershed management are required.
- A land use plan is required; farming of steep slopes must be reduced.
- Land users need further training and skill development.
- Forests and rangelands require protection; the carrying capacity of rangelands must be respected.
- Ecosystem degradation must be prevented; religious motives must be used to protect natural resources.
- Water harvesting is essential to improve livelihood resilience.
- Jobs need to be created to reduce stress on natural resources and erosion; the government should stimulate privatization.

The Livelihoods Resilience Project will address these issues if this falls within its mandate and capacity. Planning and implementation of integrated watershed management need a Catchment Management Authority. (Ghafouri).

Planning rural development in an environment friendly manner needs knowledge of location and size of lands with different suitabilities. It is proposed to develop and make operational Spatial Decision Support System for the Honam and Merek watersheds. The system will comprise an Analytic Hierarchy Process, a modern multi-criteria evaluation method, and a Geographic Information System. (Kheirkhah et al.).

Agricultural development is a component of integrated watershed management. Important handicaps are the small size of farms and the fragmentation of the land holdings. Land consolidation has been limited due to farmer's traditions, religious inheritance rulings and inadequate capacity of authorities. A participatory approach to land consolidation is needed to gain acceptance by farmers and to remove obstacles. (Siadat).

Management of rangelands and forests should be based on their carrying capacities so that land degradation is prevented, biological diversity is preserved and vital natural resources are saved. Current practices are quite different: trees are cut to feed leaves to livestock and to obtain wood to make charcoal, leading to fragmented forests and open areas, while a significant number of forage, tree and shrub species are already very rare. (Shahmoradi).

Erosion and deposition both cause major problems and need to be reduced. The Karkheh dam reservoir is already in a critical condition due to the influx of sediments from degraded upstream areas (but not from the selected pilot watershed Honam and Merek). The main causes of erosion are road construction that leaves soil exposed, up and down plowing of narrow strips of farm land, and overgrazing of rangelands. Extraction of construction material from the river bed has disturbed the geomorphology of the river and destroyed its ecological system. Plans need to be developed and implemented for the conservation of upstream waterways and the main river, and accompanied by adequate regulations. Active involvement of the main stakeholders, including local communities, is needed to ensure success. Public awareness plays an important role for implementation. (Norouzi et al.).

Supplementary irrigation is crucial for agricultural development. But there is little surface water storage, the volume of groundwater is limited, and much arable land lies on slopes. Fortunately options may exist to expand supplementary irrigation. These include: (i) pumping water from the Honam spring and transporting it along gentle sloped open channels, (ii) constructing of underground dams in ephemeral rivers to store sub-surface water, (iii) a small dam is being constructed in an ephemeral river upstream of the Sarab Firouzabad' qanats in the Merek area and some of the stored water can be used, and (iv) artificial recharge stations can increase underground storage at suitable locations in the Merek plain (Heydarizadeh).

Stimulation of agricultural development needs a more integrated approach to innovations and technologies. It is essential that farm productivity and income increase through new and resource efficient crop management techniques and tools, as well as post harvesting processes. Methods and materials should be adapted to local conditions through active participation by local communities, with particular attention to environmental friendliness, sustainability and resilience to climate change. Regular participatory evaluation of the process of development of integrated watershed management enables the stakeholders, especially local communities, to propose adjustments and to adapt concepts and plans to local needs and conditions. (Moosavi).

Women have a significant role in livestock activities and marketing of its products. But provision of developmental services to women has been limited. The following interventions for women appear necessary: (i) capacity building in modern livestock and crop husbandry, including mechanization, (ii) increasing participation in community organizations (rural councils, cooperatives, etc) by encouraging women and rural managers, and (iii) providing access to bank credit and government support services. (Effati).

Porhemmat, J., M. Heydarizadeh, I. Veyskarami, H. Hessadi, B. Ghermezcheshmeh, A. Bruggeman. 2010. **Water Resources and Runoff Modeling of Merek and Honam Watersheds, Karkheh River Basin**. ICARDA, Aleppo, Syria. (in review).

To manage and develop water resources, monthly data of surface and ground water resources were measured for a full water year in Honam and Merek watersheds. Two data loggers were installed in the middle and outlet of Honam: Presk and Zirtagh stations, respectively. In addition, a rain gauge was installed in Presk village. Collection and analysis of data was continued for one water year (Oct 2007 to Sept. 2008). Result showed that annual runoff coefficient in Honam was 0.53, indicating a relatively high runoff generation potential in this basin. The amount of discharge in the outlet of Honam is 57.432 MCM for the basin area of 140.2 km^2.

As land use is one of the main components in hydrologic regime of the watershed basins, the effect of land use change on runoff and hydrograph of flood events was modeled using the HEC-HMS model. After determining different type of land use and area percentage of each land use using Landsat TM satellite Images, the vegetation cover and soil hydrologic group maps were overlaid in GIS and the Curve Number (CN) runoff values corresponding to the SCS guideline were identified. The CN values were subsequently changed for the land use change analysis. The HEC-HMS model using the CN method, SCS unit hydrograph and observed rainfall- runoff data was calibrated with one measured event and validated with another event. In the calibration step the initial loss was increased to 0.26 S (in comparison to 0.2 S in SCS guideline). The validation step with the optimized parameters showed little error in the peak discharge.

The result of the HEC rainfall-runoff modeling analysis in Honam showed that the land use change affected the peak value and volume of hydrograph so the peak discharge of the event of 16 December 2007 of 4.8 m^3/s increased to 11.3 m^3/s under poor land use and reduced to 3 m^3/s under good land use.

Similarly, two data loggers were installed in middle and outlet of Merek, Cherorish Bridge and Halashi stations respectively. In addition, a rain gauge was installed in Halashi station. Collection and analysis of data for Oct 2007 to Sept. 2008 showed that the annual runoff coefficient in Merek was very low, 0.043. This indicates the importance of infiltration and groundwater in this watershed. The amount of discharge in the outlet of Merek is 5.435 MCM. The result of the HEC modeling analysis in Merek showed that the land use change affected the peak value and volume of hydrograph so the peak discharge observed on 5 January 2008 of 1.94 m^3/s increased to 4.2 m^3/s under poor land use and reduced to 0.7 m^3/s for the optimistic scenario with good land use.

For both watersheds, continuation of hydrologic data collection to capture annual fluctuations due to wet and dry periods was recommended.

Effati, M., M. Martini, A. Abbasi, and S. Soltani. 2010. **Gender and Livelihoods in Upper Karkheh River Basin, Iran**. ICARDA, Aleppo, Syria. (in review)

In this study we have sought how to improve the livelihood of studied households with consideration of women's role in producing agricultural products as well as the existing gender division of labor in their various economic and social activities compared with men. The study population consisted of eight villages of Merek and Honam watersheds located in Kermanshah and Lorestan provinces, respectively. The study applied as social survey method along with participatory rural appraisals (PRA), eventually trying to combine results from both methods.

Leading grounds under the study included: explanation of existing gender roles in the activities related to agriculture, extend of women's access to and control over production resources, women's share in household income through their different in-and out-farm activities, rural women's perceptions and imagination about their own livelihood resilience as well as their families, and finally presentation of appropriate option to improve livelihood of rural households with emphasis on women's role.

Rural women are active in inside affairs of their house, which mostly done by women, besides agricultural activities. Out of different activities of the women, their largest shares are in laundry, house cleaning, bread baking, and child caring. Honam's rural women participation in house chores is more than Merek. The types of handicraft made by women include weaving carpet, gelim, rope, cotton, spindle making, Mashteh, Chador making, knitting, and Mojbafi, which usually accomplished by hand.

Most of the animal husbandry activities were carried out by women. Women’s roles in animal husbandry in terms of priority are in milking, dairy processing, animal cleaning, animal feeding. Moreover the rate of women participation in cattle (such as cow and calf) is more than in stock rearing (sheep and goat).

Although rural women's participation in performing agricultural activities is considerable, but their role and participation in decision-making, access and control on production resources is very little. Patriarchic culture in rural families, leave lees opportunities for women to take part in decision-making and access to resources. When access of a group of people in a society to production resources is limited, their participation will also decrease as well, because one important requirement for taking part in decision-making is having a share in properties especially in local communities.

The extent to which women can participate in traditional institutions and associations for group work is considerable. However, participation in formal institutions such as "Village Councils", "Assistance Institution for village" (Dehyari) is limited. However, an important issue is the potential for women's participation in group activities. This could be an appropriate background for establishing local institutions for organizing women in order to gain access to proper services for local development.

Considering the results of this research, following recommendations are presented for the improvement of the status of the rural women in the studied villages:

1. Girl's education beyond primary schools.
    - Literacy courses for adults are required and may help rural women.
    - Motivate young girls for education through Islamic councils, local village leaders.
    - Make families more aware about educating their girls.

2. Training/Extension
    - Livestock management, animal diseases, and delivery.

- Dairy production is traditional and lacks hygiene. Training in technologies that would improve the quality of dairy products and add value to their products in order to maximizing income and to become ready for competing in external markets.
- Crop production, pest management, irrigation technologies
- Post harvest related activities
- Training in household economy
- Introduction of new products such as mushroom growing and saffron which do not need lots of water
- Training on handicrafts

3. Credits
    - establishing cooperatives that would act as collaterals for women to get credits. The cooperative will act as provider of credits and as collaterals. Social capital is the strength of these women and this help in trusting each other for repayment of the loans
    - Training in team making within cooperatives, rules and regulations of cooperatives and credits, reproductive activities they perform.
    - Interest rate of credits should be lowered for women farmers.

4. Involvement of women in public sphere to participate into village and institution management
    - Increase number of women experts in community organizations.
    - Involvement of female adults and girls in Islamic councils at the village level.
    - Improving quality of handicraft

5. Technologies of dairy production
    - Hold meetings between local village women who produce dairy products and dairy products industrials (factories of dairy products to see how they are processed.)
    - Link livestock producers with women dairy processors to learn about new technologies and improvement of the traditional tools actually used.
    - Note: crop production is higher than livestock production; there fore milk plant can be effective in helping improve dairy products.
    - Calling for meeting between women producers and connected professionals in the region to explain and plan for designing suitable tools.

6. Improvement of the available modified chickpea harvester. New (tall) varieties of chickpea that is better than the local can be harvested by machine.

7. Lack of girls' employment especially those who hold a university degree.
    - Facilities and funds for these young girls to institute income generating activities such as those related to livestock production, mushroom production, beekeeping, protected agriculture.
    - These girls can be managers of these activities, because of their education and will have the potential to improve these activities
    - Providing them with credits
    - Training girls as local facilitators

8. Any successful activity for women should take the social and cultural aspects of women's life.

9. In female headed households, where women have to interact with men, priority should be given to their concerns.

Rafati, M., M. Zad, A. Kalaei, K. Noori, A. Aw-Hassan, P. Valipour, M. Farhadi, F. Jahannama, A. Nemati. 2010. **Livelihoods and Agricultural Policies in Merek and Honam Watershed in Karkheh River Basin.** ICARDA, Aleppo, Syria. (in review)

Livelihood surveys were conducted through interviews with people from 158 selected up- mid and downstream villages in Merek watershed (Sekher Olya, Mehdiabad Sofla, Kole joob and Baghe Karam beg) and 177 villages from rural areas of Honam watershed (Peresk Olya, Chahar Takhteh and Siyahpoosh). In Merek, the average family size is 5.1 and the average age of the head of the household is 46.8. In Honam, the average family size is 5.5 and the average age of the head of the household was 53.1. In Merek 47.5% of the household heads were illiterate while this number was 49.6% in Honam.

The average area of rainfed and irrigated lands in Merek are 4.2 and 1.2 ha, respectively, while in Honam these are 3.4 and 2.1 ha. The average number of large and small animals in Merek were 9.6 and 1.2, and in Honam 19.9 and 1.8, respectively. The results from this study showed that the rural families in Honam regions possessed more irrigated land, large and small animals than those living in Merek region. But, there were no significant differences between the two watersheds for the total land and the rainfed land possessed by families.

In general, income generation activities in these regions can be divided into three major groups: agricultural activities, livestock and animal husbandry, and other activities. In Merek, 70.1% of total income of the households was obtained from agricultural activities, 17.3% from animal husbandry and 12.6% from other income activities. In Honam, 42.5% of the total income was obtained from agricultural activities, 34.3% from animal husbandry, and 23.3% from other resources.

The studied families are divided, due to criteria correspondent with income per head, into Income Group One (so called poor) and Income Group Two (so called non-poor). In Merek, 45.6% and in Honam about 16.2% of families belong to the poor group, while 54.4% of the families in Merek and 83.8% of the families in Honam are non-poor. The irrigated and rainfed area and the number of large and small animals were significantly different between the two groups in Merek. In Honam, the irrigated land and the number of large animals was significantly different between the two income groups.

With respect to the access to different irrigation water resources, in Merek, wells and streams are the main resources for agriculture. In poor income group of this region (72 families), 29.2% of them obtain water from wells, 16.7% from streams and 2.8% from qanats; in other words, totally 48.7% of these families who belong to the group One, have access to water resources and 51.3% of them have no access to any resources at all. In the non-poor income group in Merek (86 families) 44.2% of families obtain the agricultural water from the wells, 14% from the rivers and 9.3% from the canals. In other words totally 67.5% Of these families who belong to the group Two in Merek region , have access to water resources while the rest of 32.5% enjoy access to none of the resources at all.

In Honam, streams are the most important water resources for agriculture. In the poor income group (19 families), the only water resource for agriculture is the stream and 76.9% of this group enjoyed access to this resource. Thus, other families from this group (21.1%) had no access to an irrigation water source. To the group Two of income in Honam region (98 families) rivers are the main agricultural water resource and 99% of the families had access to this resource. One% of the families from this group obtain their water from wells, in other words all families from this group in Honam region have access to water resource.

The expense of studied families was another criterion in this research. Generally, the whole families' expense was divided into five groups (food, non-food, health, education, and house repairs). Food and non-food cost were found to form the main expenses of the families. In Merek the poor spent 84.5% of their total expenses on food and non-food items and the non-poor 87.5%. In Honam these costs reached 90.8 and 87.3% for the poor and non-poor, respectively.

In Merek, in developing from group one to group two in all villages, the share of food cost finds no reduction. A similar comparison in Honam shows that in this watershed, the share of food cost is mitigated through this development while a growth is observed in the cost of non-food cost. Indeed, the consumption behavior of the families in Honam region is in accord with Engle's rule; while in Merek, there is in an opposition with this rule. A reason to this in Merek is the welfare level of the studied families; so that considering all families in Merek we find out that they are relatively in a lower welfare state when compared with Honam families and through a growth of income in these families, a part of their major needs is responded, but not being satisfied in the other group.

While policies affect the whole territory of a nation, they affect different households and different communities differently. This difference comes from the characteristics of the households and communities of their involvement in the economic activities the policy affects. Such differences in policy impacts can be seen in the watersheds of Merek and Honam. The differences between the two watersheds are noticeable; in Merek agricultural activities (crops) contributed 73% of the income and were limited to five crops, namely wheat, chickpea, sugar beet, barley, and corn.

While in Honam, 41% of the income resulted from agricultural activities, and the crops were much more diversified than those in Merek. Main crops in Honam include wheat, chickpea, alfalfa, clover, sugar beet, bean, lentil, walnut, and colza. One of the most important reasons for the difference in the crop diversity of the two regions is related to climatic conditions and limited water, and especially access to water is more limited in Merek than in Honam.

In Merek, income from livestock activities contain some 19% of the income in the region; the produced income shares from sheep and goat is more than other livestock but income-generating shares of livestock depend on the access to resources, particularly rangelands in the studied villages. In Honam, the share of livestock raising activities in total income of the region is over 33% which is much larger compared to that of the Merek region. In Honam, the income-generating share of cows is more than of other animals. Honeybees accounted for over 11% of income resulting from livestock activities in Honam, while this was almost zero in Merek region.

Studying impacts of the price change on the change in production composition of the crops in various income groups in both regions suggested that the farmers do not change their production composition for price changes fewer than 30%, especially for traditional crops like wheat, chickpea, and sugar beet. It seems that a prevailing inflation state and an expected price increase in the country are of the most important reasons for such an unchanged production composition of the crops. Since the guaranteed prices of the crops are frequently increased at a lower range than the inflation rates, it might be expected that this policy would have no significant impact on such a change.

New crops with lower area under cultivation in the regions, especially in Honam, such as rapeseed, bean, alfalfa, and clover are more sensitive to price changes. Cultivation of these products changed at a 10-20% change in their prices. There is more reaction to the price change in case of the crops used to feed animals (barley, in particular), as their increased prices may have a strong effect on livestock raising activities. Thus, the farmers tend to respond to lower price increase in such crops, so the risks of strong fluctuations in their prices cause no distortion in the livestock raising activities. Because of higher importance and share of livestock activities in Honam, it is revealed that the farmers respond to a price increase of even less than 10%.

To improve the households' livelihood through increasing the crop prices, there should be a substantial increase in prices, which would impose heavy costs to the government as well as implications like higher increases in the crop prices and food insecurity for consumers. It should be noticed, however, that the impact extent of increase in the crop prices on the livelihood of rural households depends on the extent of the crop-cultivated lands. Dominant crops of a region could play a primary role in improving livelihood, depending on a suitable response to prices, though negative effects could arise too.

Eliminating subsidies for fertilizers and pesticides in both Merek and Honam regions had a small negative impact (averagely less than 1%) on net income of the households. It is important that such subsidy eliminations have a more negative impact on the wealthier group who benefit from more subsidized inputs because of having larger lands.

Study results indicate that increased access to funds is much more effective on development of livestock raising activities rather than agricultural activities. In the first and second income groups in the both regions, there is a stronger willingness to develop the livestock raising activities because of an averagely small-irrigated land owned by each household, leading to a lower impact on the change in crop compositions. Results suggest that increased fund cause a considerable increase in keeping and breeding of cows, while certain income groups in both regions are very interested in keeping small animals specially sheep due to their better access to pastures; a case which calls for attention, as it may largely damage the rangelands, which are already severely degraded.